ANNEX 2 – Video Lessons Scripts

AREA A

DIGITAL TRASFORMATION OF CULTURAL HERITAGE

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

MODULE 1

DIGITAL TRANSFORMATION OF CULTURAL HERITAGE

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

AREA A
MODULE 1: DIGITAL TRANSFORMATION OF CH

1.1 Digitization and digitalization

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Ramona Quattrini
Duration (min)	8
Slides	12
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome to the first lesson of the module "Digital transformation of Cultural Heritage" within the DCbox online course. We are going to talk about the importance of preserving and disseminating our Cultural Heritage, particularly focusing on the digitization and digitalization processes.

Slide 2_Digitization

Although these two seem to be synonymous terms, they present a substantial semantic difference. The first one, the digitization, concerns a pure analog-to-digital conversion of existing data and documents. For instance, think of scanning a photograph or converting a paper report into a PDF. The data itself is not changed — it's simply encoded in a digital format.

Slide 3_Digitalization

The second one, the digitalization, according to Gartner glossary [1], is "the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." Digitalization moves beyond digitization, leveraging digital information technology to entirely transform a framework — evaluating, re-engineering, and re-imagining the way you do something.

Slide 4_Digital transformation

If digitization is a conversion of data and processes, digitalization is a transformation. This means that both processes are essential and must coexist in a common framework, that we can call, in order to simplify, the *digital transformation* of Cultural heritage.

According to Public Digital [2] - 'Digital transformation is the act of radically changing how your organisation works, so that it can survive and thrive in the internet era.

The question now is: How can Cultural Heritage face that?

Slide 5_Digital Cultural Heritage

Thanks to the available digital techniques and technologies, in the last decade it was possible to make almost perfect Digital facsimiles of Cultural Heritage from the architectural level to the finest detail. Nowadays, we can freely talk about a new form of heritage: Digital Cultural Heritage, D.C.H. It's dematerialized from his tangible form, but for this reason it becomes able to perform extraordinary tasks and functions.

Slide 6_Dematerialization

What is the mission of dematerializing our Cultural Heritage in order to create digital facsimiles?
Of course, the list of the possible answers is quite extended. We can summarize it as follows: to preserve and fix forever the historical memory to be used by our society whenever it is needed; to study Cultural Heritage, reproduce it, make it circulate, reconstruct it after a catastrophic event, narrate it with new forms of communication in physical or virtual museum, give it to the future generations... and much more that perhaps, even today, we are not able to guess [3].

Slide 7_The fundamentals for CH digital transformation: I. A sustainable framework

To make all these possible, a sound base is needed: a multidisciplinary, scientific approach that can deal with a number of methods and tools within the digital transformation of Cultural Heritage.
First, there is the need of a sustainable framework: thanks to the technological innovation we have cost reduction on the one hand and hardware performance increase on the other hand that may lead to even more sophisticated solutions.

Slide 8a_ The fundamentals for CH digital transformation: II. the European policies

Second, some international standards and policies as regards Digital Cultural Heritage must be provided.
For two decades the International Council of Museums (ICOM) [4] has dealt with the museums management and staff and of course with the digitization and digitalization process.
Especially in the last years the European Commission adopted some specific measures to face this phenomenon: for instance, it presented a vision and ways forward for Europe's digital transformation by 2030.
Europeana [5] provides cultural heritage enthusiasts, professionals, teachers, and researchers with digital access to millions of cultural heritage items from GLAMS institutions across Europe. (When I use the term 'GLAM' I refer to the widest definition which means galleries, libraries, archives, and museums).

Slide 8b_the Italian scenario

As a reflection of the European scenario, the Italian government launched in 2022 the National Plan of Cultural heritage Digitalization [6] that is the strategic vision with which the Ministry intends to promote and organize the digital transformation process in the five-year period 2022-2026. It is addressed in the first instance to museums, archives, libraries, central institutes, and public places of culture that protect, manage, and enhance Cultural Heritage. A debate is also observed in the skills needed for working in CH [9].

Slide 9_ The fundamentals for CH digital transformation: III: Digital maturity

Third, a fundamental aspect is the ability to analyze and understand the level of digital maturity of GLAM's institutions, since it represents an essential element on which the digital transformation process is based. Digital maturity is defined as "an individual's or an organisation's ability to use, manage, create and understand digital, in a way that is contextual, holistic and purposeful [7].
So, the self-assessment became an essential methodology for examining, through the analysis of internal processes, the state of digital maturity of an organization and its ability to implement technologies and organizational innovations that make the model of management adopted.

Slide 10_ The fundamentals for CH digital transformation: IV: Digital skills

Finally, the fourth element: digital skills. They are the skills needed for GLAM professionals to be digitally literate and therefore make use of the possibilities that digital transformation offers. 'Digital skills' have three elements: 'competency' (action), the ability to use a digital tool; 'capability' (intention), how that ability is then applied successfully to a task; and 'literacy' (reflection), the ability to evaluate the appropriateness of those competencies and capabilities [8]. Together, these three elements are essential to build digital confidence.

Despite the proliferation of digital roles and responsibilities, most institutions over all recognize that their activities are not preparing adequately for the changes brought by digital transformation.
Knowledge of personnel's digital skills or digital maturity is essential in today's workplace, which has been strongly shaped by digital trends.

Slide 11_ Digital transformation in museums

After all these definitions we can take a look at some examples of digital transformation in museums: Mobile ticketing is an essential tool for a modern museum that meets the demand of an increasingly digital public and facilitate, in many aspects, the exhibition visit. On the other hand, the possibility to have HD paintings, thanks to sophisticated 3D documentation techniques, offers remote access to the museum and a more intimate enjoyment of the artwork. Another key point, of course, is the quality of the marketing strategies adopted especially as regards the using of social media for reaching as many people as possible of any age.

Furthermore, the implementation of 3D artworks facsimiles and digital catalogues ("Europeana" for instance) enables a number of possibilities such as VR applications for experts or non-experts. The digital transformation so requires cross-disciplinary approach, suggesting the merging between humanities and informatics.

Slide 12_The Digital Curator

In this scenario, who's the digital curator?
We can try to give a concise definition according to what we have just discussed:
A Digital Curator must be a multifaceted professional able to design, perform and promote a digital strategy, for documentation, conservation, enhancement, and presentation of cultural contents. Therefore, he/she must lead the whole digitisation and digitalisation process, based on ICT, managerial and Humanities skills and competences combination. Don't worry, all these concepts will be further explored along the entire course: Supporting the Digital Transformation of Museums. The DCBox approach.

Slide 12_Next Steps

So, in the following lessons we will discuss about the multifaceted world of Digital Cultural Heritage, and you'll be aware of the most important processes, from the survey techniques to the modelling techniques, from the European policies to the management aspects, from the development of applications to the marketing strategies and even more.

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AREA A
MODULE 1: DIGITAL TRANSFORMATION OF CH

1.2 Digital Museology and Museography

Responsible	The Cyprus Institute (CyI)
Teacher	
Duration (min)	8
Slides	5
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome to the second lesson of the module "Digital transformation of Cultural Heritage" the DCBox approach. Through this lesson, we will introduce the concept and meaning of the term "Digital Museology and Museography". We will begin to form a solid base of what digital transformation and digital curation is within the museum sector. We will look at the history of museology and museography and how each discipline has shaped the role of the museum curator.

Slide 2_What is Museology?

Museum work shifts between practice and theory and creates room for personal development and for the development of the museum world. Museology in its most basic definition is an applied science. However, what does this really mean?

Slide 3_What is Museology? Part 2

Before museums, there were private collectors that kept objects to themselves and were not made for public viewing. Museums now are primarily an education centre, where collections can be made public and used for educating people on their past. This discipline also explores the history of museums and the role they have played in our ever-changing societies, as well as the activities they engage in such as curation and preservation. The International Committee for Museology favours defining museology as a specific relation between man and reality, which is expressed by documenting what is real and can be understood through direct sensory contact.

Slide 4_What is Museography?

Along with museology, museography completes the overall science of museum studies. As museology explores the history and importance of museums as institutions and the role they play in our societies, museography is the study of the actual museum structure.

Slide 5_What is Museography? Part 2

So, in contrast to museology, the term museography has long been used to identify the practical activities associated with museums. This can include the layout of the collections, displays, technical solutions, techniques and practises related to the operation of a museum. Museographers, in turn, take into account the scientific programme and collection management of a museum and aim to display the objects in a suitable manner. It is important to understand the needs of the public in order to employ the best suited communication methods for the message of any given exhibition to be realised. You can easily define this as being the practical or applied aspect of museology.

Slide 6_History of Museology, Museography and Museums

Museums are institutions dedicated to preserving and interpreting evidence of our human history and the natural world. The history of museums, of their different forms, runs together with the history of museology. The first time the word 'museum' was used to describe something close to what we have today was in the 15th century for the collection of Lorenzo de Medici in Florence. Until 17th century, it was a name for collections of curiosities such were Ole Worm's collection in Copenhagen and John Tradescant's collection in Lambeth. The first museum open to the public is considered to be the Ashmolean Museum in Oxford as it bore the name 'museum' on the building. This marks the first museum that opened to the public and also the moment 'museums' started to become institutions rather than just a private collection of items.

Since then, museums have evolved to take on many forms depending on the collections they house. Archaeology museums, Natural History Museums, open-air museums that include preserved buildings and now in this digital age even virtual museums which you will look at in more details in module 6. Museology came about later on and first appeared as a term in the early 18th century. It wasn't however until the 1970's that museology was officially acknowledged as an academic discipline.

Slide 7_Digital Museology and Museography

As times have evolved, museums have had to evolve too. Nowadays visiting a museum is much more than just looking at artefacts and reading some information on them. Technologies have advanced and museums have had to include digital aspects to their exhibitions to keep visitors coming and keep them engaged. This has been more evident during the COVID-19 pandemic, during which a number of museums around the world had to 'shift' towards an even more digital presence to essentially ensure their survival. Digital uses and advances are changing visitor expectations, forcing museums to diversify their practises. Digital Museology and Museography explores this digital aspect and how it can incorporate this 'new digital age' while keeping the core values or what museums are and how they fit into our societies.

Slide 8_Digital Museology and Museography Part 2

In the coming modules we will see how digital culture is at the forefront of museum transformations and innovative technologies such as virtual reality, augmented reality and mixed reality are being used by curators, as we will see in module 7. As with anything in our day and age, digital museology and museography is competitive online. Each curator will have to still overcome some challenges when offering digital solutions to museums. An example is that online activities and digital tools do not offer a direct source of income for

institutions, even though these tools often carry the highest cost to create and instal. These will be some of the problems you will be asked to consider and think about as you navigate this course. All these new aspects are incorporated to create digital museology and museography – keeping the core theories of the discipline but bringing them into a new age of digitalisation and technology. They allow institutions to re-establish themselves and stay relevant as places of interest and social dialogue.

Slide 9_Next Steps

In the next lessons of this first module, you will look at other aspects of digital transformation in Cultural Heritage and the specific role of a digital curator. As the course goes on you will get into much more detail on specific tools, technologies and strategies that will assist you as you navigate becoming a Digital Curator in Cultural Heritage.

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AREA A
MODULE 1: DIGITAL TRANSFORMATION OF CH

1.3 Digital Humanities (merging of humanities and informatics)

Responsible	University of Nis (UNI)
Teacher	Olivera Nikolic
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome to the third lesson of the module "Digital transformation of Cultural Heritage" within the course Supporting the Digital Transformation of Museums. The DCBox approach. Through this lesson, we will introduce the concept and meaning of the term "Digital Humanities", which comes from the connection between the humanities and informatics.

Slide 2_What are the Humanities?

First, let's define the notion of ***humanities***. "Humanities" can be described as the field of study in which people document and process the human experience. The term 'humanities' includes, but is not limited to, the study and interpretation of the following: languages; linguistics; literature; history; jurisprudence; philosophy; archaeology; comparative religion; ethics; history, criticism and theory of the arts; those aspects of social sciences which have humanistic content and employ humanistic methods; and the study and application of the humanities to the human environment with particular attention to reflecting our diverse heritage, traditions, and history and to the relevance of the humanities to the current conditions of national life. Those are disciplines of memory and imagination, telling us where we have been and helping us envision where we are going. [1]

Slide 3_What are the Digital Humanities?

The Digital Humanities (DH), also known as humanities computing, are a field of study, research, teaching, and invention related to the intersection of computing and the disciplines of the humanities.[2] They are methodological by nature and interdisciplinary in scope. They involve investigation, analysis, synthesis and presentation of information in electronic form. They study how these media affect the disciplines in which they are used, and how these disciplines may contribute to our knowledge of computing. DH is what happens

digitally in each of the disciplines of the humanities. They have to be distinguished from humanities computing, which is what these separate digital activities have in common and which takes place at some kind of institutional centre, be it physical or notional.

Slide 4_History of Digital Humanities

Digital humanities descend from the field of humanities computing, whose origins reach back to 1940s and 50s, in the pioneering work of Jesuit scholar Roberto Busa, which began in 1946, and of English professor Josephine Miles, beginning in the early 1950s. In collaboration with IBM, Busa and his team created a computer-generated concordance to Thomas Aquinas' writings known as the Index Thomisticus (www.corpusthomisticum.org). In the following decades, archaeologists, classicists, historians, literary scholars, and a broad array of humanities researchers in other disciplines applied emerging computational methods to transform humanities scholarship. The advent of personal computing and the World Wide Web meant that Digital Humanities work could become less focused on texts and more on design. The multimedia nature of the internet has allowed Digital Humanities work to incorporate audio, video, and other components in addition to text. Digital humanities are at the leading edge of applying computer-based technology in the humanities. The field has grown tremendously over the past 40 years or so. It originally focused on developing digital tools and the creation of archives and databases for texts, artworks, and other materials. From these initial uses, and as computation developed, computers offered increasingly sophisticated ways of handling and searching digitised culture. For example, with recent advances in digital imaging, it is now possible to produce very high-quality reproductions of books and artworks that can transform our ability to study them.

Slide 5_Use of Digital Humanities

By producing and using new applications and techniques, DH make new ways of teaching possible, while at the same time studying and critiquing how these impact cultural heritage and digital culture. DH are also applied in research. Thus, a distinctive feature of DH is their cultivation of a two-way relationship between the humanities and the digital: the field both employs technology in the pursuit of humanities research and subjects the technology to the humanistic questioning and interrogation, often simultaneously.

Slide 6_ Digital Humanities Methodology and Tools

Like DH concepts, it is hard to delineate clearly what is new for methodology in DH, the traditional research methods in social science still apply but they are more influenced by the use of technologies. In many ways, the emerging digital tools helps humanities scholars to modify research methods to explore patterns and uncover the hidden messages of research data. The most commonly used methodologies in DH projects are:

- **Data Collection / Curation**
- **Data Interpretation & Analysis**
- **Data Visualisation**

Data Collection / Curation

In DH, data collection is a process of creating, gathering and acquiring information in a systematic manner. Traditionally, the humanities scholars adopt qualitative methods such as interview, focus group, oral history and ethnography to collect research data. In DH research, data can be created in many different ways to enhance the scope, quantity and quality of data collected and to open up new possibilities in humanities research. Humanities data can be text, geospatial, data, results of analysis, and more. Data collection can be conducted using: ***DigitAJsation, Text Encoding, Data Extraction.***

Slide 7_ Digital Humanities Methodology and Tools

- **Data Interpretation & Analysis**

Basically, data analysis means the process of understanding, evaluating and summarising the data collected. There is a great variety of data analysis methods in DH based on researchers' disciplines. Data interpretation and analysis can be classified as: ***Text Mining & Analysis, Spatial and Temporal Analysis with GIS, Image Analysis.***

Slide 8_ Digital Humanities Methodology and Tools

- **Data Visualisation**

The latest tools in digital humanities enable the researchers to visually represent their data in a more sophisticated way with pictorial and graphical images. Data Visualisation method is important in cultural heritage field, and in Digital Transformation of Museums.

Digital humanities tools can be useful in the three main stages of a project: they can help you to Advance in your research, to disseminate your results more effectively, and they can help your audience to understand what you're trying to tell them.

Researchers can make use of visualisation tools to map out the linkage between their research objects in network graphs instead of listing all the objects in tables to explain solely in plain words. Researchers can make use of handy online tools and platform in creating their research project websites, online exhibitions, et. in showcasing their research outputs to the world.

As for diffusing findings, digital humanities can offer a wide range of platforms for presenting and sharing data, in many different ways. Data presented in innovative formats will make research more accessible and understandable by different types of learners.

Visual representations could be better for younger audiences or those unfamiliar with area of study because reading and interpreting visualizations of data can be easier and quicker than databases or text. Data in visual forms are also more attractive and more likely to be remembered, there by facilitating their retelling.

They also enable the public to engage with research in an accessible way. A typical Digital Humanities project will use digital methods in both its research methodology and dissemination plan, simply by making the products of its research (data, tools, web apps etc.) publicly accessible at the end of the project. The Project “Platform for 3D digitization of immovable cultural treasure of Serbia” – „3D Serbia“, is an examples of this.

Slide 9_ Digital Humanities Projects

A Digital Humanities project uses digital methods and computational techniques as part of its research methodology, dissemination plan, and/or public engagement. A typical Digital Humanities project will use both digital and non-digital methods in its research design. Digital methods enable scholars to ask questions that are difficult to answer using non-digital methods, due to the size or complexity of the source material.

Slide 10_ Examples of Digital Humanities Projects

In 2018, the Ministry of Culture of the Republic of Serbia support the project of digitization of the architectural heritage in the inaccessible location of southeastern Serbia, which they designed Faculty of

Electronics in Niš and archaeologist of the National Museum of Toplica in Prokuplje, which started work on the digitization, protection and presentation of the architectural heritage of Serbia, persisted to this day. So far, at 38 locations in Serbia, using video game technology, historical buildings have been recorded with a drone, 3D scanner and 360 camera, digital copies have been made and presented on the platform https://www.srbija3d.rs/EN/index.html [4] with reliable information about the history of the buildings. The platform is design to work on desktop and mobile devices and on all operating systems. Its support all kinds and sizes of screens, as well as various types of input/output devices, from keyboards and mice, through touch-sensitive screens, all the way to virtual reality glasses.

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AREA A
MODULE 1: DIGITAL TRANSFORMATION OF CH

1.4 Digital Curator's Role

Responsible	Universidad de Córdoba
Teacher	Massimo Gasparini
Duration (min)	8
Slides	
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome to the third lesson of the module "Digital transformation of Cultural Heritage" within the MOOC Supporting the Digital Transformation of Museums. The DCBox approach. Through this lesson, we will introduce the Digital Curator's Role according to the history of this role, laws and the educational curriculum.

Slide 2_ Digital Curator's Role through decades

Since the Middle-Age the figure of "curator" has been defined as the responsible for private collections. This figure should be able to classify the objects, but without the aim of a public exhibition, and their qualities should include a proper knowledge and taste.
Till the first half of the 19th century the role of the curator was strictly referred to cataloguing, classification and preservation of artworks.
In the 1990's, it reached its peak [1]. Public institutions and universities provide training courses approaching this profession.
From this point on, the curator could be considered as the intermediary between the artwork and the public of a museum/cultural heritage exhibition.
Due to the digital revolution promotion and preservation of digital information came to the fore in the mid-1990s. Moreover, digital competences were included in digital curation education programmes [2].
The term "digital curation" was first used at the "Digital Curation: digital archives, libraries and e-science seminar" sponsored by the Digital Preservation Coalition and the British National Space Centre held in London on the 19th of October 2001. [3]
Due to the growing mass of digital assets in research centres, universities, archives, museums and libraries, the role of digital curator is now slowly consolidating in many cultural institutions and research centres as an inter-disciplinary figure with a solid subject domain background, mixing skills of data curation and digital preservation.

Slide 3_ Laws managing Digital Curator's Role

The Digital Curator (DC) profile per se is not yet a defined and regulated professional figure with specific skills, so there is not a specific law according to manage DC's role. Despite that, we can rely on certain recommendations and European laws that point out some competences and aims in accordance with this role.
In 2004, ICOM (International Council of Museums) provided the Curricula Guidelines for museum professional development. It defined competencies such as:
- Information and collections management and care competencies: Knowledge of and skills in creating, preserving and sharing museum resources. Referred to archives and collections.

In 2006, the European Commission provided the Recommendation on the digitisation and online accessibility of cultural material and digital preservation: advise about the preservation of Europe's collective memory.
In 2008, the ICOM International Committee for the Training of Personnel (ICTOP) drafted the Museum Professions – A European Frame of Reference: It says museum's professionals should have a university degree and competences in museology.
But the profession of a Digital Curator is still under discussion in all the countries participating in this Erasmus+ project, namely Cyprus, Greece, Serbia, Spain, Portugal and Italy.

We will focus more on all the laws regarding the digital preservation of cultural heritage in AREA C.

Slide 4_DC's educational curriculum

As far as we know, to date there is still no unique definition of digital curator, his/her skills and competencies. This obstacle in identifying the role is basically due to the fact that responsibilities in digital curation can apply to a diverse range of employment characteristics and roles [4]. We need to connect disciplines that belong to disciplinary area of archival, history, computer science and law.
The Digital Curator's educational curriculum must be flexible, adapted to change, that establishes the profile of an ICT professional whose skills are based on the technical and operational capacity to interpret the nature of the information content present in the documents of libraries, archives and museums, and then transfer it in the digital environment.
According to the Digital Curation Centre, in UK, digital curation is the management and preservation of digital data/information over the long-term [5].
For example, the author M. Madrid [6] provided this definition:
"Digital curators have a range of managerial and operating skills including: domain or subject expertise; good IT skills; and knowledge of best practices in acquiring, organising and managing digital objects and digital collections for long-term access, preservation, sharing, integrity, authenticity and reuse."

Slide 5_Developed projects

References about the educational curriculum of the digital curator can be taken from several programs and projects developed in the past. Some examples are:

The DigCurV project (2011) [7], which has constructed a framework to support the development of curricula for the vocational training of digital curators working in cultural heritage. It developed three distinct lenses or views on the framework: Practitioner, manager and executive. These lenses were extended in a course of 600 hours modulated into six sections:
1. The document in the transition from analog-to-digital.
2. The culture heritage and the digital perspective.
3. Metadata, standards, and tools for digitization projects.
4. Communication in the digital age

5. Preservation in the digital age
5.1 Access rights, licensing, public domain, and orphan works in digitization projects
6. Case studies
Digital Curation Getting digital objects into the archive (2013) [8] is a course put into practice by the 5th International Summer School for Archivists. The summary of the curriculum was:

- Planning: file formats, policy, keep documentation…
- Identifying the digital content.
- Selecting the portion of the digital content that will be preserved. (Storing, protecting, managing and providing)
- Recognition of errors, appropriate media, documenting the process…

Slide 6_

The Mu.SA "Museum Skills Alliance" project (2019) [9]: It names the role of Digital Collections Curator as a person who is responsible for implementing the digital strategy relevant to collecting, storing, archiving, preserving and making accessible the digital collections (either born – digital or digitized). In larger museums this could be a role-profile, while in smaller museums a curator should be up skilled in the area.

The BIBLIO project (2019) [10]: It refers especially to the perspective of the Library and Information Science (LIS) on the discipline and profession of the Digital Curator. It says that students need to become digital curators and librarians who can engage with present and future digital information. A digital collection encloses not only digitized books, but also resources of totally different kind and objects, whose management, fruition and preservation need specific digital skills and competences. It is when the Digital Curator's role takes action.

Slide 7_ DC's features

To date there is no single, unanimously agreed, reference framework to empower learners with skills, competences and expertise a DC should master, such as a synthesis of technical knowhow and humanistic background. On account of this, we can sum up the features of the Digital Curator according to the points seen in this module.
The main areas which have been identified as strategic for training the next generation of Digital Curators can be gathered as follow:
Digital Humanities (DH): Incorporate educational methodologies; Recognise the main challenges in the field of digital humanities and heritage (technical and ethical).
Digital Museology: Knowledge of skills in the application of the intellectual foundations of museum work; integration of technological interfaces; understanding of the new relationship of museums with their audiences, reflecting on new educational models and opportunities offered by technology, critical use of ICT for the creation of new curation models for the museum of the future.
Digitization and VR: Digital documentation of cultural material; knowledge of the advanced procedures and techniques of computer 3D modelling and animation; create interactive visualizations and use intuitive interfaces for various types of augmented (AR) and virtual (VR) realities.
Digital Management: Role of museum management and the basis of museum governance as well as cultural policymaking at national, European and International level; regulatory and legal issues raised in relation to information and digital media management.
Digital Design: Skills and competence required to solve problems creatively and be in charge of complex design processes; recognise and assess the ethical challenges; Produce technically and aesthetically high-quality design work.
Digital Communication: Public engagement through the effective use of digital methods and applications; Expanding Roles of Museum Marketing and Communications; use of computer technology in the communication and transmission of culture to specialist and non-specialist audiences.

Conclusion

To summarize up, DCs role is important for the future of our cultural heritage, and we will learn more about it in the next lessons.

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AREA A

MODULE 1: DIGITAL TRANSFORMATION OF CH

1.5 Storytelling for Cultural Heritage

Responsible	Universidade Lusófona
Teacher	Carlos Smaniotto
Duration (min)	8
Slides	12
Version	draft

Slide 1_ Introduction

Welcome to the lesson on **Storytelling** of the module "Digital transformation of Cultural Heritage". The aim of this lesson is to define what sorytelling is and to raise awareness on its power. It is backed by examples of interesting and engaging practices of telling stories - not only in museums, but we also want to comprehend how it can be used in preserving, enriching and disseminating Cultural Heritage assets.
There are different ways of telling a story: visual stories in photographs, spoken stories in videos and recordings, and written words on books and blogs.

Slide 2_ The power of storytelling

Litherland [1] pinpoints "… [stories] *delight, enchant, touch, teach, recall, inspire, motivate challenge. They help us understand. They imprint a picture on our minds. Want to make a point or raise an issue? Tell a story."*
Storytelling is a term that is becoming widespread - whereas the phenomenon that it designates is an ancient and a valuable form of human expression. It reflects how people learn and communicate, how we share information, knowledge and skills.
New is the deliberate use of storytelling in a narrative-centred approach, in order to collate and share human experiences - in our case, telling stories about a Cultural Heritage asset. It can be a powerful communication tool. This raises the question: how to "create" stories from/about museum contents, because storytelling has to be more than just entertainment. According to Poletta [2], storytelling has the power for mobilising political and social movements.

Slide 3_ Storytelling in/for museums

Storytelling is by no means new to museums; an exhibition does not only display objects, but it interprets and narrates the context, this means it tells stories [3]. Thus, museums are also storytellers. They not only collect and preserve objects, but they can also give visitors valuable experiences and impressions [4], bringing visitors to new adventures. Through these stories, visitors can get a new perspective, better understand contexts and place themselves in the situation.

Slide 4_ The relevance/benefits of storytelling

Stories can capture people's attention, and (hopefully) provoke them to think differently about an issue. Storytelling is a way of encouraging people to delve deeper into their own history and culture. Storytelling thus creates an emotional connection to the CH. Storytelling helps create a sense of belonging, shape social identity, and it is an important community builder and a society's bonding medium [5,6]. It can support museums in their efforts to evolve "into places to gather and share human experiences" [2] and generate an attachment to the place [5].

For this reason, storytelling should not be merely understood as a way of displaying an asset. To be effective, telling a story needs to be strategically developed and implemented. In this way storytelling can result in variegated benefits - cultural, social and even economic.

Slide 5_ Communicating content through storytelling

The benefits and the power of storytelling call for providing a stage for the CH assets, to create a portrait to tell each story. However, once there is already a story to tell, it has in the end to be tailored to the target audience and to the goal(s) of the story. The purpose of telling a story, the goals for it, and the feelings and perspectives to be conveyed to the audience need to be discussed.

Storytelling is always interactive; it involves a two-way interaction between the one who tells the story and one or more listeners. It can also be more than just telling a story, it can create a conversation [1], where the listeners also influence how the story is being told. This can increase the exchange of ideas, and enable museums to gain dynamic and people-based insights. This in turn enable museums to promote diverse perspectives and experiences.

Such interactivity is also of relevance for *enriching* the assets - this will be discussed later (slides 8-10).

Slide 6_ Digital storytelling

In the digital era, where digital and mobile technology are ubiquitous and pervasive, a story and telling it are gaining a new dimension - the digital storytelling. A digital story combines one or more digitalised media to tell, communicate and disseminate the story. It is a multimedia presentation combining the story (content) with a variety of digital elements and media, such as text blocks, images, video, audio, with social media elements (e.g. Tweets, Instagram posts) and interactive elements (e.g. digital maps).

Postings in a social media platform means giving others the access to see and comment one's life without actually being there.

In the forthcoming modules it will be discussed how digitalization is a potential for increasing and spreading stories. Different tools and techniques will be discussed to create digital stories.

Slide 7_ Basics on creating a digital story and telling it

In a short lab, the basic of creating the frame for telling a story will be discussed. It will tackle the brainstorming for the development of a script and storyboard, defining goals, etc. Also different readily available source materials for creating a story will be introduced. Two basic concepts will be discussed: K.I.S.S. (keep it simple and short) and the art of share our story, listening to stories of others.

Slide 8_ Europeana and storytelling

Europeana acknowledging the benefits of storytelling created and is collecting responses to storytelling and engagement activities - it is creating a valuable resource for those interested in developing stories and gain from them. The seven tips for digital storytelling with CH will be discussed.

Slide 9_ Learning from Storytelling labs

We want to discuss two examples where storytelling is used to engage the community - in order to create awareness on CH, as well as to enrich them with people's narratives.

Study cases in Córdoba/Spain and Lourinhã/Portugal will be used to illustrate the process of building a process for creating content for a cultural asset, and on the flip side, how the collection and interpretation of the people's narratives can be used to enrich their own CH.

These two cases where organised within the Working Group on Digital Practices for the Study of Urban Heritage at the Dariah.eu. These cases associate both semantic enrichment of CH and placemaking.
The discussion is around how to gain and make use of stories, narratives, memories people share, and how to create a lasting and genuine enrichment of assets. The two **Story Labs** allow the WG DigiUH to widely discuss a systematic model to collect and analyse how people can add personalised views, storytelling, images, videos and sounds to assets, and to mix these with new footage and edit them, in order to enrich these with new metadata and linking the past with present societies.

Slide 10_ Case Studies Córdoba (Spain)

In the case of Córdoba, the Story Lab is centred on the Patios de la Axerquía. Here the local organization PAX-Patios de la Axerquía is working on preserving the built heritage (courtyards houses, called patios). It organises local activities to debate the benefits of sustainable living in the courtyards, this includes architectural aspects, like local materials, bioclimatic performance, contributions to achieve the Green Deal goals and SDGs, as well as social aspects, ie. community lifestyle and sharing experiences.
A developed digital tool (Dariah app) is used for visualising and communicating design scenarios and for mapping the patio houses that meet the relevant preservation criteria.
With the help of the Storylab it was possible to organise a survey on conservation status of the houses, and enrich the documentation with old photographs and "narratives" related to the former inhabitants and their activities in the patios. This case demonstrates how collecting stories of locals can enrich and expand the knowledge on the patios and the former residents.

Slide 11_ Case study Lourinhã (Portugal)

With the case of Lourinhã/Portugal we want to illustrate the process of creating content for a cultural asset, and on the flip side, the collection and interpretation of the people's narratives to enrich their own CH. Lourinhã is a small village full of history and heritage. In Lourinhã, the WG UDigiSH together with the City Council and the Aspiring Geoparque Oeste provided support for the community to create a Rota da Cal (Limestone Route), linking the different sites of the limestone production (quarry and kilns) to its use for whitewashing buildings (Municipal Council, church and museum). One goal of the StoryLab was focused in collecting and analysing narratives, stories of people around the limestone production and use, and the sites of production and use as heritage asset. Digital tools were used to inspire residents and tourists to share their narratives, memories and stories. The StoryLab enabled the development and testing of techniques for raising awareness and engaging people. This will help to find solutions that combine the protection of heritage and its access by the generations of today and tomorrow.

Slide 12_ Next steps

Now you know what storytelling is and its benefits, we will come back to storytelling in different modules. As seen in this lesson, it can be a useful tool that can be organised with few efforts and resources. Most of the time storytelling won't be an explicit subject, but it will be pervasive in the discussion of the Digital Cultural Heritage and your role as Digital Curator. Keeping in mind that "story is king", it has to be bespoke to the target audience to allow harnessing connections and create common understandings.

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AREA B

ADVANCED 3D DIGITIZATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

MODULE 2

DIGITIZATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

2.1. Range-based digitization

Responsible	The Cyprus Institute
Teacher	Dante Abate
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

Good morning everyone, welcome to Module 2 of Area B which will address the topic of Digitization, focusing on Cultural Heritage assets. My name is Dante Abate, I am an Associate Research Scientist at the Cyprus Institute and today I will introduce you to range-based digitization techniques.

The trend of digitally and faithfully reconstructing Cultural Heritage in three dimensions helps to simulate reality in a more objective and reliable way and provides the opportunity to use digital 3D models for different purposes that can change through time.

Recent technological advances supported by the development of fast and efficient algorithms and computer power have enabled the gradual adoption of the above by almost all scientific communities including Cultural Heritage experts.

The 3D reconstruction contactless techniques can be grouped in two main domains: non-reality based and reality-based.

Slide 2_Non-reality-based 3D modelling

Non-reality-based 3D modelling is usually referred to applications where the 3D reconstruction is performed using traditional manual computer graphic methods. Historical documents, maps, visual references (i.e., paintings) are used as main data sources without the support of the existing artefacts because the latter do not exist anymore.

Non-reality-based models relies also on the so-called Procedural Modelling (PM). PM is a technique that enables to vary and change existing models based on a sequence of rules, instructions, or algorithms instead of creating entirely new ones manually. This technique is completely automated and it is usually employed when a large amount of data is needed.

Slide 3_Reality-based 3D modelling

On the other hand, reality-based 3D modelling is the process of 3D modelling that starts from surveyed data and ends with a digital twin of the real artifact.

It relies on real and accurate digital copies of an object, monument or landscape which is still visible and existing.

Reality-based 3D surveying and modelling are playing an important role in various domains and applications.

They are widely used in the documentation, preservation and valorisation of Cultural Heritage but also for example for city planning, energy assessment and audit, territorial monitoring, hazard recording, etc.

Slide 4_Active and Passive sensors

Reality based 3D modelling can be achieved through two main optical methodologies exploiting Active and Passive sensors.

Both techniques collect data which are visible at that given time by the data collection system.

Active techniques, usually referred as range-based, use 3D scanners.

The use of these devices differs according to the scale, the scope and final goal of a specific 3D project.

Passive techniques instead, usually referred as image-based, use photographic equipment (cameras) to collect images which are subsequently converted in 3D models.

Active and Passive techniques output is usually represented by a point cloud featuring intensity values and or RGB colours or a solid/mesh model with textures.

Slide 5_3D scanning

In order to understand the concept which lies beyond 3D scanning, it might be useful to recall the 2D digitization of documents.

The latter is focused on the transformation of a printed page in a matrix of numbers which represent the colour of each pixel of the image.

What is considered given is the flat shape of the image and its extension (i.e., an A4 page).

In 3D scanning the a-priori knowledge of the object shape is not considered mandatory,

and no assumption is made about the external surfaces of the artefact.

The choice of the 3D scanner is based on the size of the object to digitize and on the object-sensor distance.

Slide 6_Laser Light

The type of light which allowed to engineer 3D scanners is the laser light.

Thanks to its physical properties it allows to generate extremely focused light spot if compared to other light sources regardless the distance (i.e., halogen lights).

Laser is indeed based on coherent and monochromatic light (one single light wavelength), which means the wavelengths of the laser light are in phase in space and time.

The main effect of these two principles is that the device's optics are much more efficient since they are manufactured to deal with a single wavelength,

and a larger amount of light can be concentrated on a specific surface.

Slide 7_Triangulation Laser Scanning

For small objects, usually 3D scanners are based on triangulation or structured light principles.

Large areas instead are modelled using Time of Flight (ToF) sensors.

Laser based 3D scanners use a process called trigonometric triangulation to accurately capture a 3D shape as millions of points.

Triangulation Laser scanners work by projecting a laser line or multiple lines onto an object and then capturing its reflection using a single sensor or multiple sensors.

The distance between the sensor and the laser emitter is called baseline (*b*).

The image of the laser light is then focused on the sensor plane which is located at a *f* distance from the lens.

This distance is called focal distance.

These values together with the angle of inclination of the emitter (α) allows to estimate the location of the points in the space.

Slide 8_Structured Light Scanning

For small scale objects another system which is currently used in reality-based 3D modelling is based on structured light.

This kind of device is used to measure the three-dimensional shape of an object using projected light patterns and a camera system.

The light pattern is projected all at once without moving elements.

The trigonometric principle of the system is similar to the one described already for the triangulation 3D scanner.

The triangulation is obtained by translating the camera laterally according to the light emitter.

The light pattern is deformed by the shape of the object.

Each transition between the black and white pattern will act as the laser light on the sensor.

The system projects a sequence of patterns (grey code).

The latter is based on an initial pattern with one black/white transition.

The digital camera acquires the image of the object and save it.

In the next steps the pattern black/white get denser per each step.

The number of images, and the level of the pattern refinement correspond to the sensor resolution and the optic quality of the structured light system.

Slide 8_Time of flight (ToF)

When it comes to the digitization of large areas such as building, archaeological sites and infrastructures, Time of Flight (ToF) devices are normally used and became today a standard routine thanks to more affordable models.

A laser pulse is emitted by the scanner.

The time it needs to travel to the target-object and being received back by the sensor is computed.

Together with the a-priori knowledge of the internal angles, it is possible to retrieve the 3D coordinates of the surface acquired.

Thanks to the speed of light of the laser beam, the time needed to digitize an object is very small.

Systems designed on ToF are usually referred as LiDAR acronym of Light Detection and Ranging.

Slide 9_SLAM

Another typology of scanners is represented by mobile mapping systems based on the `SLAM algorithm.

SLAM stands for Simultaneous localization and mapping

The SLAM algorithm is developed for a synchronized calculation of the laser scanner trajectory.

The Inertial Measurement Unit (IMU) controls the spatial movements of the system.

One sweep of the spinning 2D sensor is needed for scanning the field of sight.

The next sweep yields the initial trajectory and scans from a different viewpoint.

Sequential sweeps are used to match the point clouds together, and correct and smooth the trajectory.

This process is continuously repeated, whereas every new iteration refines the overall geometry and improve the device's location.

The point cloud quality improves accordingly.

Slide10_LiDAR

3D scanners based on the ToF can be operated both on the ground (Terrestrial Laser Scanners) or exploiting Aerial platforms (UAVs helicopter, planes).

The principle behind the data collection remains unchanged.

However, together with the 3D sensor, the aerial platform features additional hardware components such as Global Positioning System (GPS) and Inertial Measurement Unit (IMU).

These modules allow to estimate the position and the flight direction of the aerial platform.

Aerial Scanning is commonly included in the family of Mobile Mapping Systems (MMSs).

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2.2. Range-based survey techniques

Responsible	The Cyprus Institute
Teacher	Dante Abate
Duration (min)	8
Slides	8
Version	draft

Hello everyone and welcome to this second lesson of the Module 2 Area B. My name is Dante Abate, I am an Associate Research Scientist at the Cyprus Institute and today I will introduce you to the survey techniques exploiting active sensors.

Slide 1_Introduction

Active sensors create dense point cloud (and/or mesh) models in a short time with a high level of accuracy and reliability of the data.
The scanner works on the line of sight principle and, therefore, needs to be run in multiple scan stations to capture all of the details required.
Each resulting range map is referenced to the sensor coordinates system.
All of these scans must be aligned or registered from their respective coordinates systems into a common reference system.

Slide 2_Desk Based preliminary assessment

A fundamental, but sometime neglected, step for the digitization of heritage assets is represented by a preliminary desk-based assessment of the project, its requirements and final goals.

The outcomes of this exercise will lead to the choice of the most suitable techniques, the most appropriate sensor, the strategy for data collection, and the expected resolution and accuracy.

For this task the use of

images of the area or of the artefact,

the direct contact with the owners of the site (or the curator of the museum),

will contribute to a proper planning of the survey and to shape a risk and contingency plan.

Additionally, a proper assessment of logistic information (i.e., availability of electricity on site) or knowledge of possible obstacles, the time of day to reduce the presence of people or vehicles, and the position of the sun, to avoid shadows or very bright conditions for the imagery are also parameters to take into proper consideration.

Slide 3_3D Scanning Parameters

During a 3D scanning campaign, the main parameters which have to be set according to the object to digitize are the distance between the scanner and the object and the expected point cloud resolution (spacing between points).

Every manufacturer usually certifies a specific range within the scanner is able to collect the larger amount of data at a given accuracy. The further the instrument is placed from the surface the worst the accuracy of the data become, until no data can be collected.

In this slide, you can observe how the precision and the accuracy of a device are correlated. On the top-left corner, the scanner collects data with low accuracy and low precision: the points are scattered on the surface, far from the centre.

On the top right, the scanner is able to collect data with low accuracy (far from the centre) but with high precision (the points are grouped together). In the bottom left corner, the points have a high accuracy (close to the centre), but low precision (not grouped together). The bottom right image shows the best-case scenario where the device is able to acquire data with high accuracy and high precision.

Slide 4_Terrestrial Laser Scanner (TLS) Survey

A reconnaissance exercise should include decisions on the locations of the scanner to obtain most of the subject, filling the gaps because of the presence of, for example, vegetation, vehicles, fencing, etc.

This approach will help to Plan as many scan position as necessary to collect all the morphological features of the target object (this would avoid extra field-work campaign or gaps in the model).

Another important consideration for good coverage is to ensure there is a significant amount of overlap between scans, especially if the survey is heavily reliant on cloud-to-cloud registration (Activity 2.3): consider the location of the scanner in relation with the amount of scene/object overlap

Fence the area, if possible, to avoid unnecessary hazards in the area of the scanning operations due to people walking in close proximity to the equipment.

Slide 5_TLS Topographic Network

During a field campaign, TLS can be coupled with topographic measurements, materializing targets on site or measuring natural features.

The benefit is twofold.

First this procedure will improve the point clouds registration introducing in the system a solid topographic network.

This will be possible thanks to the highest accuracy provided for example by a total station.

Second it will be possible to georeference in a real coordinate system the 3D models exploiting GPS coordinates.

Slide 6_Triangulation and Structured Light 3D scanning

When the final goal of a project is to digitize small objects or there is a need to achieve the highest spatial resolution in the magnitude of micrometre, Triangulation and Structured Light sensors are considered the most appropriate devices.

For small artefacts, usually, the object is placed on a rotating table and the scanner is located in a fix position on a tripod. For each step a single range map is acquired. The table is rotated by an average of 5-10 degrees, according to the complexity of the object.

Due to the need of having a strong contrast of the laser light (or the black and white pattern) on the artefact surface, a dark environment is recommended for a better data collection.

As per TLS survey, range and resolution have to be set beforehand.

Slide 7_SLAM Survey

Coverage considerations for walking handheld and backpack scanners are similar with TLS but their flexibility of operation and ability to access tight spots means that shadow areas are usually less of a problem.

The use of the SLAM technique for indoor scanning (and, therefore, without GPS signal) requires meticulous planning to ensure that the algorithm can calculate the trajectory accurately. This relies on steady progress, a route that is usually a maximum of 20min to avoid drift and, most critically, a return to the start point.

This is particularly important for long linear areas.

These types of scanners can also operate from platforms, scaffolding, crane baskets, etc, because movement of the scanner is not an issue.

For the outdoor backpack scanners (that include both GPS and IMU systems) there is less need to return to the start point, although accuracy may be improved if this is done.

Slide 8_Aerial Laser Scanning Survey

For the digitization of landscapes or when the morphologic features of buildings or structures hamper the data collection of the highest parts, the use of aerial systems is nowadays considered a common practice.

Aerial Laser Scanners (ALS) have reached a high level of automation which allow to collect a large amount of data according to the surveyed area extension.

ALS field campaigns need a higher level of planning in terms of authorization from competent authorities (i.e., Civil Aviation Authority) since specific laws have been implemented at European level.

Logistic arrangements (for example the number of flights/batteries to complete the survey) are also fundamental.

A flight plan has to be set up beforehand selecting the altitude and the speed of the system according to the expected point cloud resolution.

Ground Control Points can be materialized on the ground and measured using a conventional GPS to improve the point cloud (strip) alignment.

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2.3 Point Cloud Alignment

Responsible	The Cyprus Institute
Teacher	Dante Abate
Duration (min)	23
Slides	20
Version	draft

Slide 2 and 3_ Introduction

Once the field campaign has been completed, and all data securely stored, the post-processing stage begins. The latter has the final goal of obtaining a complete and optimized 3D digital representation of the object, which describes all its morphological features or at least those which have been collected during the field survey.

The range-data post-processing pipeline consists of several steps which can be manual, automatic or semiautomatic.

Slide 4_ The Software

CloudCompare is a 3D point cloud opensource processing software which allows to perform all the steps necessary to complete the range-based post processing pipeline and obtain optimized 3D models, either in form of point clouds or mesh.

Slide 5_ Why and How

Each single point cloud collected from a specific scan position bares an individual reference system which center is spatially located at the scanner original position.

In order to reconstruct the model completely from all the point of views, the point clouds need to be aligned together in the same space. This process is usually performed exploiting a semi-automatic approach.

Slides 5 to 9_ Manual Pre-alignment

The first step is to identify at least three common points and manually mark them (pick) over the overlapping areas of two point clouds.

The result of this procedure will be a rough alignment where one point cloud is used as a reference and the other one is roto-translated on it.

Slides 10 to 12_ Internal and external orientation

Once the pre-alignment of two or more point clouds is completed, several algorithms can be used to refine the registration. These procedures exploit the geometric features of each range map. It follows that point clouds of flat objects can hamper the successful range maps alignment.

The most common algorithm used for range maps alignment is the Iterative Closest Point (ICP) which reduce the Root Mean Square (RMS) error.

Slides 13 and 14, Point Clouds Merging

Once all range maps are aligned in a single reference system they can be fused (merged) together. Before this procedure is performed, each map is still present as a single entity, afterward the complete 3D model will be managed as a single object.

Slides 15 to 18, Point Clouds Filtering

Point cloud filtering refer to the process aims at removing unwanted data which are not related to the surface of interest (i.e., people, trees, cars, obstacles); or modifying the quality of the data since they don't reflect the features of the surveyed object (i.e., noise reduction).

This processing step can be performed either manually or automatically.

During this process all redundant information, such as overlapping points which describe the same geometric features, will be removed. Accordingly, the number of points of the range map will be reduced without losing geometric details.

Slides 19 to 21, Meshing

Once the 3D point cloud has been merged in a single entity, it is possible to create a surface model formed of polygons. These are the result of the point cloud vertexes triangulation.

One of the most used algorithms is the Poisson Surface Reconstruction. It creates a watertight (closed) surfaces from oriented point sets.

2.4 Image-based digitization

Responsible	Universidad de Córdoba
Teacher	Massimo Gasparini
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

In this section, we will talk about the Image-based 3D digitization. This technique is based on the use of passive sensors, as camera; and when we talk about Image-based 3D digitization, we are referring basically to digital photogrammetry.

Slide 2_What is Photogrammetry

Photogrammetry is defined by the American Society for Photogrammetry and Remote Sensing (ASPRS) as “the art, science, and technology of obtaining reliable information about physical objects and the environment, through processes of recording, measuring, and interpreting imagery and digital representations of energy patterns derived from noncontact sensor systems”.

The name “Photogrammetry” comes from Greek "phos" (light), "gramma" (something written or drawn) and "metron" (measure). Photogrammetry is the science of making measurements from photographs.

Through digital photogrammetry, it is possible to obtain a “digital twin” of a real element (in the form of point clouds, textured 3D models, orthophotos and Digital Elevation Models) by a series of photos of the same element that are captured by different position.

The digital photogrammetry, compared to Range-based surveying methods (such as laserscanning), presents a series of advantages and disadvantages that can be summarized in:

Advantages:

- Photogrammetry allows to acquire metric data without a physical contact whit the objects.
- It allows to acquire data of large areas in short time.
- The primary data (photographs) can be processed multiple times and using different softwares and methods.
- It is one of the cheapest methods to digitize Cultural Heritage in 3D.

Disadvantages:

- The processing of photogrammetric datasets requires a greater amount of time compared to data from laserscanner.

- Photogrammetry depends on the light. It is impossible to obtain good data in a dark environment without light sources.
- Limited visibility and occlusions affect photographed objects.

Slide 3_History of Photogrammetry

The ideas behind photogrammetry dates back to the end of XV century, when Leonardo da Vinci started working on the principles of perspective and projective geometry, that later became the fundamentals of photogrammetry.

In mid-XIX century, Aimé Laussedat, known as the "father of photogrammetry", was the first person to use terrestrial photographs for topographic compilations.

In 1865 the Italian geodist Ignazio Porro designed the photogoniometer. This instrument allowed to remove the lens distortion of the cameras.

In 1867, Albrecht Meydenbauer coined the term "photogrammetry" and in the 1910 the International Society of Photogrammetry and Remote Sensing was founded.

An important role for the development of photogrammetry was played by the combination of photography and airplanes and the development of the aerial photography in military field during the I and II World Wars.

In the last decades, thanks to the development of sensors, and the paradigm shift between analogical and digital photography, the geomatic and remote sensing domains witnessed the boost of digital photogrammetry due to the parallel increase of digital born data.

Photogrammetry, combined with the powers of computer vision technology, contribute to the massive production of three-dimensional data exploiting digital photographs.

Slide 4_Classification of Photogrammetry

Based on the distance between the camera and the element subject to photogrammetric survey and the dimensions of the photographed object or scene, it is possible to define various types of photogrammetry:

- Terrestrial/Close Range Photogrammetry: the distance between the camera and the object to be photographed is quite small (it can vary between a few centimeters and several tens of meters)
- Unmanned Aerial Vehicle Photogrammetry: It is carried out through cameras placed on an unmanned aerial platform with a distance between camera and object below 300 m. It is very useful for the documentation of various elements, from multi-hectare areas to buildings.
- Aerial Photogrammetry: It is carried out through cameras placed in planes in a nadiral position and is used to document large portions of the territory.
- Satellite Photogrammetry: carried out through satellites, it is mainly used to document very large areas.

All these photogrammetry typologies are used in the field of cultural heritage for different aims such as the documentation of a buildings or objects, the recording of landscapes and archaeological excavations, measuring architectural features.

Slide 5_ Basic principles of Photogrammetry

At a theoretical level, photogrammetry makes it possible to univocally relate the three-dimensional space of the object (X, Y, Z coordinates) with the two-dimensional space of the photographic image (x, y coordinates). In this way it is possible to match selected points between the two dimensional systems. This operation is possible thanks to two basic principles of descriptive geometry:

- Conditions of collinearity: it states that the points of a real tridimensional object (A, B), its projections (A1, B1) on the projection plane (in this case the sensor of the camera) and the center of projection (O) are on the same projection line (r).

- Epipolar geometry: it is the geometry of the stereo vision. it describes the geometric relationship between two images of the same object but that are captured by two different positions and orientations.

In a more graphic way, we can say that certain points of a real three-dimensional element (A, B) are projected on the image planes (A1, B1; A2, B2) of photographs obtained from two different shooting points (O1; O2). In this context, therefore, the points A, B of the three-dimensional element correspond to the points A1, B1 of the shooting point O1 and to the points A2, B2 of the shooting point O2. Knowing the exact position of the points A1, B1 and A2, B2 in the two images taken and the spatial position of the shooting points O1 and O2, the points A, B of the three-dimensional element are geometrically defined, because they are the points of intersection of the projection axes r1, r2 of the shooting point O1 and of the projection axes r3, r4 of the shooting point O2.

Slide 6_ The workflow of a photogrammetric survey

The photogrammetric process is made up of different sequential phases that will be detailed in the following lessons:

1- Acquisition (Lesson 2.5): phase that refers to taking the images.

2- Orientation (Lesson 2.6): operations for the definition of the parameters that allow positioning the points of taking the images and the photographic sensor in space in order to proceed with the reconstruction of the shapes and dimensions of the photographed element. This phase is subdivided into:

   a. Internal orientation: parameters that allow the reconstruction of the projection rays (from the projection point to the image point), that is, the positioning of the shooting point with respect to the photogram. This orientation is deduced from the internal characteristics of the camera, such as the focal length, the main point (prospective center projected on the image plane) and the distortion values of the lense. The internal orientation of digital images is obtained from the metadata contained in the corresponding image files.

   b. External orientation: repositioning of the photograms in the spatial position occupied at the moment when the photograph is taken. It is subdivided into:
      i. Relative: determines the relative position of two images through the intersection of the projection rays (i.e., of the 3d model of the object), but without binding to the absolute XYZ reference system.
      ii. Absolute: the model obtained in the phase of relative external orientation is subjected to rototraslation and scaling in relation to an absolute reference system and, therefore, scaled to real size. To carry out this phase, it is necessary to know the real coordinates of some well-defined points of the photographed element.

3- Restitution (Lesson 2.6): operation that, as a result of the good success of the previous phases, allows measurements to be made on the reconstructed model of the object.

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2.5 Image-based survey techniques

Responsible	Universidad de Córdoba
Teacher	Massimo Gasparini
Duration (min)	8
Slides	7
Version	draft

Slide 1_Introduction

In this lesson we will show how to plan and realize a photogrammetric data acquisition campaign.

Slide 2_ Photography – The First Part of Photogrammetry

The production of a good quality photogrammetric model largely depends on the quality of the frames acquired for its production.

Therefore, before carrying out any dataset acquisition for photogrammetry, it is necessary to have a basic understanding of the structure of a digital camera and of the variables on which the quality of a photo depends.

There are multiple types of digital cameras (DSLR, Bridge, Mirrorless, compact camera) and also lenses (standard lenses, wide angle lenses, telephoto lenses, macros) but they all share the same structure, characterized by:

- Sensor
- Shutter
- Lenses
- Aperture

The knowledge of the specific characteristics and parameters of all these elements that characterize our camera, represents the starting point from which we plan a photogrammetric acquisition project that meets our needs and objectives.

Slide 3_ Camera adjusting

Knowing the characteristics of our camera, it is possible to establish and control some of the main variables for obtaining a good photo. These variables are:

-Exposition

- Focus and depth of field

- Field of View

Slide 4_ Camera adjusting: Exposure

Exposure, in photography, is the amount of light that reach the surface of an electronic image sensor: it is a combination of the time and the level of illumination received by the photosensitive material. As a general rule, a correct exposure is obtained when a balance is reached between light and shadow, thus achieving a good level of detail in the photographed scene. Through light meters integrated or external on the cameras it is possible to establish the correct exposure of the scene. The exposure is controlled through the following three parameters that define the “exposure triangle”:

- shutter speed
- Aperture (F-stop)
- ISO value

Shutter speed: it refers to the period during which the shutter of a camera is kept open and is expressed in seconds and fractions of seconds. Depending on the shutter speed, therefore, the photographic sensor receives more or less light.

Aperture (F-stop): it refers to the aperture of the diaphragm (flap system present in the lens) that is set by the operator. Whit a larger aperture of the diaphragm (lower F values), more light reaches the sensor, but less depth of field is achieved; a lower aperture of the diaphragm (higher F values) means that less light reaches the sensor in favor of a greater depth of field.

ISO value: it refers to the level of sensitivity of the photosensitive surface (in our case the electronic image sensor). A low scale number indicates a lower sensitivity of the sensor to the reception of light; a high scale number indicates a greater sensitivity of the sensor to the reception of light. It is important to specify, but the more the ISO value increases, the more background noise is generated in the photographic image, decreasing the general sharpness of the frame.

In summary, a correct exposure of the photographed scene can be achieved in different ways by modifying these three values, depending on the needs. For example, at F-stop parity, a correct exposure value can be obtained by increasing or decreasing the Shutter speed and ISO value.

Slide 5_ Camera adjusting: Focusing and Depth of Field (DoF)

In addition to a correct exposure of the scene, it is necessary that the photographs acquired are well focused.

Focus refers to the point where light rays originating from a point on the observed object converge. An image is defined as focused if the light from the object points is converged as much as possible in the image and out of focus if the light is not well converged.

The Depth of Field (DoF) indicates the area that is included from the closest point to the furthest point of our visual field in which the objects in the image remain focused and sharp in relation to the plane of focus. The Depth of Field is determined by three factors:

- Focal Length
- Aperture (F-Stop)
- Focus distance

The Focal Length is the distance between the optical center of the lens and the focal point (Focus). The effect of the Focal Length on the DoF is inversely proportional: keeping the other parameters constant, a shorter focal length corresponds to a higher DoF.

Aperture (F-stop), as seen above, refers to the opening of the diaphragm. Relative to DoF, a tighter diaphragm provides a higher DoF.

Focus distance is the distance between the optical center of the lens and the object plane of focus: the smaller the distance between the optical center and the element to be photographed, the smaller the DoF; the greater the distance between the optical center and the photographed element, the greater the DoF (up to the hyperfocal distance limit, which is the point where the maximum depth of field allowed is obtained).

Slide 6_ Field of View (FOV)

The Field of View (FOV) refers to the visual angle encompassed by the photographic sensor. This depends on the photographic shooting distance, the focal length and the size of the digital sensor. That is, at the same focal length, a larger sensor always corresponds to a wider FOV; at the same sensor size, a shorter focal length of the lens corresponds to a wider FOV.

Slide 5_ Planification of a photogrammetric data acquisition

When planning a data acquisition for photogrammetric processing, it is necessary to consider a series of factors:

- Reproduction scale
- Camera features
- Data collection distance
- Overlapping of the frames
- Displacement in x and y axes

All these aspects allow us to establish the **GSD (Ground Sample Distance)** of our photogrammetric project, as we will explain in the following slides.

Slide 7_ GSD

The Ground Sample Distance (GSD) represents the distance between the center of two pixels of the frame measured on the photographed element. That is, in an image with a GSD of 10 cm, two adjacent pixels of the photograph are representing 10 cm of the photographed reality.

We can summarize the GSD in the following concept: the shorter is the distance between the camera and the object, the higher is the spatial resolution; the higher is the distance between the camera and the object, the lower is the spatial resolution. The number of images and the time of data acquisition is contingent upon a higher or lower GSD value.

The GSD, therefore, is the data on which to establish our photogrammetric acquisition project, because it defines the maximum definition that could be reached by the photogrammetric elaboration.

Through the definition of the parameters broken down in the previous slide, it is possible to calculate the GSD that will be obtained in our photogrammetric acquisition process or, also, from an established GSD *a priori* it is possible to adjust these same parameters to achieve the result.

The parameters to calculate the GSD are defined by the following expression:

$$\frac{D}{c} = \frac{GSD}{px} = \frac{W}{w} = \frac{H}{h}$$

In which:

- **D** is the data collection distance (data established by the operator).
- **c** is the focal length (data set by the operator).
- **GSD** is the Ground Sample Distance.
- **px** is the size of a pixel of the camera sensor.
- **W** and **H** are the "real world" horizontal and vertical footprint that is captured in the photographic image.
- **w** and **h** represent the size of the camera sensor (in pixels or in mm. The technical data of the camera specifies this values).

Several of these data are already known by the operator, either because of the camera's technical characteristics (w and h), or because of parameters established directly in relation to the working conditions (D and c). Therefore, from this information it is possible to calculate the missing data.

The Footprint is calculated as follows:

$$W = \frac{w\ (mm) \times D}{c} \qquad H = \frac{h\ (mm) \times D}{c}$$

The width of the GSD is calculated:

W/w (px) x 1000 (if we want to convert to meter unit)

The height of the GSD is calculated:

H/h (px) x 1000 (if we want to convert to meter unit)

Slide 8_ Overlap, sidelap and displacement of the image capture points

For a correct acquisition of an image dataset for photogrammetric processing, it is necessary to acquire the images with a horizontal (sidelap) and vertical (overlap) overlapping of at least 60% (although an overlap of 70%-80% is recommended): that is, adjacent images have to share more than 2/3 of the photographed reality:

SIDELAP (m) = W x % sidelap

OVERLAP (m) = H x % overlap

In addition, in this way it is also possible to calculate the horizontal and vertical displacement of the imaging points to reach the overall GSD with the established overlap:

CAMERA MOVEMENT axis X = W - sidelap (m)

CAMERA MOVEMENT axis Y = H - overlap (m)

Slide 9_ Acquisition techniques

The acquisition of photographs for photogrammetric processing must also consider the morphological complexity of the scene to be acquired, that is, the number of dominant planes to be acquired (object, surface, open or closed space).

Depending on this data, it is possible to use different photographic acquisition techniques, which can be summarized in:

- acquisition according to parallel axes
- acquisition according to converging axes
- acquisition through panoramas.

Each type of scene is associated with a preferred acquisition system or, also, with a combination of several systems: in this aspect, the experience and skill of the operator will favor the choice of the most suitable systems for each type of scenario.

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2.6 Digital photogrammetry workflow

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Romina Nespeca
Duration (min)	8
Slides	12
Version	draft

Slide 1_ Introduction

Good morning everyone, my name is Romina Nespeca and I am a Researcher at the Polytechinc University of Marche. In this lesson I will show you the workflow of data processing phase starting from three-dimensional image-based acquisition.

Slide 2_ Before and now

In recent decades, we have witnessed a sudden increase in computer automation that has led to a sharp reduction in working time and simultaneously to an exponential increase in extractable data. We have gone from analogue photogrammeters for the manual extrapolation of a few points to software that allows the automatic generation of millions of points, known as point clouds. This evolution was possible thanks to the implementation of computer algorithms that allow the automatic reading and recognition of features on images. The procedure that has thus come about is called in the literature "structure from motion" or "multi-view stereo" or "close-range photogrammetry", to indicate more generally the application of digital photogrammetry on an architectural scale. For its use, there are numerous software packages, some open-source or web-based, that share the working pipeline I am about to describe.

Slide 3_ The workfolw

After the image design and acquisition phases, seen in the previous lessons, we first work on the pre-processing of the images to facilitate the automatic algorithms. Then the images must be oriented "internally and externally" according to photogrammetric theory; scaled with respect to a reference measurement and then processed for the generation of the 3D point cloud and mesh models. The last step is mapping and texture creation. We are going to see them in more detail.

Slide 4_ Pre-processing of images

The pre-processing of images is an operation that is sometimes underestimated, but which instead determines the success of the work. The photos must be taken in .raw format to record as much information as possible and must then be edited, varying the parameters of exposure, contrast, white balance, clarity, saturation and sharpness, so as to bring out the geometric and colorimetric variations, but avoiding creating aberrations. In addition, cropping masks that exclude certain parts of the image from the computation to

lighten the processing can be created. This is essential if the object is shifted relative to the background, as in the case of the pyx in the figure, which has been turned upside down to capture its backside.

Slide 5_ Internal and external orientation

The next step is called 'alignment' in some software and corresponds to the internal and external orientation of classical photogrammetry. The photos are assigned the characteristics of the camera used, in particular the focal length, optical centre and distortion coefficient. This association can be done automatically by reading the exif data or by manual calibration done with specific software. Having established these values, the photogrammetric problem is solved in three steps:

- feature extraction, in which feature recognition algorithms (e.g. SIFT or SURF, among the most widely used) identify recognisable points;
- feature matching, in which those points are associated with their homologues in other images, working in pairs;
- and, finally, structure from motion which can be incremental or global with the bundle adjustment calculation that refines the position of points that are projected from image space into 3D space.

Slide 6_ Internal and external orientation

This is the result of this phase. The images are positioned in space and an initial 3D model of the object begins to take the form of a sparse point cloud. In this example, digitisation was carried out by placing the pyxis on a turntable, taking 12 shots for 4 vertical positions, in one of which the object is turned upside down to digitise its underside.

Slide 7_ Measuring and scaling

It is very important to emphasise that unlike the range-based method, in the image-based method no measurements are acquired, so it is necessary to impose reference measurements or coordinates, acquired in different ways, in order to scale or georeference the object surveyed. In the case shown, a scalimeter was placed in the photographed scene and then manually set its size as a scalebar. For surveys of objects on an architectural and urban scale, it is common to integrate a topographical or GNSS survey in which the coordinates of certain reference points are known.

Slide 8_ Densification step

Now, all the information required to generate the 3D model is available. This process, called Densification or Multiview stereo, uses algorithms (such as CMVS or PMVS) to generate a dense point cloud. This is a discrete, highly detailed 3D model consisting of many points which, in addition to their spatial coordinates, contain the RGB values of their corresponding image points. It is shown in the literature how good geometric and colorimetric results can be obtained from good design and photogrammetric acquisition [1].

Slide 9_ Mesh reconstruction

In the next step, the 3D model becomes discrete to continuous (from point cloud to 3D mesh), thanks to the reconstruction process that converts the point cloud into a triangular mesh. There are several algorithms that generate different results in terms of resolution, polygon geometry, noise and holes. Among the most popular are Ball Pivoting and Screened Poisson, the latter being faster and more accurate, but invasive in terms of contours and closing holes.

Slide 10_ Mesh editing

It is often necessary to edit the surface to improve its geometry. Noise elimination serves to mitigate errors due to the 3D reprojection of the point cloud. In some areas, holes have to be closed due to gaps or the low density of the point cloud, or spikes generated by incorrect triangulation calculation have to be eliminated. For the next step, it is very important to check the direction of the normals, i.e. the vectors perpendicular to the faces that determine which side is visible. To reduce the number of triangles and thus lighten the model, decimation can be done by prioritising the geometry of the triangles, the curvature of the surface or by imposing a number of faces. The images show the before and the after editing, in which the 3D reconstruction of the inner surface of the pyxis, which was very noisy due to its dark colour, generated many holes than the ones closed.

Slide 11_ Texture mapping

The last stage is texture mapping, which consists of projecting the images onto the mesh surface and generating a texture. Each photo is projected onto the most perpendicular portion to the projecting beams, which are distributed according to the conical projection pattern starting from the optical centre of the camera. The only parameter to be controlled is the rendering in the common areas between several photos, choosing whether to let one image prevail over the others or to merge the RGB values. At this point, the textured model shows all the geometric and colorimetric characteristics of the real object, the three-dimensional file is usually linked to a raster file and, in the case of the .obj format, an .mtl file describes this link. The scale of detail obtained is determined by the GSD value imposed during the design phase.

Slide 12_ Final Outputs

As shown by the case studies presented in previous lectures, with regard to the architectural scale, image-range surveying can be defined as the most widespread method to create orthoimages and to vector redraw the façades. At the urban or landscape scale, this technique has undergone a major increase in recent years thanks to the spread of UAV instrumentation due to lower costs and increased ease of use. In the archaeological or museum field, it is the most economical and widespread solution for the creation of 3D digital catalogues. In the field of cultural heritage in general, today we often speak of integrated surveying, where both techniques are used to achieve the best possible Digital Twin [2].

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2.7 High Resolution image production

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Renato Angeloni
Duration (min)	8
Slides	8
Version	Draft

Slide 1_Introduction

Welcome to these two lessons regarding high-resolution imaging.
My name is Renato Angeloni, and I am currently a post-doc research fellow at the University of Marche Region. My research interests are related to Cultural Heritage digitization and virtual experience, and in this first lesson I will describe a photographic methodology and equipment that have been put into practice by our research group to achieve a very high level of detail and chromatic fidelity, in the documentation and dissemination of artworks.

Slide 2_Definition

High-res imaging of artworks, often defined as gigapixel, having a resolution around 1000 megapixels or greater, is a quite novel technique that is beginning to be used by some important international museums as a means of documentation, analysis, and dissemination of their masterpieces.
This line of research is extremely interesting, not only for art curators and scholars but also for the public. The results of such kind of digitization can be disseminated through online virtual museum, offering a detailed interactive visualization.

Slide 3_High-resolution imaging: workflow

The workflow here presented is based on tools widely used in the field of photography, avoiding specific tools for high-resolution imaging, not suitable for Cultural Institutions with low budgets.
Even the software used for data processing are free software for non-commercial use.
The workflow is structured in two main phases: data capturing and data processing, which can be divided into editing of the single images acquired and their processing to be stitched in one.

Slide 4_High-resolution imaging: tools

Regarding the capture system, it can be divided into three main components: the image-capturing system, the lighting system, and lastly the support system, to hold and move the previous two.
The image capturing system is just a digital camera, the higher the performance, the higher the quality of the final output. Two specs must be mainly considered in this kind of acquisition: 1. The sensor: its dimension, and number of pixels. All other things equal, a larger sensor allows to reduce the number of shoots, speeding up the data capturing phase. Being equal the sensor dimension, the higher the number of pixels the higher the details that are acquired. 2. Another key aspect concerning the camera is the depth of field. Mounting a lens that allows an adequate depth of field is fundamental to have all the captured images on focus, and so all the areas of the final high-res image.

The lighting system must be obviously made of lamps that do not damage the work of art. The use of led panels is an efficient solution, being not expensive and having an adequate operating temperature.
The support that holds and moves the whole system is maybe the trickiest matter, as it must guarantee the stability of the camera during the acquisition, but also to automatically move it from a shot to another, offering the operator the possibility of controlling it. To this purpose, it is possible to use sliders readily available on the market, whose movement is programmable thanks to specific easy-to-use applications. This kind of solution usually allows the movement on only one axis, so it is necessary to fix it on stands to manually move it vertically after capturing a row of images.
For reflective surfaces, a key tool is a polarizing filter, to be mounted on the camera and on the lights to avoid light spots. Instead, the use of a color-checker and metric references is always essential for the image editing phase.

Slide 5_High-resolution imaging: data capturing

The data capturing phase could be designed according to the indications provided by the previous lessons regarding Structure from Motion 3D reconstruction.
A specific aspect to be considered in high-res imaging is that, as a general rule, the framed surface must be comparable to the sensor dimension. It means having about 1:1 magnification ratio, as in macrophotography. This underlines the absolute need to thoroughly check the depth of field, so the distance of the camera from the subject, to be sure that both the first image and the last one on the same row are on focus. As you can see from the image, even having only one shoot out of focus could affect the quality of the final high-res image.

Slide 6_ High-resolution imaging: data processing

Consisting in editing the captured images, the first phase of data processing is fundamental for the quality of the final image and its colour accuracy. Special care should be taken to the white balance and the colour-profile settings. As shown in the video the image of the colour-checker should be imported in the related software, generating a colour-profile for the performed acquisition. Importing the image in the image editing software, makes it possible to apply it to all the images, thus correcting their colour information.
The second data processing step consists in the image-orientation and 3D reconstruction, and in the end, in the projection of the whole set of images previously aligned on the reconstructed geometry. A workflow corresponding to the one already shown for the structure from motion 3D reconstruction.

Slide 7_ High-resolution imaging: final output

The final output is an orthoimage that represents the entire artwork, keeping in all its parts the resolution of the single stitched images to process it.
As you can see in the images, as expected, the level of details depends on the ones of the single shoots; the table below the images highlights the difference in data capturing related to these different outcomes.

Slide 8_Conclusions

In this lesson we discussed the main aspects related to capturing and processing single shoots to get a single high-res image. Other kinds of workflow are obviously available, taking advantage of more specific, but of course more expensive tools, or avoiding the 3D reconstruction process. The choice of this specific workflow was aimed at exploiting flexible tools and techniques already partly shown in the previous lessons, and able to ensure the scientific accuracy of the digital reconstruction.

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2.8 Projects overview: HD paintings

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Renato Angeloni
Duration (min)	8
Slides	8
Version	Draft

Slide 1_Introduction

As presented in the previous lesson, high-resolution imaging is paramount for the documentation and the storytelling of artworks, usually the masterpieces of a collection.
This presentation will be focused on two different case studies: a desktop experience and a mobile app, both taking advantage of this technique to improve the experience of two great masterpieces: Rembrandt's Night Watch and Titian's Pala Gozzi.

Slide 2_Experience the Night Watch

"Operation Night Watch" is a website dedicated to Rembrandt's most famous painting, offered by the Rijksmuseum.
The Rijksmuseum continually monitors the condition of the Night Watch, and it has been discovered that changes are occurring. To gain a better understanding of its condition, it has been decided to conduct a thorough examination of the painting; a study to determine the best treatment plan, involving different imaging techniques, high-resolution photography, and highly advanced computer analysis. Using these methods, it is possible to form an incredibly detailed picture of the painting – not only of the painted surface, but of every layer, from varnish to canvas.

Slide 3_Experience the Night Watch

Concerning the high-resolution image of the painting, being 717 gigapixels in size, it is the largest and most detailed photo of a work of art ever taken.
It means that considering the size of the canvas, 3.59 x 4.38 meters, the distance between two pixels is 5 micrometers, which means that one pixel is smaller than a human red blood cell.
The digitization team used a 100-megapixel camera to make 8439 individual photos measuring 5.5 x 4.1 centimeters. Artificial intelligence was used to stitch these smaller photographs together to form the final large image, with a total file size of 5.6 terabytes.

Slide 4_Experience the Night Watch

With this resolution, it is possible to clearly see the precise physical state of the painting. Lead soap protrusions, tiny cracks, the shapes of individual paint pigment particles, past retouches, and the beautiful details of Rembrandt's painting technique are all extraordinarily clear. This enables researchers to understand the painting's condition to make the best plan for future conservation treatments. It also allows to better understand how Rembrandt painted, and it creates a 'snapshot' of The Night Watch at this moment in its history.

Slide 5_Experience the Night Watch

Taking advantage of this incredibly high-resolution digitization, NTR TV channel and the Amsterdam Rijksmuseum jointly developed an interactive Night Watch tour. “Experience the Night Watch” allows visitors to explore its world-famous scene, to step across the red cord, being carried away into the world of the Night Watch.

Who exactly are those militia men? Where is Rembrandt hiding? Who is the girl? All these secrets are revealed in this experience.

After a short intro, the user is enabled to pan and zoom the high-resolution image of the painting to discover its details, using clickable hotspots, and it is possible to select what to deepen specifically: the history of the painting, its composition, its characters and so on. Each hotspot activates the reproduction of a short video that moves the user’s point of view to focus on a specific part of the painting, coherently to the voice-over.

Slide 6_The Pala Gozzi digitization

The second experience is related to the Pala Gozzi by Titian, his first autographed painting, fundamental in the dating of all his work. The altarpiece is displayed at the Zampetti Hall in the Civic Art Gallery of Ancona. The collection of this museum is characterized by a huge variety of artworks on display. Paintings by Francesco Podesti, after whom it is named the Civic Art Gallery of Ancona, are displayed alongside modern works by the greatest artists of the Italian 20th century, even medieval and Renaissance masterpieces by Carlo Crivelli, Titian, Lorenzo Lotto and Sebastiano del Piombo are exhibited alongside contemporary works, generating a continuous dialogue between past and present.

The high-resolution digitization of the altarpiece by Titian was carried out following five steps: image acquisition using visible light, image postprocessing, 3D reconstruction, retopology and texture baking. The entire process was handled using opensource software, freely accessible also to Cultural Institutions with low budgets. Coherently, low-cost tools were used, a digital camera, LED panels and a color-checker.

With a final amount of 2.000 pictures, the final level of detail reached is 0.03 mm, both for the front and the back, where some original sketches are visible.

Slide 7_The Pala Gozzi experience

The mobile app was also developed using free software, specifically the game engine Unity, and taking advantage of the Vuforia platform to implement the augmented reality functions.

The storytelling has been structured differently from the traditional museum’s didactic logic, combining the engaging power of digital tools with the scientific rigour, and offering two usage scenarios: a remote experience and an onsite one.

By selecting in the main page “Are you at home?”, it will start a completely virtual experience of the artwork, structured in three sections: “Explore”, “Discover” and “Virtual Tour”. “Explore” allows to freely navigate the digital reproduction of the altarpiece and to appreciate its details. The “Discover” section is the main interactive proposal, structuring an engaging and evocative storytelling, thanks to short videos animating the high-resolution images processed and focused on the characters in the scene, on its geometric composition, on the landscape and its details, on the execution technique and colours used.

And finally, “Virtual Tour” allows users to explore the Zampetti Room, where the Pala Gozzi is now exhibited, offering to the visitors the opportunity to discover brief information on other paintings, in particular the Crucifixion, Titian’s work exhibited in front of the Pala Gozzi, in an interesting dialogue between his art in young and in old age.

By clicking on “Are you at the museum?”, it starts an augmented reality experience of the painting, the user device is conceived as a digital tool to support the physical visit at the art gallery; the use of the device and of the augmented reality technology is not meant to replace the human eye during the visit, preserving that emotional circuit in which the visitor enters in front of the physical artifact, the enjoyment of his unique existence in the place where it is.

The aim of this section is to guide the user in reading the artwork, allowing him to identify and discover details otherwise invisible to human eyes.

The relationship between user and the artwork therefore remains central, being further supported by multimedia contents that are layered to the painting.

Slide 8_Conclusions

High-resolution imaging, as presented in these two lessons, has proven to be an effective tool for Cultural Heritage documentation and experience. Showing a work of art to the finest detail enables the storytelling of countless stories and anecdotes that have always fascinated visitors, from the hidden characters among a crowd represented in a painting to the historical events faced by the work of art.
A technique able to provide a high-quality content for both desktop and mobile solutions, augmented and virtual reality technology.

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MODULE 3

3D MODELING AND DATA IMPLEMENTATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

3.1 3D modelling and data optimisation

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Mirco D'Alessio
Duration (min)	8
Slides	11
Version	draft

Slide 1_Introduction

Today we will speak about non-reality-based models, already defined in a previous lecture. They are basically obtained by direct and procedural methods. The first is performed modifying manually the 3D geometry using transforms and modifiers. With the second method we can create complex model by using algorithms, so the model is generated only changing the variables of the mathematical functions. The models generated by both the methodologies can be used as base for the information modelling, by adding other metadata in addition to the geometric data.

Slide 2_Software

There are several useful software to create non-reality-based models such as Autocad, 3D Studio Max, Maya, Rhinoceros, Sketchup, Blender etc.. Specifically in this lesson, we are going to treat the bases of the direct modelling and optimization within the modelling environment of Blender software, a free and very stable open-source program.

Slide 3_3D model types

Now I'm going to describe what types of models can be used. From a theoretical point of view, we can identify 3 types of 3D models, CSG models, B-REP models, and Mesh models: The last one is a polygonal model described by vertices, edges and faces: vertices are single entities described only by the 3 spatial coordinates x,y,z; edges represent the line connecting two vertices; faces are planes bounded by a minimum of 3 edges. From the perspective of this course, we will treat mesh modelling since it appears to be the most flexible and often used in the field of gaming and 3D virtual visualization, so useful in the cultural heritage field.

Slide 4_3D Mesh model example

The direct mesh modelling, especially in the field of cultural heritage, is mainly used in three, different cases: to create objects that no longer exist, that we cannot acquire,(for axample we can make a 3D virtual reconstruction of the representation of painting); to create missing part of real object (virtual anastylosis) or to create existing generic objects, for which we are not interested in having the precision and accuracy of a reality-based model (forniture or stuff importat to make the virtual environment more realistic).

Slide 5_Coordinate system

Getting into the more operational field of the lesson, we need to know that each 3D object is identified through the coordinates of a single point, called the origin, described by 3 coordinates x,y,z. Another fundamental concept is the difference between global coordinates and local coordinates. The first one is expressed relative to the centre of the virtual environment, i.e., how far our object is from point 0. The second one is relative to the origin of the 3D object; the position of an object's vertex is identified as the distance from the origin of the 3D model.

Slide 6_Simply modifiers

Now we can briefly describe the main operations that can be performed on the 3D objects, all these operations are related to the coordinate system:

Translation: This operation allows us to change the position in space of a vertex, edge, face, or entire object.

Rotation: This operation allows us to rotate a vertex, an edge, or an entire object.

Both operations are carried out by using handles, which allow the object to be moved by dragging the mouse, or by entering coordinates, which will be calculated in relation to the centre of the object as the centre of rotation or translation.

Extrusion: This is a simple method for creating extruded shapes starting from a basic 2D drawing or a plane polygon, assigning it a certain height and an extrusion direction.

Revolution: A revolution can be considered as an extrusion around an axis, always starting from a basic polygon, and instead of depth an angle of revolution is assigned.

Slide 7_Generators

Generators, on the other hand, are functions that can make changes to the 3D object by modifying input parameters, the most common are:

Array: This function allows us to copy the 3D object in series, either in a regular manner following the direction of the axes, x,y,z; following a path, or in a completely random manner.

Bevel: This function allows faces to be added to an edge in such a way as to make it less sharp and more realistic.

Boolean operations: these are subtraction, union, intersection. For a correct operation, it is necessary to work with closed objects since the modelling software must identify the inside and outside of the object. A main object to be joined, subtracted, or intersected by a second object must be identified.

Mirror: this function mirrors the object according to different axes of reference, again the origin of the model is important beacuse it is the centre of reflection of the geometry.

Slide 8_Retopology

Once the model is completed, one of the main problems is its visualisation. 3D models, especially of complex objects, have curved parts, minute details, or even surface imperfections, which are described by many small polygons. This high number is directly reflected in the file size and the time required to compute the visualisation. The procedures used to simplify the calculation and speed up the visualisation are native to the gaming sphere, but can be used for any 3D model, including therefore in the production of 3D objects in the cultural heritage field. It is important to stress that this step of model optimisation is strictly needed also for reality-based models, especially for web dissemination purposes.

Slide 9_Retopology Workflow

Let us look in detail at the highlights of this workflow:

Remeshing: In this phase, the 3D model is recreated, taking care to use as few faces as possible. It can be done by drawing the faces manually, or by using automatic functions, so you have two models, one with high definition (high-poly) and one with low resolution (low-poly).

Unwrapping: the next step is to create a correspondence between the three-dimensional faces of the low-poly model and the two-dimensional UV texture space. It is necessary to project the two-dimensional texture information or maps onto the 3D object

Baking: in this phase we create the maps that will be reprojected onto the low-poly object according to the previously created coordinate system. In this step it is important that the two objects (low/high-poly) are perfectly superimposed in virtual space. We have to select the high-poly object, the low-poly model, and the texture of the last one, then a render process transfers the required feature of the high-poly object to the UV co-ordinate system of the low-poly model ,creating textures.

The resulting loss of detail of the remeshing fase is recovered by means of the creation of maps or textures, which simulate the presence of these lost details during rendering.

Slide 10_Textures

The choice of the types of textures to be created must be made in accordance with the chosen render pipeline, but the most common maps are:

diffuse: This handles the colour of the low-poly object.

normal: With this map you can simulate the presence of surface micro-details and small bas-reliefs, it modifies how the reflection of light from the object's surface is calculated during rendering.

Ambient occlusion: This is the diffuse light shadows of the high-poly object, in the case of micro-details they are highlighted and made become more visible.

Slide 11_Conclusion

In this lesson, after briefly introducing the main methods of 3D direct modelling, we have explained the main modifiers and functions for mesh solid modelling within the working environment of the Blender software. Obviously, they do not represent the entirety of the possible cases, but the necessary notions for taking the first steps in direct modelling and optimization.

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3.2 Projects overview: direct modelling

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Mirco D'Alessio
Duration (min)	8
Slides	18
Version	draft

Slide 1_Introduction

Good morning, today we are going to explain some case studies related to cultural heritage in which direct 3D modelling is a central aspect. These examples belong to a larger and more complex projects always aimed at exploring innovative methods of digital fruition, but will limit ourselves to describe the operative procedures adopted for the realisation and modelling of the scene or virtual environment.

Slide 2_The School of Athens: Introduction.

The first case study we can take as an example concerns a VR experience realised in 2019 for the exhibition "Raffello e Colocci, Bellezza e scienza nella costruzione del mito della Roma antica". An exhibition realised in Jesi as part of the activities proposed for the 500th anniversary of the death of the Renaissance artist Raffaello . The VR experience includes the possibility of entering and exploring the famous fresco "The School of Athens". This example lends itself particularly well as a case study of direct modelling, since the core of the entire work consists of creating an imaginary a real architecture, represented till now only on its 2D dimension, so thanks to the inverse prospective method we can pass from the 2D to 3D representation.

Slide 3_The School of Athens: Introduction: Preliminary study.

One of the main difficulties in a direct 3D modelling job is knowing what we must realise, both from a metric and geometrical point of view. Working with a fresco introduces three problems that must be solved before starting the modelling: Obtaining a metric dimension from a painted perspective; envisaging what is reasonably in the parts of the architecture that are not visible; correcting architectural structural errors inserted for compositive purposes. The resolution of these points leads directly to the creation of plans, sections, and elevations of an architecture, which will be used as the basis for direct 3D modelling. As similar works constitute interpretative studies, they are always supported by experts such as, in this case, art and architecture historians.

Slide 4_ The School of Athens: The Project

Once the main characteristics of the architecture were identified, it was possible to proceed with the definition of an operative plan. In the specifics of this project, one of the key concepts is symmetry, and since we had to realise a building with a central plan, in the form of a Greek cross, it is evident that we could model a quarter of the building and then mirror it to obtain a complete architecture.

Slide 5_ The School of Athens: Direct modelling.

Having understood the design principles and having a clear and complete vision of the work, we could proceed to the concrete realisation of the model. All detailed elements such as plinths, capitals, column bases were realised by extruding the identified detail profile of the object along the plan drawing. For the roofs on the other hand, being coffered elements, we have realised a single descriptive unit, and then multiplied by array, for the vaults, and by revolution for the dome.

Slide 6_ The School of Athens: Conclusion

Once the model was made, equirectangular panoramas were rendered and mounted through vfx visual effects technique , completing the experience. This case study clearly shows us the potential of direct modeling in creating new worlds, starting from non-real and non-existent elements, arriving at new ways of enjoying cultural heritage.

Slide 7_ La Tomba della Regina di Sirolo-Numana: Introduction.

The second case study we can show concerns the VR experience of the Tomb of the Queen in Numana-Sirolo. This application was realised in collaboration with the Regional Authority Parco del Conero. The object of study is a Picenian funerary site. In this experience, the user is accompanied by the queen's voice to explore the two tombs, and at some points also to interact with the virtual environment.

Slide 8_ La Tomba della Regina di Sirolo-Numana: Preliminary study.

Unlike the previous case study, in this we have many artefacts from the archaeological site. For this reason, we decided to proceed with the realization of the virtual environment following a hybrid approach between direct modelling and reality-based modelling.

Slide 9_ La Tomba della Regina di Sirolo-Numana: The Project

No wooden remains of the tombs have reached us, so we decided to model them directly, based on the study of the excavation. The different colours of the ground suggest dimensions, while through comparison with Italic funerary complexes of the same period it was possible to outline the construction details necessary to have a realistic and complete vision of the scene. This archaeological site is characterised by the presence of more than 2000 pieces, so we selected the most iconic, particular and better-preserved objects to be digitised using SFM techniques and relocated within the virtual scene.

Slide 10_ La Tomba della Regina di Sirolo-Numana: Direct modelling.

We created the two wooden tombs and Furnitures by direct modelling, using plans, and sections as base. The work was very simple we made only two axes by extrusion, then multiplied by arrays and mirrored.

Slide 11_ La Tomba della Regina di Sirolo-Numana: The Optimimisation 3D Models

Starting from the SFM models of the finds, we obtained finished objects through direct modellig of the missing parts, then we performed the retopology to include them in the VR scene in the game engine.

Slide 12_ La Tomba della Regina di Sirolo-Numana: Conclusion

Then we completed the application creating animations and mixing original music and voice over. We chose to show this work to explain how SFM models blend well with non-reality-based 3D models and maintain a highly realistic and emotional impact through collaboration with entertainment industry experts.

Slide 13_The reconstruction of the Forum of Augustus in Rome: Introduction.

The last example is the Virtual Reconstruction of the Roman Forum of Augustus. This work, carried out by the CNR ISPC, shows us a further case study in which direct 3D modelling and reality-based models are merged to obtain an immersive VR experience, up to the creation of Serious game.

Slide 14_The reconstruction of the Forum of Augustus in Rome: The Project

They proceeded by identifying a design process characterised by 3 different moments: Pre-production; Production; and the creation of the interactive environment. The first step consists of the realisation of all the 3D surveys, digitalisations, and historical research studies. The second step consists in the 3D modelling of the assets, the archaeological scientific validation, and the performance analysis and optimisation studies for proper VR operation. The last step is to create the scene by inserting all the elements created in a single system and adding all those elements that introduce realism and favour immersive involvement, such as lights, particle systems, sounds and interactions.

Slide 15_The reconstruction of the Forum of Augustus in Rome: The 3D survey

The remains of the Roman forum of Augustus (Via dei fori Imperiali) in Rome were surveyed in an integrated way, using TLS and SFM technique.

Slide 16_The reconstruction of the Forum of Augustus in Rome: Direct Modelling.

The 3D model thus created was used in various ways to obtain a complete reconstructive model. In this specific case direct modelling can take different forms depending on the object to be reconstructed. It can be used to reconstruct in situ evidence to obtain the same object but without the degradation caused by the time, as in the case of the basement and the main steps. It can be used to perform a virtual anastylosis, i.e. to reconstruct missing parts of elements present in situ, as in the case of the reconstruction of a broken column. We can virtually rearrange objects present on site but no longer present in their original position; for example, a statue or a capital, and finally model from scratch elements not found on site but which are essential to complete the reconstruction. The creation of these models is part of a more complex process characterised by a specific iterative procedure of scientific validation.

Slide 17_The reconstruction of the Forum of Augustus in Rome: Optimization

For the virtual reality application to function optimally, specific optimisation work was carried out on the geometries and resolutions of the textures to be used by performing specific studies on the visualisation features of the environment, so the created a hierarchy of resolution and visual quality performing the Retopology.

Slide 18_The reconstruction of the Forum of Augustus in Rome: Conclusion

What is interesting about this work is to see how all the techniques and methods of 3D modelling can be integrated for the realization of complex VR experiences, with particular attention to the reliability of the scientific data.

Slide 19_Conclusions

In this lesson, we showed three emblematic cases of the use of models derived from direct modelling. In the first case, therefore, we saw how they can be used in art for the 3D representation of 2D works, giving the possibility of new uses and visualisations. In the other two we looked more specifically at their application in the archaeological field, emphasising their use for the representation and reconstruction of what is no longer there; and highlighting the relationship with reality-based models and thus with archaeological remains.

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Videos

3.3 Projects overview: reality-based modelling

Responsible	Università “La Sapienza” | Università Politecnica delle Marche
Teacher	Umberto Ferretti
Duration (min)	8
Slides	24
Version	final

Slide 1

Slide 2_introduction

Good morning, good afternoon and welcome to the third lesson of the 3d modelling and data implementation module. I’m going to show you some peculiar cases concerning the reality-based modelling, especially focusing on its possible uses and objectives.

Slide 3_recap and main objectives

In the previous lesson you have learned that it is possible to model completely new architectures or ancient destroyed findings that makes you able to walk in a Renaissance painting or in a Picenian necropolis. Now we are going to see three cases of heritage buildings where visits are currently available, but they may be subject to some restrictions or need some improvements. 3d modelling is implemented in order to create virtual replicas of Cultural Heritage, facing different scenarios and enabling various possibilities, as we will see.

Slide 4_case I: the Campana caves in Osimo

The first case concerns the fascinating complex of underground tunnels and galleries, of uncertain dating, extended below Palazzo Campana in the city of Osimo, in Italy.

Slide 5_ case I: the Campana caves in Osimo

The sandstone caves are composed of two sections, one free branch and one rectangular ring. Along walls and vaults of the main galleries, this ring shows several bas-reliefs in bad conditions, due to the material fragility.

Slide 6_ case I: the Campana caves in Osimo

Other issues include the microclimatic variations due to the stream of visitors
and the high risk, in such a narrow space, to hit the sculpted elements in the walls.

Slide 7_ case I: the Campana caves in Osimo

Nowadays different recording techniques make the generation of extremely accurate 3D models possible. In this study, the integration of Terrestrial Laser Scanner and Digital Photogrammetry is stressed in order to obtain a high-resolution photo-realistic 3D model. Due to the lack of illumination in the cave, the laser

scanner was not able to obtain the RGB colour information. Therefore, the panoramic images were assembled from 12 single images captured using two different lighting conditions.

Slide 8_case I: the Campana caves in Osimo

The 3D model was further elaborated. As you learnt in the lesson 3.1, there are many possibilities for the data optimization. In particular, the model was decimated with "curvature priority" in order to preserve more details in such critical areas. Once the number of polygons was reduced, the UV coordinates have been generated for each vertex in the mesh with the unwrapping operation. The last step was the projection of the geometric and visual features of the high-poly model on the low-poly one.

Slide 9_case I: the Campana caves in Osimo

Such operation has been essential for the implementation of an immersive-VR application, as accurate as possible, that makes user able to experience the entire underground site.

Slide 10_case II: Barone Fortress in Sibenik

The revitalization of the Barone fortress of Šibenik in Croatia is our second case-study.

Slide 11_case II: Barone Fortress in Sibenik

The scenario is rather different. The project is part of a consistent plan promoted by the city of Sybenik that counts a significant number of fortresses and other prestigious heritage buildings. Despite the wealth of cultural and historical resources, Šibenik didn't use all the opportunities in the development of cultural tourism.

Slide 12_case II: Barone Fortress in Sibenik

The institutions' initiative aims to establish the Barone Fortress as an innovative and unique cultural attraction of the local tourism.
The 3d model of the fortress was implemented with the techniques and tools we explained in previous lectures. Hence, the workflow started from digital photogrammetry data, then a rough 3d model was generated and optimized for visualization and for the application development.

Slide 13_case II: Barone Fortress in Sibenik

In fact, the main features of the Barone Fortress project are its digital contents. By means of a high-tech augmented reality viewpoint the visitor can experience the story of the fortress' construction and of the successful defence of Sybenik from the Ottoman invaders.

Slide 14_case III: Palazzo Ducale of Urbino

For the third and last case we come back to Italy, more precisely in the Ducal Palace of Urbino.

Slide 15_case III: Palazzo Ducale of Urbino

The main feature is that a Building Information Modelling has been adopted. What does BIM mean? Perhaps I should take a step backward in order to easily explain it. We are talking about the world of Information modelling that, in a sentence, consists of the implementation of aware 3d models.

Slide 16_case III: Palazzo Ducale of Urbino

These objects include the geometry represented in a certain level of detail, as usual, and above all, they collect information. What kind of information? Literally everything you need; from mathematical equations to material descriptions, from construction phases to historical data, among others.

Slide 17_case III: Palazzo Ducale of Urbino

For more than a decade, this approach has been extended to Cultural Heritage, enabling a new action line labelled as Heritage BIM. It could involve many professional figures, from the restorer to the archaeologist, from the architect to the digital curator and so on. The framework usually starts from the acquisition of built heritage with sophisticated technological tools, such as laser scanning, till the developing of a semantically aware 3D model.

Slide 18_case III: Palazzo Ducale of Urbino

This process, in the scientific bibliography, is known as Scan-to-HBIM.

Slide 19_case III: Palazzo Ducale of Urbino

As I said, in the present case this approach has been adopted. The Ducal Palace of Urbino houses the National Gallery of Marche. It was the residence of the Montefeltro family since the fifteenth century and it's an emblematic piece of art of the Italian Renaissance.

Slide 20_case III: Palazzo Ducale of Urbino

I personally worked in the implementation of the HBIM model of the Piano Nobile (which is the first floor of the Palace). I started from the point cloud (that you've seen in the previous slide) and I modelled each architectural elements, from the massive walls to the single moulding.

Slide 21_case III: Palazzo Ducale of Urbino

The main benefit of a parametrical modelling is that with a single 3d object where mathematical rules and proportions are embedded, I could cover the entire knowledge domain of the Palace that counts more than a hundred of different architectural elements among doors, vaults, columns and so on.

Slide 22_case III: Palazzo Ducale of Urbino

Moreover, we implemented a Data Enrichment of the artworks' models with some cataloguing information, such as author, location, painting techniques, inventory number and some useful microclimatic data for museum management.

Slide 23_case III: Palazzo Ducale of Urbino

In order to obtain a proper parametrical HBIM, a significant investment of time is necessary. Despite this, we collected a novel library of parametric objects which are reusable in future modelling works. Furthermore, in the present case we used the HBIM model of ducal Palace as a base for developing Extended reality applications both for museum management and enjoyment. This topic will be discussed more in depth in the Module 7.

Slide 24_Conclusions

The usage of 3D models in the interpretation of Cultural Heritage is an essential ingredient for understanding the research results. They represent an effective way of artworks' presentation and are equally useful and understandable to non-experts as well as to experts. In fact, virtual replicas allow the formers to understand basic information and on the other hand, provide experts with relevant information about heritage science research.

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3.4 Virtual Reconstruction

Responsible	The Cyprus Institute
Teacher	Dante Abate
Duration (min)	11
Slides	11
Version	draft

Introduction

Hello everyone and welcome to the lesson 3.4 of Module 3 of area B.

My name is Dante Abate. I am an Associate Research Scientist at the Cyprus Institute and in this presentation, we will deal virtual restoration, model reconstruction and scientific analysis.

Slide 1_

Before the execution of any scientific analysis, 3D data have to follow an optimization process in order to obtain reliable results.

Image and range data can indeed produce a variety of outliers which need to be corrected. This is due to the acquisition strategy, the sensor, the object material and the environmental conditions. Additionally, range-based sensors not always can collect data which completely describes the target object due to the line of sight and possible obstacles.

Slide 2_Post Processing Software

Two of the most used software for topological error correction are Meshlab and Geomagic Wrap. Both are today widely used in the scientific and industrial domain. They provide a wide array of tools to perform data optimization and virtual reconstructions.

Meshlab is an open-source software widely used which can benefit of the support of a large user-community.

Geomagic instead is a powerful tool which however is commercial oriented and such as needs the purchase of a license to be fully operational. Without license it can be used only as a viewer.

Slide 3_Topological errors correction

During the range-based data mesh model creation (specifically the point cloud triangulation), it is quite common that the connections between triangles are not correct, leading to topological errors.

The most common are represented by:

Non-manifold Faces. This error occurs when more than one triangle shares the same edge.

Redundant Faces. This error occurs when for a single vertex more edges are present.

Crossing Faces. It occurs for those faces that cross a mesh without connecting with it in anyway.

Unstable Faces. It occurs for those adjacent faces which features inverted normal.

Slide 4_Reconstruction of missing parts

As mentioned before, it is not always possible to acquire all the surfaces of an object. This will result in a digital twin which shows gaps (missing areas) on the surface.

When the gaps are quite large, their reconstruction can be quite challenging and not always accurate. Both Meshlab and Geomagic allow to create bridges between triangles in order to reduce the holes in smaller areas and potentially close them evenly.

For smaller gaps automatic or semiautomatic procedures can be followed. Gaps on planar surfaces are usually closed automatically. In case there is a surrounding curvature, the algorithm tries to take that into account when filling the hole.
It should be mentioned that the reconstruction of missing parts is more effective the cleaner are the edges of the hole.

Slide 5_Model Decimation

At the end of the editing process, a 3D model can feature a total number of polygons which is not suitable for interactive applications or not needed for the final goals of a project.

Model decimation is an automatic process which reduces the number of polygons. The original 3D model will result in a lighter version which will have less details and resolution. A proper balance should be considered during this step. A strong decimation might smooth too much the original surfaces.

Modern algorithm can be set considering the curvature of the models. This will result in stronger decimation on flat surfaces and lower decimation in areas with high curvature.

Slide 6_Geometric data extraction

3D models can be processed to extract any kind of geometrical information at macro and micro scale in terms of sections, plans, or 3D views.

According to the user's input, the model is cut along the X, Y, or Z planes and sections are extracted.

The vertical or horizontal section thickness is established by the user's input parameters.

The minimum feature which is measurable is directly related with the resolution set during the data collection. These kinds of outputs are used in a variety of analysis.

The most common relate to the production of CAD technical drawings in the architectural domain.

Slide 7_Archaeological features identification and landscape archaeology

Airborne 3D data has been successfully used in disciplines such as landscape archaeology to identify and interpret archaeological sites or their features spread over a large geographical area.

The use of techniques such as scientific visualization, manual reclassification, filtering of ground points, and interpolation are today widely used.

The application of processing techniques such as roughness or curvature analysis can highlight features otherwise invisible.

Thanks to the capabilities of Aerial LiDAR sensors, it is indeed possible to acquire data below dense vegetation, unrevealing features or structures not visible through traditional satellite or aerial photography.

Slide 8_Deformation Analysis

Deformation analysis is a technique mainly applied by structural engineers which is today exploited also in the heritage domain. It receives as input a 3D mesh model used to simulate forces which can occur in real life (i.e., earthquakes).

Specific algorithms (i.e., Finite Element Method) are used to assess the buildings behaviour when specific forces are applied.

Deformation analysis has seen also successful applications in museums when applied to specific classes of artefacts.

For example, paintings, especially those on wood, suffer from the deformation of the support over time if the conservation conditions are not maintained (temperature and humidity).

Assuming the original planarity of the wooden support, the deviation can be digitally assessed using the digital-born data, and a best-fitting-plane method.

Slide 9_Identification of invisible geometric features

The application of digital technologies for the improvement of the readability and the interpretation of archaeological material can be successfully applied to a large variety of objects.

In this slide you can observe the application of roughness analysis techniques aimed to highlight functional areas where in-depth analysis can be eventually performed (digital microscope, Scanning Electron Microscope).

Non-contact and non-destructive techniques are sought in order to geometrically document artefacts. The application of geometric features extraction algorithms and the artificial simulation of different lighting directions and camera viewpoints will contribute to highlight hidden and invisible to naked eye details.

Slide 10_Multitemporal Analysis

As already mentioned, 2D and 3D data feature spatial and geometric information, describing a specific period in time. When the latter has to be taken into account the data become 4D.

For example, multitemporal comparison of digital data can be used to assess the conservation conditions after the original artefact or monument went through a restoration process.

The colour coded map will show which areas have changed and its metric dimension. CloudCompare is commonly used to perform such process using a cloud to cloud or a mesh to cloud algorithm.

Slide 11_3D printing

Reverse engineering is a powerful way to create digital designs from a physical part, and can be a valuable tool alongside technologies like 3D scanning and 3D printing.

Over the last decade, museums and other cultural institutions around the world have constituted one of the most exciting test-beds for 3D printing.

This is probably driven by the nature of objects and sites which cultural institutions study, collect and display.

Given their nature and historical importance, collections cannot be touched and are normally exhibited to people behind enclosed glass displays.

Reality-based models can be used to create 3D printed replicas for scientific and social applications (i.e., tactile experience for visual impaired people).

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AREA C

POLICIES AND DIGITAL DATA PRESERVATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

MODULE 4

POLICIES RULES AND LICENSING

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

4.1. Excursus over the last decades

Responsible	LUSO
Teacher	Ricardo Geraldes
Duration (min)	8 min
Slides	10
Version	draft

4.1. Excursus over the last decades

Slide 1_Introduction

Good morning, good afternoon and welcome to the first lesson of the module "POLICIES AND DIGITAL DATA PRESERVATION" within the DCbox MOOCs. In this section 4.1 "Excursus over the last decades" we will take a look at how Policymaking has been established in these past years, determining the principles of the Information Age.

Slide 2_Information Age – a brief historical context on the rising of Network Societies

The Information Age (IA), an epochal transition from traditional forms of industrialization to an economy based on information technologies, can be traced historically in the mid-20th century. According to Manuel Castells (2010), there were a "number of major social, technological, economic, and cultural transformations" (xvii) that gave rise to the *network society*. A new social structure "(…) because it is made of networks in all the key dimensions of social organization and social practice"(xviii)." In short, from Library expansion, to information storage and transmission, to computation and genetic information, we live in a time of expanded information, where everything can be seen as something to be *read*.

Slide 3_ Information Age – a brief theoretical context

The emergence of Network Societies in the Information Age is reliant on the diversity of all cultures and institutions throughout the world. As Manuel Castells puts it these new social structures are connected with the "(…) emergence of a new mode of development, informationalism, historically shaped by the restructuring of the capitalist mode of production (14)". This approach assumes that societies are mainly organized around human processes aligned by historically determined relationships of ***production***, ***experience***, and ***power***. According to Manuel Castells:

- ***Production*** "is the action of humankind on matter (nature) to appropriate it and transform it for its benefits by obtaining a product, consuming part of it, and accumulating surplus for investment according to a variety of socially determined goals."
- ***Experience*** "is the action of human subjects on themselves, determined by the interaction between their biological and cultural identities, and in relationship to their social and natural environment. It is constructed around the endless search for fulfilment of human needs and desires.

- ***Power*** "is that relationship between human subjects which, on the basis of production and experience, imposes the will of some subjects upon others by the potential or actual use of violence, physical or symbolic. (14)

In short, the productive relationship between labour and transformation of nature acts on the groundwork of energy, knowledge and information. Being technology the way this connection is established.

Slide 4_Policy making in the Information Society – UNESCO guidelines: from *information societies* to *knowledge societies*.

In 2003, at the World Summit on the Information Society (WSIS), the Geneva Plan of Action (GPA) was tabled to engender and support sustained critical reflection on the changing stakes of the information society, with a view to formulate normative codes of conduct and principle-based frameworks for governmental and civil society policies in relation to the *Infosphere*. This meeting was pointed as a first phase (out of two) to promote and develop strong statements of political will. The second phase was presented in Tunis in November 2005 with the objective to put in motion the GPA, as well as to discover solutions and reach resolutions in *Internet governance* (e-governance) and financing mechanisms. New York, December 2015, evaluating the outcomes of the GPA, in which it was defined as a primary statement that "the same rights that people have offline must also be protected online"[1]. The next review process – WSIS+20 – will be held in 2025.

Slide 4.1_UNESCO guidelines: Declaration of Principles

The first meeting resulted in a *common vision of the Information Society* enabling a set of common principles to ensure that all stakeholders can benefit from the opportunities that ICTs can offer:

1. **The role of governments and all stakeholders in the promotion of ICTs for development:** Building a people-centred Information Society is a joint effort, which requires cooperation and partnership among all stakeholders.
2. **Information and Communication infrastructure: an essential foundation for an inclusive information society:** connectivity is a central enabling agent in building the Information Society
3. **Access to information and Knowledge:** The ability for all to access and contribute information, ideas and knowledge is essential in an inclusive Information Society.
4. **Capacity building:** Each person should have the opportunity to acquire the necessary skills and knowledge in order to understand, participate actively in, and benefit fully from the Information Society and the knowledge economy.
5. **Building confidence and security in the use of ICTs:** Strengthening the trust framework, including information security and network security authentication, privacy and consumer protection.
6. **Enabling environment:** An enabling environment at national and international levels is essential for the Information Society. ICTs should be used as an important tool for good governance, as well as for Intellectual Property protection.
7. **ICT applications: benefits in all aspects of life:** Applications should be user-friendly, accessible to all, affordable, adapted to local needs in languages and cultures, and support sustainable development.

[1] Retrived from https://en.unesco.org/themes/building-knowledge-societies/wsis#:~:text=The%20Geneva%20Plan%20of%20Action,potential%20of%20ICTs%20for%20development.

8. **Cultural diversity and identity, linguistic diversity and local content:** The Information Society should be founded on and stimulate respect for cultural identity, cultural and linguistic diversity, traditions and religions, and foster dialogue among cultures and civilizations.
9. **Media:** Commitment to the principles of freedom of the press and freedom of information, as well as those of the independence, pluralism and diversity of media.
10. **Ethical dimensions of the Information Society:** The Information Society should respect peace and uphold the fundamental values of freedom, equality, solidarity, shared responsibility, and respect for nature.
11. **International and regional cooperation:** The Information Society is intrinsically global in nature and national efforts need to be supported by effective international and regional cooperation among governments, the private sector, civil society and other stakeholders, including the international financial institutions.

Slide 5_ Ethical and Societal Challenges of The Information Society - EGovernance

The concept of E-Governance is an outcome of the *electronic* changes in society. By *egovernance* one must realize that it is more than the implementation of ICT's. The authors of *Understanding egovernment and egovernance* (2007) give a broader definition as "(…) the use of the Internet and information and communication technologies (ITCs) and particularly the Internet as a tool for achieving better government. (…) relating to the transformation of bureaucratic mechanisms such as improving internal operations, and streamlining transactions and administration" (3). In this paper four levels of *egovernance* are pointed out:

1. **Transforming** the business of government.
2. **Increasing** participation, openness, transparency, and communication.
3. **Transformation** in the interactions between government and its internal and external clients, classified as government to-citizen (G2C), government-to-business (G2B), government-to-internal-employee clients (G2E), government-to-other-government institutional clients (G2), and citizen-to-citizen (C2C).
4. **Transformation** of society through the emergence of e-societies, which comprise networks of relationships such as citizen-to-citizen connections and relations between non-government organizations (NGOs). (5-6)

Slide 6_ Ethical and Societal Challenges of The Information Society – Digital Identities

The cyberspace is a place where identity takes many forms. From common citizens, to governments, and all kinds of institutions, we use a common ground identity in the digital world. According to the **2011 OECD** report on "National Strategies and Policies for Digital Identity Management, there are six areas of policy and user empowerment that need to be addressed:

1- ***A citizen registration policy***, which can provide the basis for the bond and legal binding between the individuals and their electronic identity.
2- ***Adoption of the citizen credentials*** (mandatory or voluntary)
3- ***Interoperability policy***: The common policy objectives are described independently of the possible technical solutions to achieve them.
4- ***Security Policy***: one hypothesis is that Identity Management (IdM) security stems from broader government information security policy and is not specifically addressed by governments at a policy level.

5- ***Privacy Policy***: Technical privacy protection measures can be seen as an efficient way to address legal privacy issues and are also important to enhance trust in and acceptance of the IdM framework
6- ***User Empowerment***: The promotion of "usability" through awareness raising, helpdesks for identity fraud, and innovative applications which enables users to log in to Web sites without filling in ID password information.

With this in mind, it is essential to assure not only personhood but also identity integrity in IdM.

Slide 7_*Interoperability and the functional macrostructure for egovernance*

The ISA2 Programme from the European Commission (2016) aims to develop digital solutions that enable public administrations, business and citizens in Europe to benefit from **interoperable cross-border and cross-public services.**

Interoperability is the ability for disparate and diverse organizations to interact in order to achieve common goals with mutual benefits, defined by mutual agreement and implying the sharing of information and knowledge between organizations, within the administrative processes they support, through the exchange of data between their respective ICT systems.

Semantic Interoperability is knowledge-level interoperability with the ability to correct semantic conflicts arising from differences in implicit meanings, perspectives, and assumptions, thus creating a semantically compatible information environment based on the concepts agreed upon between different entities.

Syntactic Interoperability is the ability of a system to interact and communicate with another system at the application level, allowing for the application of various software components, such as language implementation, interfaces, and execution platforms.

Physical interoperability is understood as the level of communication that focuses on infrastructure, network protocols or other applications.

Information organization models that involve the sharing of information and knowledge in order to create bridges to interoperability must ensure the proper management of archival information, which must be endowed with attributes of **authenticity**, **trustworthiness**, **integrity**, and **usability**.

Slide 8_ Policies in the making

Alongside with the methodologies already showed, governments have a major role in maximizing the resources that streamline the entire production and management data. Therefore, strategies must be created to make the full confluence of informational inputs (i.e. policies, licensing and digital preservation practices) into society and, in turn, the resulting outputs.

From the proposals we've mentioned, already in the making (from UNESCO, EU and others institutions), we conclude this topic with essential questions that are still unanswered, and have direct repercussions for citizenship, the private sector and geopolitics at large:

- Is governance about protection or restriction?
- What is more important between property protection and the free exchange of ideas and data?
- Should self-regulation prevail in various industry sectors or should regulation be the responsibility of national governments or international organisations?
- Should governments give priority to national competitiveness or to international compliance and protection of national identity?

- Should governments promote their own interests or provide assistance to developing countries? (Mukherjee, 2013, p. 24)

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https://digital-strategy.ec.europa.eu/en/library/declaration-european-digital-rights-and-principles -

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Slide 1_Introduction

4.2. CH Laws

Responsible	
Teacher	Ricardo Geraldes
Duration (min)	8 min.
Slides	5
Version	draft

Good morning, good afternoon and welcome to the third lesson of the module "POLICY RULES AND LYCENSING / DIGITAL DATA PRESERVATION" within the DCbox MOOCs. In this section 4.2. we are going to address the European and International standards regarding cultural heritage laws.

Slide 2_ Cultural Heritage a brief introduction

Culture is an instrument of civilization. Civilization can be seen as an artifice – through instruction, imposition and imitation. Thus, one could say that the concept of civilization is of the spectrum of artifice, which could also reveal that the human subject is apparently, or externally, civilized, but internally lacks of polish or politeness. So, civilization – as an artificial way of living in community – can be seen as a process of domestication, and its maintenance and complexity goes through culture. A definition of Heritage, according to Laurajane Smith in *Uses of Heritage* (2006), is "(…) a cultural process that engages with acts of remembering that work to create ways of understand and engage with the present, and the sites themselves are cultural tools that can facilitate, but are not necessarily vital for, this process"(Smith, 2006, p. 44). As such, heritage can be assumed as a cultural practice in understanding and engaging with time (past and present) and space (*topos)* mediated through discourse practices.

Slide 3_ Cultural Heritage as (Political) Discourse

Laurajane Smith expands the concept of heritage as the *Discourse of Authorized Heritage* (Smith 2006). The notion of "official heritage" may be best understood by turning to Michel Foucault in The Order of Discourse (1999): "discourse [...] is not simply that which manifests (or conceals) desire; it is also that which is the object of desire; [...] discourse is not simply that which translates struggles or systems of domination, but that by which, for which one struggles, the power of which one wants to take possession"(10). Discourse is then assumed as a form of mediation that manages the way we inhabit the historical world, constituted by all kinds of materiality. It is in this perspective that governments and cultural institutions, to promote a sense of national identity, generally use the concept of "official heritage". This discourse carries within it techniques of power that consequently already change the way we perceive cultural heritage.

Slide 4_ Cultural Heritage vs. National Heritage

A distinction between cultural heritage and national heritage is also important to mention. Heritage plays a prominent function in developing a sense of national identity around a certain national culture. However, it is important to clarify the idea of a national culture with false empirical claims that nations are culturally homogeneous: in fact, the intra-national diversity of cultures is the fact from which the political problem of multiculturalism arises. That said it is clear that significant cultural diversity exists in cultural sets of many kinds, nationalist or otherwise. That is why it is necessary to promote strategies that address heritage in a broader scope enabling the safeguarding of all the materialities that constitute human history.

Slide 5_ Cultural Heritage – a framework

According to the UNESCO Heritage Sustainability document (2014), Cultural heritage is both a product and a process, providing all societies an abundance of resources from the past, created in the present, for the benefit of future generations. The following is a general conceptual framework and terminologies regarding Cultural Heritage, as a guide to identify cultural heritage and mechanisms to promote sustainability [1].

1. **Cultural Heritage** refers to: a) monuments: architectural works, works of monumental sculpture and painting; inscriptions, cave dwellings; b) groups of buildings; c) sites: works of man or the combined works of nature and man.

2. **Natural Heritage** refers to: a) natural features consisting of physical and biological formations b) geological and physiographical formations; c) natural sites or precisely delineated natural areas of outstanding value from the point of view of science, conservation or natural beauty.

3. **Underwater culture and natural heritage** refers to: all traces of human existence having a cultural, historical or archaeological character which have been partially or totally under water, periodically or continuously for at least 100 years.

4. **Intangible cultural heritage** refers to those practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces: a) oral traditions and expressions; b) performing arts; c) social practices, rituals and festive events; d) knowledge and practices concerning nature and the universe; e) traditional craftsmanship.

Slide 6_ Cultural Property – a context

The concept of "cultural property" implies the notion that an artefact, monument, or work of art, style, place, etc., can be owned by a cultural group, implying a set of collective rights regarding ownership, access, and use. Therefore, the notion of "cultural property" raises a number of difficult philosophical questions concerning cultural groups, the nature of property, and the relationship between them. But apart from the strains regarding cultural property the following is a list of categories regarding Cultural property as presented in the UNESCO Heritage Sustainability document [1]:

a. rare collections and specimens of fauna, flora, minerals and anatomy, and objects of paleontological interest;
b. property relating to history (including the history of science and technology and military and social history), to the life of national leaders, thinkers, scientists and artists;
c. products of archaeological excavations or of archaeological discoveries;
d. elements of artistic or historical monuments or archaeological sites, which have been dismembered;
e. antiquities more than one hundred years old, such as inscriptions, coins and engraved seals;
f. objects of ethnological interest;
g. property of artistic interest, such as: (i) pictures, paintings and drawings produced entirely by hand on any support and in any material; (ii) original works of statuary art and sculpture in any material; (iii) original engravings, prints and lithographs; (iv) original artistic assemblages and montages in any material;

h. rare manuscripts and incunabula, old books, documents and publications of special interest (historical, artistic, scientific, literary, etc.) singly or in collections;
i. postage, revenue and similar stamps, singularly or in collections;
j. archives, including sound, photographic and cinematographic archives;
k. articles of furniture more than one hundred years old and old musical instruments.

Slide 7_ UNESCO – Convention Concerning the Protection of the Cultural and Natural Heritage – an overview

The World Heritage Convention adopted in 1972 by the General Conference of UNESCO promotes an international viewpoint on cultural heritage. The purpose of this treaty was to engage member states to propose an inventory of properties that composes its national cultural and natural heritage to be incorporated in a list of World Heritage sites. This convention urges national efforts to protect cultural and natural heritage and encourages international recognition and collaboration in conservation and preservation of the world's heritage. The following are some guidelines and frameworks that each State Party must undertake to ensure effective and active measures regarding Cultural Heritage: [2]

a) Adopt a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of that heritage into comprehensive planning programmes;
b) To set up within its territories, where such services do not exist, one or more services for the protection, conservation and presentation of the cultural and natural heritage with an appropriate staff and possessing the means to discharge their functions;
c) To develop scientific and technical studies and research and to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage;
d) To take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage;
e) To foster the establishment of the development of national or regional centres for training in the protection, conservation and presentation of the cultural and natural heritage and to encourage scientific research in this field.

Slide 8_ European Union standards concerning CH – Lisbon Treaty

In this part we will present some of the most relevant documents of the European Union considering Cultural Heritage. [3]

Lisbon Treaty

- **Article 167**: specifically devoted to culture
- **Preamble**: the Treaty is inspired by "Europe's cultural, religious and humanistic legacies, from which the universal values of inviolable and inalienable human rights, freedom, democracy, equality and the rule of law have developed".
- **Article 3 (3)**: the European Union "shall respect the richness of its cultural and linguistic diversity and shall ensure the safeguarding and development of the European cultural heritage".
- **Article 6**, in this section entitled "Categories and areas of competence of the Union", different actions can be undertaken by the EU to "support, coordinate or complement the action of Member States".

Slide 9_European Union most relevant recommendations concerning CH

- Recommendation of 20 December 1974 from the Commission to the Member States on the protection of the architectural and natural heritage (OJ L 21, 28.1.1975, p.22-23) 31975H0065
- Council conclusions of 17 June 1994 on the drawing up of a Community action plan in the field of CH (OJ C 235, 23.8.1994, p. 1-1) 31994Y0823(01)
- Council Resolution of 12 February 2001 on architectural quality in the urban and rural environment (OJ C 73,6.3.2001, p.6-7) 32001G0306(03)
- Council Decision of 1 December 2011 on the practical and procedural arrangements for the appointment by the Council of four members of the European jury in the framework of the EU's action for the European Heritage Label (OJ L 330, 14.12.2011, p. 23-24) 32011D0831
- Decision No 1194/2011/EU of the European Parliament and of the Council of 16 November 2011 establishing a EU action for the European Heritage Label (OJ L 303, 22.11.2011, p.1-9) 32011D1194
- Resolution of the Ministers responsible for cultural affairs, meeting within the Council, of 17 February 1986 on the establishment of transnational cultural routes (OJ C 44,26.2.1986, p.2-2) 41986X0226
- Resolution of the Ministers responsible for cultural affairs, meeting within the Council of 13 November 1986 on the conversation of objects and works of art (OJ C 320, 13.12.1986,p. 3-3) 41986X1213(02)

Slide 10_Cultural Heritage – from the past to the future

As we've been showing it is necessary to establish policies that secure our entire common heritage. From monuments, to expressions and skills, to natural and biological formations, everything is part of this collection of history. A number of relevant policies and recommendations, as well as frameworks, must be put into action by each State as to ensure the safeguarding of our cultural heritage. Information organization models that involve the sharing of information and knowledge in order to create bridges to interoperability must ensure the proper management of archival information, which must be endowed with attributes of **authenticity**, **trustworthiness**, **integrity**, and **usability**. By applying these attributes, better policy implementation will be ensured, enabling better data storage, sharing and management practices.

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Links:

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[2] https://whc.unesco.org/en/conventiontext/ - Convention Concerning the Protection of the World Cultural and Natural Heritage

[3] https://www.coe.int/en/web/herein-system/european-union - European Heritage network - most relevant documents

https://whc.unesco.org/archive/convention-en.pdf - Convention Concerning the Protection of the World Cultural and Natural Heritage

https://unesdoc.unesco.org/ark:/48223/pf0000368300 - Unesco on cultural property protection

4.3. Digital Cultural Laws between Public institutions and private businesses

1. Digital cultural heritage law: Does it exist?

The reality is that there are a series of recommendations, projects and laws, both at European level and by country, in which in some way the profession of digital curator and its legal framework are described in a very broad brushstrokes in the legal field. It is since the 2000s that the digitization boom began to be particularly helpful for the conservation and study of cultural heritage, and this is reflected in these recommendations. But if we want to have a complete idea of digital cultural heritage's legal sphere, we will have to collect all those laws, recommendations and projects like pieces of a puzzle to be built.

1.1. European Laws, recommendations and projects.

* ICOM ***Curricula Guidelines for museum professional development*** (2004) y ***Museum Professions – A European Frame of Reference*** (2008): Defines competencies and requirements that curators and museum professionals should meet.

*The **European Commission** (EC) (2011) - ***Recommendation on the digitisation and online accessibility of cultural material and digital preservation:*** Updated set of measures for digitising and bringing cultural heritage online and for digital preservation. Encourages the development of digitised material in order to ensure that Europe maintains its place as a leading international player in the field of culture.

* In 2021, the **European Commission** presented a **vision and avenues for Europe's digital transformation by 2030:** Although this document is not specifically depicted in reference to the CH sector, it is undoubtedly part of the disruption caused by the pandemic.

* The **European Commission** - ***Recommendation on a common European data space for cultural heritage*** (2021): Declares the importance of facing the financial loss due to the COVID-19 pandemic. Encourages Member States to put in place appropriate frameworks to enhance the recovery and transformation of the cultural heritage sector. Upgrading the way in which for museums work with creative and technology partners.

* **Europeana Portal** (2008): European Digital Library.

* **Directive (EU) 2019/790** of **the European Parliament and of the Council** of 17 April 2019 **on copyright and related rights in the Digital Single Market and amending Directives 96/9/EC and 2001/29/EC:** Includes the use of copyrighted works as part of cultural conservation. Institutions dedicated to cultural heritage conservation must use digital technologies to do so.

1.2. European countries laws

Current laws of the countries participating in this Erasmus+ project:

CYPRUS

- **Department of Antiquities:** The Curator of Antiquities oversees the process of renovating museums, creating new ones, digitizing collections, sites and monuments through several EU or other co-funded projects.

- **'Digital Strategy for Cyprus'** (2012)**:** Included measures and actions specifically for digitization of museums.

ITALY

- **Italian Ministry of Cultural Heritage - 'Three-year Plan for the Digitization of Museums'** (2019): Provide all Italian museums with a coherent reference framework capable of guiding the adoption of digital solutions.
- **The "Piano Nazionale di Ripresa e Resilienza" (National Recovery and Resilience Plan)** (2021): Allocates 500 million euros in grants for the digitization of public and private cultural heritage and for the creation of digital infrastructures and platforms for conservation and access to digital cultural resources.

SERBIA

- **Strategy of Serbian cultural development during** (2017-2027): Legal framework for digitization processes, collecting digital versions of books and important documents of their national libraries.

SPAIN

- **Law 16/85 of 25 June 1985 on Spanish Historical Heritage:** Matrix Law about the protection and enrichment of cultural property in the whole country. Each autonomous region has its own individual regulations based on this law. It includes the digitization of cultural heritage on each autonomous region.
- **Law 8/2022 of 4 May:** By which the National Library of Spain has included digital heritage in its collections.

2. Museums vs. Private businesses

2.1. ICT Society. The need of digitalization.

Nowadays, the New Information and Communication Technologies have taken great importance in our lives. Internet access, the ease of organizing, exploring, creating content that these technologies provide us with have made our lives more comfortable. We have seen the passage of cassettes, CDs, DVDs, pen drives, even cloud computing to store, manage and process our content.

Due to this, it is normal to think that ICTs are a good conservation and useful tool for everything, including cultural heritage.

2.2. The acceleration of digitization in pandemic.

Owing to social distance because of the pandemic, quarantine, travel restrictions... new technologies have been a great way to keep up with everything, work, interact and even see the world.

This has been reflected in the museums and institutions in charge of cultural heritage, since those that already had an investment in these new technologies were developing their content during this time of pandemic. We can say that, thanks to the pandemic, these institutions invested and developed (and continue) in platforms and services to maintain their content and heritage. Therefore, the institutions and museums that were still lagging in this, in the last two years have accelerated their digitization.

As we have seen in the laws, before the pandemic, projects and regulations were already being developed that included this digital conservation. Nevertheless, it has been in recent years that it has been considered the most. But, what about the content that these museums and institutions upload to the networks? [1]

2.3. Intellectual Property in public domain.

We know that the content of a museum has the intellectual property of the author, as long as this has been testified. If this is not the case, or the work per se belongs to the museum, we would be talking about public domain content, which is included in different regulations both in Europe and worldwide and in physical and online fields.:

- WIPO - World Intellectual Property Organization: Regarding the management of Intellectual Property in museums, it states that museums must guarantee the respect of these rights to artists and authors. It argues that museums, notwithstanding the type of IP at issue, are stewards of their collections and rely on private companies to fulfil their mission of preserving their collections, educate the public about them and provide the public with access to the collections. This alliance between museums and commercial companies must find a balance between each other objectives, bearing in mind that museums are not for-profit companies. [2]

- CC0 1.0: It is a non-profit organization dedicated to promoting access and exchange of culture. Many private companies dedicated to cultural heritage are runed by this license to offer its content to the public domain. It encompasses certain owners who wish to permanently relinquish the rights to their works for the purpose of contributing to a common of creative, cultural and scientific works ("Commons") that the public can use without fear of later claims of infringement. [3]

- Directive (EU) 2019/790: As we have seen, this directive states that institutions responsible for cultural heritage can make copies of works for conservation purposes and distribute an author's content without damaging their Intellectual Property. However, it mentions that it is necessary to adapt the current legal framework by establishing a mandatory exception to the right of reproduction to make these acts of conservation possible by those institutions. It also mentions that reproductions of works of visual art in the public domain should not be protected by copyright or related rights. Likewise, it allows institutions responsible for cultural heritage to make available, for non-commercial purposes, works or other contents (physical or online) indicating the name of the author or any other identifiable rights. [4]

2.4. Digital Platforms.

The EU directive states that institutions responsible for cultural heritage that do not necessarily have the means or the technical knowledge to carry out by themselves the necessary acts to preserve their collections, especially in the digital environment, must be able to be helped by other cultural institutions and third parties to this purpose. These private companies will act on institution’s behalf and responsibility, including those established in other Member States, to make copies. Some of the most common platforms for this would be:

- Sketchfab: Private platform used to view and share 3D content online. Many museums and institutions have their account on this website and with it they upload their 3D content which can be accessed by everyone. As long as the platform works, users can upload the relevant 3D content, being the copyright of the user and not of Sketchfab. When third parties download free content, the

license they are subject to is that of CC0 1.0. If the content is paid, the license they are subject to is provided by Sketchfab, and among other things, the violation of intellectual property is prohibited.

- Google Arts&Culture: Website of the Google Cultural Institute that presents a collection of high-resolution images of works of art exhibited in various museums around the world, as well as a virtual tour of the galleries in which they are found. Content uploaded by these institutions is the property of those institutions. Third parties may not use the content without authorization from said institution. Google grants its license to content protected by Intellectual Property.

- Europeana: European Digital Library currently funded by Horizon2020. Its access is free and contains the contributions of cultural institutions of the Member States. Primarily advocates the public domain (CC0 1.0) and acknowledges in its content usage terms that copyrighted content will be made available to third parties with the user-selected rights statement.

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4.4. ISO and EN standards

1. ISO

ISO, better known as the International Organization for Standardization, is the organization that promotes the development of international standards for manufacturing, trade and communication that covers the different industrial and commercial sectors. [1]

ISO is made up of different national standardization institutes from 166 countries. All are coordinated from the Central Secretariat. The purpose of ISO standards is:

- Coordination of national standards to facilitate and avoid barriers to trade.
- Promote the exchange of information.
- Contribute to the development and transfer of technology through common standards, enriching collaboration between companies.

Its application is voluntary, since ISO is a non-governmental organization and does not depend on any international organization. Therefore, its authority is not mandatory to be imposed in any country.

1.1. ISO Standards.

Some of the ISO Standards determine the conservation and management of Cultural Heritage. We will see as example those that regulate digital cultural heritage:

- ISO 21127:2014(en) Information and documentation — A reference ontology for the interchange of cultural heritage information: establishes guidelines for the exchange of information between cultural heritage institutions.[2]
- ISO/TR 19263-1:2017(en) Photography — Archiving systems — Part 1: Best practices for digital image capture of cultural heritage material: specifies how to perform quality analysis of imaging systems used for digitization of reflective two-dimensional originals.[3]
- ISO 19264-1:2021(en) Photography — Archiving systems — Imaging systems quality analysis — Part 1: Reflective originals: This document describes a method for analysing imaging systems quality in the area of cultural heritage imaging. This specification applies to scanners and digital cameras used for digitization of cultural heritage material.[4]
- ISO 25964-1:2011(en) Information and documentation — Thesauri and interoperability with other vocabularies: The objective is to review the structural models of mapping between structured vocabularies to release the richness of cultural assets through the vocabulary.[5]
    - Part 1: Thesauri for information retrieval: gives recommendations for the development and maintenance of thesauri intended for information retrieval applications.
    - Part 2: is applicable to thesauri and other types of vocabulary that are commonly used for information retrieval.

1.2. European Standards (EN)

EN standards are European Standards which are drawn up, proposed and developed by experts from different Member States, from industrial or technological sectors within the standardization structure of the European Committee for Standardization (CEN). [6]

Currently, EN qualified technical recommendations are not binding and their use is voluntary. Within the area of Digital Cultural Heritage, we will focus on those whose meaning falls within this area:

- UNE EN 17429:2021 Conservation of cultural heritage - Procurement of conservation services and works: This document outlines the principles, processes, and best practice for procuring conservation services and works for cultural heritage. This can embrace any conservation action or measure, whether it be a preventive measure, a remedial treatment, investigation, planning, policy, or project management, etc. [7]
- UNE-EN 16853:2018 Conservation of cultural heritage - Conservation process - Decision making, planning and implementation: This file determines measures and actions aimed at safeguarding cultural heritage while respecting its heritage interest, including its accessibility to present and future generations. [8]
- UNE EN 15898:2020 Conservation of cultural heritage - Main general terms and definitions: This European Standard defines the main general terms used in the field of conservation of cultural property with particular attention to those terms which have wide use or significance.[9]
- UNE 41531:2018 IN Accessibility of the Immovable Cultural Heritage. General criteria and methodology: it proposes that, in order to achieve the adopted accessibility objectives, the different action options should be analyzed jointly, comparatively and in a complementary manner and opt for options such as the implementation of information and communication technologies (ICT). [10]

2. The use of ISO and EN standards in the Digital Cultural Heritage

As we have seen, the use of these standards is not mandatory. But it is quite recommendable since it allows us to implement a universal language that can be understood both at a European and global level. And this is one of the objectives of heritage conservation, to be accessible to everyone.

Although there is no ISO or EN standard that refers itself to digital cultural heritage, as we have seen in the previous section, there are some standards that mention it.

To apply them we will have to know them well and carry out an information filter to know which ones are interesting for our digital curator role and which ones are not.

Finally, in the legal field, to implement these standards, a certification audit would be carried out with an official audit.

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4.5. Open File Formats: images, videos, sounds, point clouds and meshes

1. Open File Formats and Standards

Open format means a specification for storing digital data without legal and economic restrictions, usually published and sponsored by an open standards organization.

The main objective of open formats is to guarantee long-term access to digital data, without depending on the uncertainties that are related to the use of closed/proprietary storage formats created by private companies.

Indeed, the current trend by public administrations in several countries worldwide (and also by private companies) is the promotion and use of open formats files.

This trend is also reflected in the field of Digital Cultural Heritage: the use of open formats favors the circulation and dissemination of digital heritage, the exchange of information between cultural administrations and the preservation of digital data over time.

In this class we will try to break down the free formats recommended for storing images (raster files), videos and sounds.

2. Open File Formats for Images

The most common free formats for storing images are:

- GIF: abbreviation of the name Graphics Interchange Format, is a free digital graphic format, commonly used on the world wide web. It was created by CompuServe in 1987 since its previous version was in black and white. GIF is limited to 256 colours, so a problem could be the loss of image quality if the image has more colours. It allows animations and transparencies, also it is able to compress large images. For slow connections, it uses the Interlacing method, which allows you to see the entire image in low quality. [1]

- JPEG: Joint Photographic Experts Group is the name of the committee of experts that gives its name to this free format. This committee created a standard for compression and encoding of files and still images, which is currently one of the most widely used formats for photographs. It is an image compression format, but it is often considered a file format because it allows very high compression ratios to be obtained while maintaining very high image quality, since it supports up to 16 million colours. [2]

- PNG: stands for Portable Network Graphics, it is a patent-free digital format, it was developed to solve the quality problems of the GIF, so it compresses images without any loss. Likewise, its compression is totally reversible and therefore the image that is recovered is exactly the same as the original. As it does not support animations, the APNG was created as an extension. It has obtained the MIME (Multipurpose Internet Mail Extensions) [3] specifications aimed at exchanging all types of files over the Internet. [4]

- TIFF: from the name Tagged Image File Format, it is a very flexible computer file format for storing bitmap images. Its initial release was in 1986 and was created by Aldus and Microsoft, although it is currently owned by Adobe Systems. In practice, TIFF is used almost exclusively as a lossless image storage format without any compression. Consequently, files in this format are usually very large and of high quality. [5]

3. Open File Formats for Videos

As for the videos, we can talk about the following free formats for storage:

- **AVI:** for Audio Video Interleave, it is an audio and video container format launched by Microsoft in 1992. The AVI format allows simultaneous storage of a video data stream and several audio streams. The specific format of these streams is interpreted by an external program called a codec. That is to say, the audio and video contained in the AVI can be in any format. By admitting several audio streams, the same video can contain several sounds in different languages, it will be the user who decides the audio to put. By taking up a lot of space, it makes it difficult to upload them to the internet. [6]
- **MPEG-4:** Group of international standards for the compression of digital audio and visual data, multimedia systems, and file storage formats. It was originally introduced in late 1998 as a group of audio and video coding formats and related technology agreed upon by the ISO/IEC Moving Picture Experts Group under the formal standard ISO/IEC 14496 – Coding of audio-visual objects. MPEG-4 contains patented technologies, the use of which requires licensing in countries that acknowledge software algorithm patents. [7]
- **MOV:** from the name QuickTime Movie, this container is from Apple Computer's QuickTime multimedia architecture and technology. This video file format is openly documented and available for anyone to use royalty-free. As a result, there are several non-Apple video player software available which can play QuickTime video files. The QuickTime format was used as the basis of the MPEG-4 MP4 container standard. [8]

4. Open File Formats for Sounds

The following free formats are the most common for storing sounds:

- **AAC:** acronym for Advanced Audio Coding, is one of the most widely used audio formats today. It is not only characterized by its popularity, but also by the quality it offers compared to other formats. Based on a lossy compression algorithm, a process by which some of the audio data is removed in order to obtain the highest degree of compression possible, resulting in an output file that sounds as close as possible to the original. It corresponds to the international standard “ISO/IEC 13818-7” as an extension of MPEG-2: a standard created by MPEG. It allows legal inclusion of copyright protection, unauthorized audio files that have copy protection will not work in AAC. [9]
- **MP3:** MPEG-1 Audio Layer III or MPEG-2 Audio Layer III, more commonly known as MP3, is a digital audio compression format that uses a lossy algorithm to achieve smaller file sizes. It was developed by the Moving Picture Experts Group. An MP3 file can also be recorded at higher or lower bit rates, with higher or lower resulting quality. Its format specifications include ISO/IEC 11172-3 and ISO/IEC 13818-4. [10]
- **FLAC:** Acronym for the name Free Lossless Audio Codec, it is an open-source lossless audio compression format. FLAC files are allowed to be used on multiple operating systems and platforms. Its sound quality is superior to that of MP3 because it includes losses in its compression. It is manageable and saves file storage space. [11]
- **WAV:** a shortened form of Waveform audio file format, it is a digital audio format with or without data compression developed by Microsoft and IBM that is used to store digital audio streams. WAV is compatible with almost any audio codec. It is used in the LPCM format which is lossless and suitable for professional use. Uncompressed WAV files are large, so sharing WAV files over the Internet is rare. It has also been used for non-audio data. [12]

5. Open File Formats for Point Clouds

Point clouds are the base product that is obtained as a result of data acquisition through active sensors (laser scanners) and passive sensors (cameras), in this case in the field of image acquisition for processing photogrammetric.

The open formats for this area are:

- **LAS:** The LAS (LASer) file format is a public file format for the interchange of 3-dimensional point cloud data between data users. Although developed primarily for exchange of lidar point cloud data, this format supports the exchange of any 3-dimensional x,y,z tuplet. It is an open, binary format specified by the American Society for Photogrammetry and Remote Sensing (ASPRS). The format is widely used and regarded as an industry standard for LIDAR devices. In addition, it is proposed as an alternative to ASCII files, which lose a large part of the information of the LIDAR data and which would generate files of excessive size and difficult to handle. [13]
- **LAZ:** It is obtained from the compression of LAS files by means of a compression library, which we owe to Martin Isenburg, and who is also the creator of the LASzip tool. This tool is available to any user for free, since it is open source and allows us to process LIDAR data. Thanks to it, any LAS file compressed in LAZ allows us to reduce the file size by up to 80%, preserving all the information without altering it in any way. [14]

6. Open File Formats for Meshes

Polygon meshes are 3d surface models that can be derived from point clouds acquired by active or passive sensors or from a 3d modelling process from scratch.

The most common open formats for Meshes are:

- **OBJ:** The OBJ file extension is known as Wavefront 3D Object File which was developed by Wavefront Technologies. The file format is open and has been adopted by other 3D graphics application vendors. It is a file format used for a three-dimensional object that contains the 3D coordinates (polygonal lines and points), texture maps, and other object information. It contains a standard 3D image format that can be exported and opened by various 3D image editing programs. [15]
- **PLY:** Polygon File Format is an extension used to store data collected with 3D scanners. It is also known as the Stanford Triangle format because it was created at Stanford University in the mid-1990s, with a design inspired by the Wavefronts OBJ vector format. A PLY file contains a 3D description of an object through a list of nominally flat polygons, as well as information about colour, transparency, textures, etc. The format permits one to have different properties for the front and back of a polygon. There are two versions of the file format, one in ASCII, the other in binary. [16]
- **COLLADA:** Collaborative Design Activity is an interchange file format for interactive 3D applications. It is managed by the non-profit technology consortium, the Khronos Group, and has been adopted by ISO as a publicly available specification, ISO/PAS 17506. Defines an XML-based schema to make it easy to transport 3D assets between applications, enabling diverse 3D authoring and content processing tools to be combined into a production pipeline. The COLLADA format takes up more storage space than other similar file types, such as OBJ. [17]

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MODULE 5

DIGITAL DATA PRESERVATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

5.1. Digital Cataloguing strategies for Cultural Heritage

1. Cataloguing for Digital Cultural Heritage

Cataloguing is a process that begins with the systematic collection of data. Therefore, all the heritage assets that we are going to catalogue must be quantified and identified, for this it is convenient to carry out a work inventory with the descriptions and contexts of said heritage assets [1].

The importance of this process is due to the fact that, if a cultural asset is catalogued, it will be able to have public visibility and legal protection and this will give it better conservation and durability over time. Particularly when we talk about computerized catalogues, since the high number of descriptions and heritage assets that we can catalogue, as well as their accessibility, will make digital curator's role an easier job.

2. Methodological approach.

As we know, the digital preservation process is achieved under quality standards that guide as a fundamental criterion the capture of the semantic, symbolic, historical and contextual content of the object to be preserved, with the greatest possible fidelity. For this reason, the tasks involve digitization in high resolution format and, as a consequence, its digital cataloguing.
For the cataloguing of these data, the international and European cataloguing rules, ISAD and UNIMARC, respectively, are taken into account.

2.1. International Standard Archival Description (ISAD)

ISAD is an international standard used for the description of records and archival documents [2]. It helps us to identify the heritage asset or document and, on the other hand, to explain its content and its creation context, throughout its entire life cycle, in order to make it accessible.

This rule is applicable to any archival document, regardless of its documentary type and its physical or digital support. Among the objectives pursued by the ISAD (G) standard are:

- To guarantee the elaboration of coherent, pertinent and explicit descriptions.
- To facilitate the retrieval and exchange of information related to archival documents.
- To share authority data.
- To enable the integration of descriptions from different places in a unified information system.

Archival description with ISAD (G) is hierarchical and multilevel. It begins by describing the general and goes down to the particular, that is, it begins with the description of the documentary collection and is specified until reaching the documentary unit.

2.2. Universal MARC format (UNIMARC)

They are standards that allow the exchange of bibliographic records in digital format between different bibliographic bodies, through a common language. They are a machine-readable catalog record, usually a computer, that can read and interpret that data. This information is what is found

in the catalog files. They are more widely used in Europe than the MARC standards, from which they come from [3].

There is a debate with these standards and it is that, on the one hand, they are quite complex storage formats and based on outdated technology. But currently, there is no equivalent catalog record and there are millions of records in these formats, so it is in a problem of computer stagnation [4].

3. Tools and Techniques

By cataloguing, we make the heritage asset distinguishable from other similar assets. To do this, we use different techniques and tools:

Inventory is understood as a precise identification instrument that quantifies all the elements that are part of a given set of assets. It constitutes the exhaustive and orderly list of the patrimonial assets that are part of an institution.

In the first place, to carry out an inventory of the heritage assets that we want to catalogue, we will have to make a correct identification of the heritage asset, followed by a succinct description and its cultural-historical context. With this, we will make a collection, classification and ordering of related documents, which will be part of the context of the asset. Likewise, catalog is understood as the in-depth development of that inventory, divided into datasheets.

Once this inventory has been made, we will be able to make the datasheet of the asset represented [5]. The datasheet is used to select, organize and catalogue documents according to their characteristics. Following ISAD, it is organized into 7 description areas:

1. Identification: includes the essential information to identify the unit of description.
2. Context: deals with the origin and custody of the unit of description.
3. Content and structure: describes the object and the organization.
4. Access and use: offers information on the conditions of access and use.
5. Associated documentation: this section includes those documents related to those we are describing.
6. Notes: special information and data that we have not been able to include in any other area and that we consider of interest.
7. Description control: in this area we identify how, when and who has prepared the archival description.

Below is an example table with the description areas of the datasheet in the most common computer cataloging databases:

EUROPEANA	GOOGLE ARTS&CULTURE
Provider Institution	Title
Object type	Creator
Supplier	Creation date
Media license in this record (unless otherwise specified)	Style
	Provenance

User Generated Content	Original Title
Origin	Physical dimensions
Identifier	Type of heritage asset
Provider country	Artistic technique
Collection Name	
Creation stamp	
Updated stamp	

These areas will depend on the type of heritage asset that is being catalogued, whether it is a piece of art, an article, a monument etc.

To conclude, through cataloging the cultural assets can be preserved, conserved and reach the public for its study and valorization. For this reason, it is highly important to know the tools and techniques for catalog.

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5.3. Database design

Responsible	University of Nis (UNI)
Teacher	Bata Vasic,
Duration (min)	8 min
Slides	12
Version	draft

Slide 1_Data

We can define the notion of the Data as a collection of discrete values that includes information describing quantity, quality, fact, statistics, other basic units of meaning, or simply sequences of symbols.

Slide 2_Data in Museology

In the context of museology, the relevant data sets represent all kind of information about historical events, cultural heritage artefacts, art pieces, different old textual content and books, libraries, but also dates and numerical information from measuring and quantity counting information.

Slide 3_ Big Data

Advances in computing technologies, especially in the field of an automatic photogrammetric reconstruction of historical monuments, have led to the advent of ''Big Data'', which in the architectural context refers to very large quantities of data in the sense of spatial coordinates, normals and image maps related to huge amount of points in the generated point clouds.

Using traditional data analysis methods and computing, working with such large datasets is difficult, even impossible. In response to this kind of challenge, the relatively new machine learning and AI methods are introduced, allowing most of efficient applications of analytic methods to Big Data.

Slide 4_ Huge Data

Without the emphasis on the previously mentioned big data, we have to note the sudden increase in the exchange, sharing and storage of huge amounts of images, audio and video files, 3D models and VR scenes. All these files and related information about them can also be classified as the Big Data.

In the other hand, advances in computing technologies and increasing in computational speed allow using even traditional methods in Database design and management.

Slide 5_What is a Database?

We are talking about data that is incalculably important for the whole humanity, and this fact implies their collection, organisation, and storage including ensuring their security and privacy of sensitive data.

A database is an organized collection of data that is stored and accessed electronically. The basic database design encompasses formal techniques and practical considerations, including data modelling, efficient data representation and storage, and query languages [1].

In museology, the mentioned security and privacy of sensitive data, and distributed computing issues, including support for concurrent access and fault tolerance are advanced level of database development and management.

Slide 6_Types of Databases

There are two types of databases in database management: operational databases and analytical databases.

- Operational databases are the backbone of many companies, organizations, and institutions throughout the world. This type of database is primarily used in online transaction processing (OLTP) scenarios, that is, in situations where there is a need to collect, modify, and maintain data on a daily basis.
- In contrast, analytical databases are primarily used in online analytical processing (OLAP) scenarios, where there is a need to store and track historical and time-dependent data. An analytical database is a valuable asset when there is a need to track trends, view statistical data over a long period of time, and make tactical or strategic business projections. This type of database stores static data without any modification.

Slide 7_Database models

The main database models are defined based on the way of manipulating data:

1. The hierarchical database model;
2. The network database model.

Slide 8_The hierarchical database model

Data in the hierarchical type of database is structured hierarchically and is typically diagrammed as an inverted tree. A single table in the database acts as the “root” of the inverted tree and other tables act as the branches flowing from the root. A relationship in a hierarchical database is represented by the term parent/child. In this type of relationship, a parent table can be associated with one or more child tables, but a single child table can be associated with only one parent table.

Slide 9_ The network database model

The network database is developed to address some of the problems of the hierarchical database. The structure of a network database is represented in terms of nodes and set structures. A node represents a collection of records, and a set structure establishes and represents a relationship in a network database. It is a transparent construction that relates to a pair of nodes together by using one node as an owner and the other node as a member.

Slide 10_The relational database model

The relational database was first conceived in 1969 and it is still one of the most widely used database models in database management today. The father of the relational model, Dr. Edgar F. Codd, was an IBM research scientist in the late 1960s and was at that time looking into new ways to handle large amounts of data.

A relational database stores data in relations, which the user perceives as tables. Each relation is composed of tuples, or records, and attributes, or fields. The physical order of the records or fields in a table is completely virtual, and each record in the table is identified by a field that contains a unique value. These are the two characteristics of a relational database that allow the data to exist independent of the way it is physically stored in the computer.

Slide 11_What is important for Digital curators?

Most information in the research field of Data and Databases is redundant for users without advanced technical knowledge. The complex mathematical terms and complex relationship inside the databases can be pretty confusing and discouraging.

The purpose of this presentation is to provide a theoretical basis for the user to recognize certain types and models of databases in order to speed up and ease of navigation in the data structure.

Slide 12_What is important for Digital curators?

Due to the above, we can define three fields that would be helpful to users when understanding databases and their proper use.

- Database development process
- Retrieving Data
- Database management

The next lesson describes these processes in more detail, of course in accordance with the needs of students who have opted for this DCBox program.

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5.4. Data models (ER, EER)

Responsible	University of Nis (UNI)
Teacher	Bata Vasic,
Duration (min)	8 min
Slides	14
Version	draft

Slide 1_Entity–relationship model

Entity–relationship (ER) modelling was developed for database and designed by Peter Chen 1976 [1]. Today it is commonly used for basic explanation of data base structure. In software engineering, the ER model is commonly used to represent things a business needs to remember in order to perform business processes. Consequently, the ER model becomes an abstract data model that defines a data or information structure which can be implemented in a database, typically a relational database.

A basic ER model is composed of entity types and specifies relationships that can exist between entities, but some ER models show super and subtype entities connected by generalization-specialization relationships.

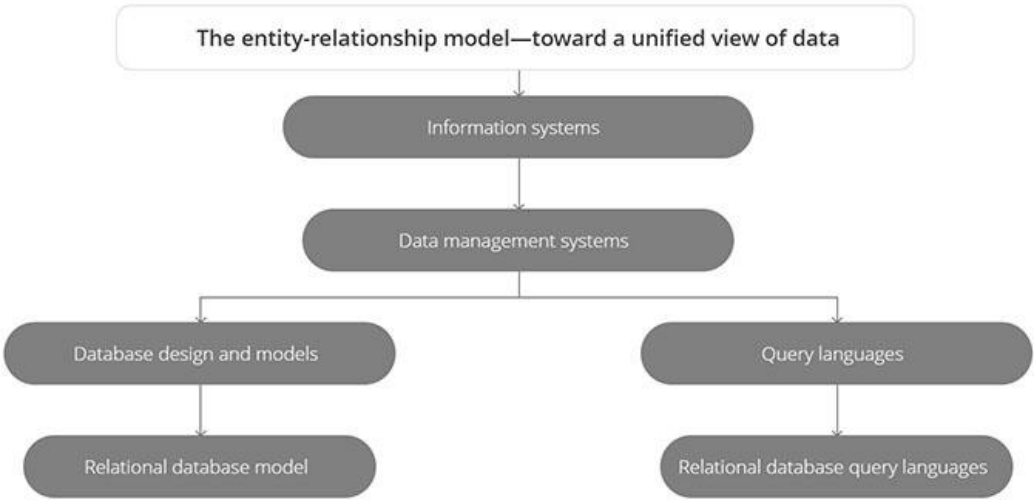

Figure 1. The ER model chart [2]

Slide 2_Multilevel Views of Data

In the study of a data model, we should identify the levels of logical views of data with which the model is concerned. In this context we can identify four levels of views of data:

1. Information concerning entities and relationships that exist in our minds,
2. Information structure (organization of information) in which entities and relationships are represented by data,
3. Access-path-independent data structure - the data structures which are not involved with search schemes, indexing schemes, etc.
4. Access-path-dependent data structure.

Slide 3_The first level

At this level we consider entities and relationships. An entity is a “thing” which can be distinctly identified. A specific person, company, or event is an example of an entity. A relationship is an association among entities. For instance, “father-son” is a relationship between two "person” entities.

We have to note that some people may view something (e.g. marriage) as an entity while other people may view it as a relationship. We think that this is a decision which has to be made by the enterprise administrator. He/she should define what entities and relationships are so that the distinction is suitable for his/her environment.

The database of a museum for example contains relevant information concerning artefacts (entities) and relationships in which the museum is interested. A complete description of an entity or relationship may not be recorded in the database of a museum. It is impossible and usually unnecessary to record every potentially available piece of information about entities and all their relationships. Rather, we shall consider only the entities, relationships and the information concerning them, which are to enter into the database development.

Slide 4_An example

The figure below represents a simple example of the data structure design.

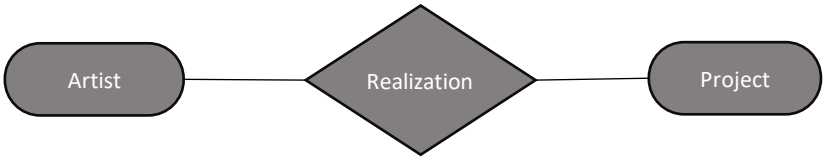

Figure 2. A simple entity-relationship diagram

The entity “Artist” can be a set of artists and the entity “Project” can be set of projects or set of artistic pieces. Analogous to that, the relationship “Realisation” can be defined as a set of relationships in the case of multiple relationships between the authors and projects.

Slide 5_Entity–attribute-relationship diagram

The ER model is usually represented in a graphical form as boxes (entities) that are connected by lines (relationships) which express the associations and dependencies between entities. However, Entities may be characterized not only by relationships, but also by additional properties (attributes), which include identifiers called "primary keys". Diagrams created to represent attributes as well as entities and relationships may be called entity-attribute-relationship diagrams, rather than entity–relationship models.

An ER model is typically implemented as a database. In a simple relational database implementation, each row of a table represents one instance of an entity type, and each field in a table represents an attribute type. In a relational database a relationship between entities is implemented by storing the primary key of one entity as a pointer or "foreign key" in the table of another entity.

Slide 6_An example

With regard to the figure 2, we can extend entity-relationship structure by adding an attribute or set of attributes to all sets: sets of entities and/or sets of relationships. This simple structure is presented on the next figure.

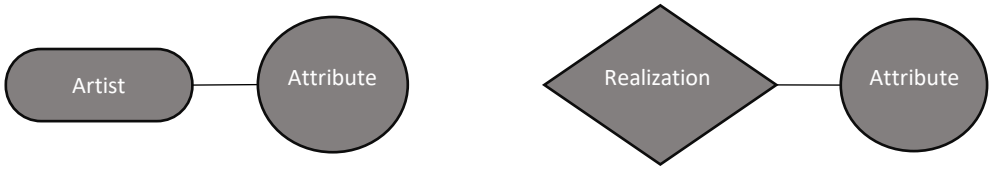

Figure 3. A simple entity-attribute and relationship-attribute diagram

In the case of the museum collection structure, set of attributes of both “entities” and “relationships” can be in a relationship with their sets of attributes. For example, an attribute of the realisation can be date and time, artistic technique etc.

Slide 7_Limitations

- An ER model is primarily conceptual, an ontology that expresses predicates in a domain of knowledge.
- ER models are readily used to represent relational database structures but not so often to represent other kinds of data structure (data warehouses, document stores etc.)
- Some ER model notations do not include symbols to show super-sub-type relationships and mutual exclusion between relationships.
- The ER model does not show history of an entity's life (how its attributes and/or relationships change over time in response to events).
- Today, even where ER modelling could be useful, it is uncommon because many use tools that support similar kinds of model, notably class diagrams for object-oriented programming and data models for relational database management systems. Some of these tools can generate code from diagrams and reverse-engineer diagrams from code.
- The lack of guidance and support for data integration..
- For modelling temporal databases, the ER model was found unsuitable for multidimensional databases without dominant conceptual model.

Slide 8_Enhanced Entity–relationship model

As a response to the limitations of the standard ER model the Enhanced Entity–Relationship model (EER modelling) introduces several concepts closely related to object-oriented database design. The enhanced entity–relationship (EER) model is a high-level conceptual data model and it was developed to reflect more precisely the properties and constraints that are found in more complex databases, such as in engineering design and manufacturing (CAD/CAM), telecommunications, complex software systems and geographic information systems (GIS) [3].

The EER model includes all of the concepts introduced by the ER model, but additionally it includes the concepts of a subclass and superclass, along with the concepts of specialization and generalization. Furthermore, it introduces the concept of a union type or category, which is used to represent a collection of objects that is the union of objects of different entity types. EER model also includes EER diagrams that are conceptual models that accurately represent the requirements of complex databases.

Slide 9_Subclass and superclass

Entity type Y is a subtype (subclass) of an entity type X if and only if every Y is necessarily a X. A subclass entity inherits all attributes and relationships of its superclass entity. This property is called the attribute and relationship inheritance. A subclass entity may have its own specific attributes and relationships (together with all the attributes and relationships it inherits from the superclass).

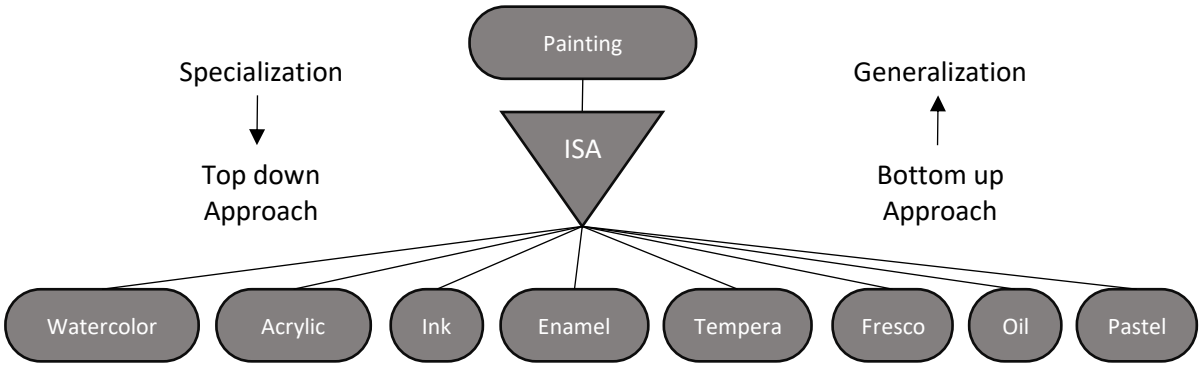

Figure 4. Subclasses and superclass

All painting techniques (materials) shown in the previous figure are all subclasses of the superclass Painting. They all inherit common attributes from painting such as art movement, category, style, technique, etc. while they have different attributes such as i.e. dimensions, authors, etc.

In the other hand, if we want to extend the whole picture on wider group of entities, we can consider the entity Painting as a subclass of the superclass Artistic piece, which contains also other subclasses: musical pieces, literary pieces, etc.

Slide 10_Valences

The *valence concept* [4] allows to describe reference sets including detailed *cardinality constraints* and variants. It also enables the database system to monitor design completeness, i.e., whether all specified references are present. Although based on a formal semantics, the resulting syntax is very suggestive and

easy to understand. The valence concept does not require any special capability of the overall data model besides typing and object identity, hence it is neutral enough to be incorporated in virtually any ERM-based or object-oriented data model.

A valence is a binary, directed edge that arises from a relationship and is directed toward another object (entity or relationship). A valence is called named if it is assigned a role. Valences are grouped according to the relation instance from which they start. The entire valences belonging to an instance of a relation form its valence bundle. The description of valence bundles during type definition is done using the valence expression. Let's observe the concept on the simple example.

Slide 11_An example

The running example used is drawn from garment industry, describing an ensemble of women's outer wear.

Figure 5. The ensemble of woman wear

For the subsequent discussion, we focus on the description of an ensemble's parts on type level by specifying the valence bundle of the complex object type or relationship type Ensemble.

Slide 12_The diagram

First, let's assume that the ensemble consists of only one dress. The corresponding valence expression is therefore just as simple: **Dress**

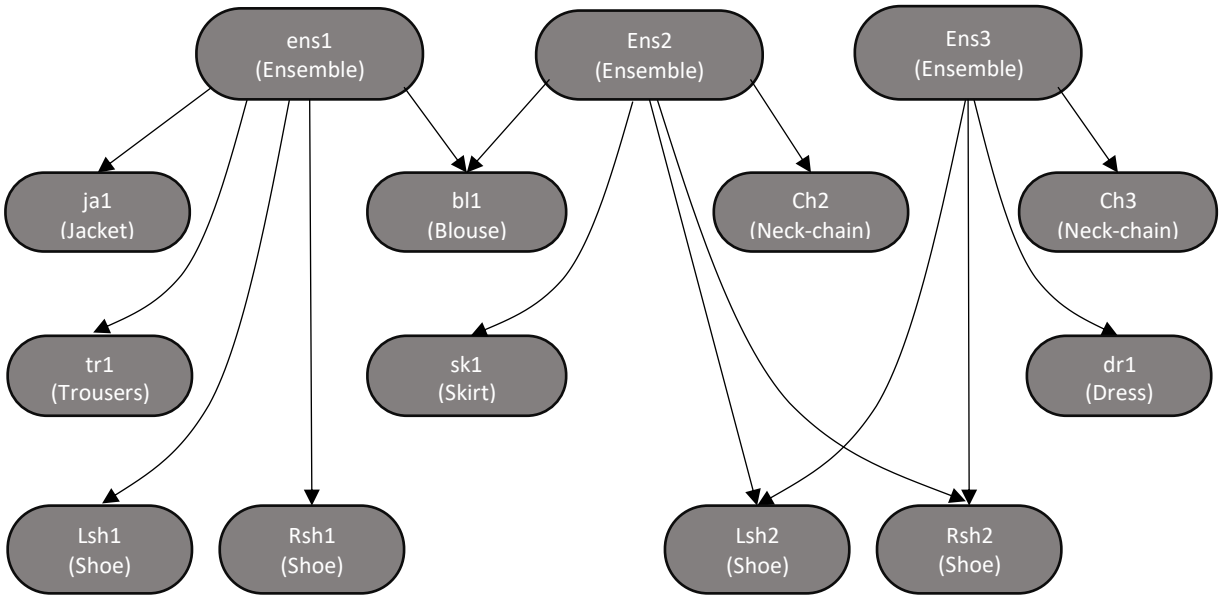

Figure 6. Complete instances of Ensemble

Slide 13_Explanation

This means that only one valence to an object of type Dress is allowed. Valences to objects of different types are described using the ***and*** operator. The expression

Dress ***and*** Jacket ***and*** Shoe

allows for one valence to a Dress, a Jacket, and a Shoe object, respectively. However, in real life one would like to wear two shoes; this can be overcome by specifying

Dress ***and*** Jacket ***and*** Shoe ***and*** Shoe

or, abbreviated by a cardinality specification,

Dress ***and*** Jacket ***and*** 2 Shoes

Let's assume there is an alternative set of women's outer wear consisting of a blouse and skirt or trousers instead of a single dress. Such alternatives can be specified using the ***xor*** operator:

Dress ***xor*** (Blouse ***and*** (Skirt ***xor*** Trousers))

It may be required to distinguish explicitly between a right and a left shoe. This is accomplished by roles

Shoe ***as*** Right ***and*** Shoe ***as*** Left

associates the role names Right and Left, respectively, with each valence to a Shoe object.

Slide 14_

By combining all features introduced so far, a complete definition of an Ensemble's components can be given:

(Dress ***xor*** (Blouse ***and*** (Skirt ***xor*** Trousers)))

and 0..1 Jacket

and 0..* Necklace

and 0..* (2 Stocking)

and Shoe ***as*** Right **and** Shoe ***as*** Left

In the classical ERM, a relationship may exist only if all references prescribed in the type definition are present. Contrary to this, the valence concept allows to establish a piecemeal relationship.

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5.5. Database development

Responsible	University of Nis (UNI)
Teacher	Bata Vasic,
Duration (min)	8 min
Slides	13
Version	draft

Slide 1_Organising attributes and entities

Every academic discipline or field creates ontologies to limit complexity and organize data into information and knowledge. Each discipline uses ontological assumptions to frame explicit theories, research and applications. New ontologies may improve problem solving within that domain.

In computer science and information science, an ontology encompasses a representation, formal naming, and definition of the categories, properties, and relations between the concepts, data, and entities that substantiate one, many, or all domains of discourse. Roughly speaking, an ontology is a way of showing the properties of a subject area and how they are related, by defining a set of concepts and categories that represent the subject.

Slide 2_Ontology components

Contemporary ontologies share many structural similarities, regardless of the language in which they are expressed. Most ontologies describe individuals (instances), classes (concepts), attributes and relations. In this section each of these components is discussed in turn.

Common components of ontologies include [1]:

- Individuals
- Instances or objects (the basic or "ground level" objects)
- Classes
- Sets, collections, concepts, classes in programming, types of objects or kinds of things
- Attributes
- Aspects, properties, features, characteristics or parameters that objects (and classes) can have
- Relations
- Ways in which classes and individuals can be related to one another

- Function terms
- Complex structures formed from certain relations that can be used in place of an individual term in a statement
- Restrictions
- Formally stated descriptions of what must be true in order for some assertion to be accepted as input
- Rules
- Statements in the form of an if-then (antecedent-consequent) sentence that describe the logical inferences that can be drawn from an assertion in a particular form
- Axioms
- Assertions (including rules) in a logical form that together comprise the overall theory that the ontology describes in its domain of application. This definition differs from that of "axioms" in generative grammar and formal logic. In those disciplines, axioms include only statements asserted as a priori knowledge. As used here, "axioms" also include the theory derived from axiomatic statements
- Events
- The changing of attributes or relations

The concept of the ontology definition is in strict correlation to the data analysing and management. Consequently, all its components in combination with the knowledge of the database design are unavoidable in the process of data structure definition.

Slide 3_Database development process

In general terms, there are three phases to the overall database development process [2]:

- Logical design: The first phase involves determining and defining tables and their fields, establishing primary and foreign keys, establishing table relationships, and determining and establishing the various levels of data integrity.
- Physical implementation: The second phase entails creating the tables, establishing key fields and table relationships, and using the proper tools to implement the various levels of data integrity.
- Application development: The third phase involves creating an application that allows group of users to interact with the data stored in the database. The application development phase itself can be divided into separate processes, such as determining end-user tasks and their appropriate sequences, determining information requirements for report output, and creating a menu system for navigating the application.

Slide 4_Logically structuring data

Firstly, we should determine the purpose of the database. In this phase of the database design, we will define relationships and dependencies amongst the various pieces of information. Then it is possible to arrange the data into a logical structure which can then be mapped into the storage objects supported by the database management system. In the case of relational databases, the storage objects are tables which store data in rows and columns. In an Object database the storage objects correspond directly to the objects used by the Object-oriented programming language used to write the applications that will manage and access the data. The relationships may be defined as attributes of the object classes involved or as methods that operate on the object classes.

The generally performed mapping implies that each set of related data that depends upon a single object (real or abstract), is placed in a table. Relationships between these dependent objects is then stored as links between the various objects.

In this phase we will use knowledge from previous lessons and determine the structure of entities and relations. More precisely, we will exploit the one of ER/EER model, or any extended variant that is described in the previous lesson. The chosen model should be appropriate to the museology field and it have to solve all issues and obstacles on this way.

Slide 5_ Retrieving Data

As a result of the process of logically structuring data, we will obtain the Logical Data Model (LDM) in the form of diagram and tables that determine all entities and relationships within our database. The data model constructs must ultimately be integrated into a single global schema and then transformed into normalized tables.
We can retrieve data in a relational database by using Structured Query Language (SQL). SQL is the standard language used to create, modify, maintain, and query relational databases. The three components of a basic SQL query are the **SELECT…FROM** statement, the **WHERE** clause, and the **ORDER BY** clause. We use the **SELECT** clause to indicate the fields we want to use in the query and the **FROM** clause to indicate the table(s) to which the fields belong. We can filter the records the query returns by imposing criteria against one or more fields with the **WHERE** clause, and then sort the results in ascending or descending order with the **ORDER BY** clause.

Slide 6_Entity-atribute table

Tables are the first structures you define in the database. You determine the various subjects that the tables will represent from the objectives you wrote during the first phase of the design process and the data requirements you gathered during the second phase. According to the example showed in previous lessons (Figure 4), we can form the table with some entities and descriptions.

Table 1. An example of the simple entity-attribute table construction

ID	Artefact	Type	Material	Artist	Period	Museum	City	Country
100	Mona Lisa	painting	oil	Leonardo da Vinci	1503	Louvre Museum	Paris	France
101	Venus de Milo	sculpture	stone	Alexandros of Antioch	130BCE	Louvre Museum	Paris	France
102	David	sculpture	stone	Michelangelo Buonarroti	1504	Accademia Gallery	Florence	Italy
103	The Starry Night	painting	oil	Vincent van Gogh	1889	Museum of Modern Art	New York City	USA
104	The Scream	painting	oil	Edvard Munch	1893	National Museum	Oslo	Norway
105	Guernica	painting	oil	Pablo Picasso	1937	Museo Reina Sofía	Madrid	Spain
106	Las Meninas	painting	oil	Diego Velázquez	1656	Museo del Prado	Madrid	Spain
107	The Last Supper	painting	fresco	Leonardo da Vinci	1495	Santa Maria delle Grazie	Milan	Italy

The final step in this phase is to establish field specifications for each field in the database. Here you conduct interviews with users and management to help you identify the specific field characteristics that are important to them and review and discuss any characteristics they may be unfamiliar with.

Slide 7_ Reviewing Data Integrity

Firstly, we want to make sure that the established data integrity is absolutely as sound as possible. As we well know, a crack in the integrity could result in inconsistent data or inaccurate information. However improbable, it is possible that we may have overlooked something.

In order to ensure that we have properly established table-level integrity, we should review each table and make sure that the table conforms to all of the following points.

- There are no duplicate fields in the table.
- There are no calculated fields in the table.
- There are no multivalued fields in the table.
- There are no multipart fields in the table.
- There are no duplicate records in the table.
- Every record in the table is identified by a primary key value.
- Each primary key conforms to the Elements of a Primary Key.

Slide 8_ Relationship-Level Integrity

Now, we have to examine each table relationship to ensure that we have properly established relationship-level integrity. We have achieved this level of integrity when we have completed these tasks:

- Properly established the relationship
- Defined the appropriate deletion rules
- Correctly identified the type of participation for each table
- Established the proper degree of participation for each table

Slide 9_Keys

Keys are crucial to a table structure for the following reasons [3].

- They ensure that each record in a table is precisely identified. As we already know, a table represents a singular collection of similar objects or events. The complete set of records within the table constitutes the collection, and each record represents a unique instance of the table's subject within that collection. We must have some means to accurately identify each instance, and a key is the device that allows we to do so.
- They help establish and enforce various types of integrity. Keys are a major component of table-level integrity and relationship-level integrity. For instance, they enable you to ensure that a table has unique records and that the fields we use to establish a relationship between a pair of tables always contain matching values.
- They serve to establish table relationships. Also, we will use keys to establish a relationship between a pair of tables. Always make sure that we define the appropriate keys for each table. Doing so will help us guarantee that the table structures are sound, that redundant data within each table is minimal, and that the relationships between tables are solid.

Slide 10_Candidate keys

The first type of key we establish for a table is the candidate key, which is a field or set of fields that uniquely identifies a single instance of the table's subject. Each table must have at least one candidate key. Elements of a Candidate Key:

- It cannot be a multipart field. We have seen the problems with multipart fields, so we know that using one as an identifier is a bad idea.
- It must contain unique values. This element helps us guard against duplicating a given record within the table. Duplicate records are just as bad as duplicate fields, and we must avoid them at all costs.
- It cannot contain null values. As you already know, a null value represents the absence of a value. There's absolutely no way a candidate key field can identify a given record if its value is null.
- Its value cannot cause a breach of the organization's security or privacy rules. Values such as passwords and Social Security numbers are not suitable for use as a candidate key.
- Its value is not optional in whole or in part. A value that is optional implies that it may be null at some point. You can infer, then, that an optional value automatically violates the previous element and is, therefore, unacceptable.
- It comprises a minimum number of fields necessary to define uniqueness. We can use a combination of fields (treated as a single unit) to serve as a candidate key, so long as each field contributes to defining a unique value.
- Its values must uniquely and exclusively identify each record in the table. This element helps us guard against duplicate records and ensures that we can accurately reference any of the table's records from other tables in the database.
- Its value must exclusively identify the value of each field within a given record. This element ensures that the table's candidate keys provide the only means of identifying each field value within the record.
- Its value can be modified only in rare or extreme cases. We should never change the value of a candidate key unless you have an absolute and compelling reason to do so.

Slide 11_Primary keys

By now, we have established all the candidate keys that seem appropriate for every table. Our next task is to establish a primary key for each table, which is the most important key of all.

- A primary key field exclusively identifies the table throughout the database structure and helps establish relationships with other tables.
- A primary key value uniquely identifies a given record within a table and exclusively represents that record throughout the entire database. It also helps to guard against duplicate records.

A primary key must conform to the exact same elements as a candidate key. This requirement is easy to fulfill because we select a primary key from a table's pool of available candidate keys. The process of selecting a primary key is somewhat similar to that of a presidential election [4]. Every four years, several people run for the office of President of the United States. These individuals are known as "candidates" and they have all of the qualifications required to become president. A national election is held, and a single individual from the pool of available presidential candidates is elected to serve as the country's official president. Similarly, we identify each qualified candidate key in the table, run your own election, and select one of them to become the official primary key of the table.

Slide 12_ Rules for Establishing a Primary Key

1. Each table must have one—and only one—primary key. As the primary key must conform to each of the elements that govern it, only one primary key is necessary for a particular table.
2. Each primary key within the database must be unique—no two tables should have the same primary key unless one of them is a subset table. We learned at the beginning of this section that the primary key exclusively identifies a table throughout the database structure; therefore, each table must have its own unique primary key in order to avoid any possible confusion or ambiguity concerning the table's identity. A subset table is excluded from this rule because it represents a more specific version of a particular data table's subject—both tables must share the same primary key.

Slide 13_Summary

The lesson opened with a discussion of the importance of organizing attributes and entities, where we introduced ontology components in order to organize information and their relationship. Next, we define the framework of the database development process. In three steps we described the base of the database design. According to previous lesson we learned how we organize logically structured data and their retrieving using SQL. We also learned to establish the entity-attribute table and reviewing data integrity inside the table. Next, we described the importance of keys. We have learned that there are different types of keys, and each type plays a different role within the database. Each key performs a particular function, such as uniquely identifying records, establishing various types of integrity, and establishing relationships between tables.

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5.6. Information Management methodologies

Responsible	University of Nis (UNI)
Teacher	Olivera Nikolic, Bata Vasic
Duration (min)	8 min
Slides	12
Version	draft

Slide 1_Who is it for?

Operational managers (DigCurV Manager Lens), Senior administrators (DigCurV Executive Lens), and staff (DigCurV Practitioner Lens) within repositories, funding agencies, creators and publishers, anyone requiring an introduction to the subject [1]. This lesson is written with the following objectives:

- To provide a strategic overview and senior management briefing, outlining the broad issues and the rationale for funding to be allocated to the tasks involved in preserving digital resources.
- To provide a synthesis of current thinking on digital preservation issues.
- To distinguish between the major categories of issues.
- To help clarify how various issues will impact on decisions at various stages of the life-cycle of digital materials.
- To provide a focus for further debate and discussion within organisations and with external audiences.

Slide 2_The challenge of a generation

Any digital object can be considered in scope for digital preservation: born digital or digitised, corporate or personal, innovative or routine. Digital preservation can encompass texts and images, databases and spread-sheets, vectors or rasters, programs and applications, desktop files and enterprise systems, email and social media, games, movies, music and sound, entire web domains and individual tweets. Digital collections can derive from laptops or desktops or smart phones; from tablets, souped-up servers or hulking great mainframes. They can be snapped at the end of a selfie stick or beamed from sensors deep in space; they can be generated by tills and cash machines, by satellites and scanners, by tiny sensitive chips and massive arrays. They can be stored in repositories or data centres or USB sticks. There is no digital object or system that is not provisionally within scope for digital preservation.

Pervasive, changing and ubiquitous, digital technologies are a defining feature of our age. Digital materials are a core commodity for industry, commerce and government. They are fundamental for research, the law and medicine. The creative industries, cultural heritage and the media depend on reliable access to digital materials while families and friends extend and sustain their relationships through digital interactions.

But digital materials - and the opportunities they create - are fragile even if they also have the capacity to be durable through replication. Digital platforms change and the long chains of interdependence on which they depend are complicated and fluid. Their longevity and utility are threatened where contents or contexts are lost: engagement and exploitation are enabled when digital materials endure. The greater the importance of digital materials, the greater the need for their preservation: digital preservation protects investment, captures potential and transmits opportunities to future generations and our own.

Slide 3_ Who needs to be involved?

The nature of digital technology dictates that it is not feasible to simply hand over stewardship of the resource at some point in the future, without having managed it sufficiently to facilitate sustainability.

In some cases, institutions will manage their own digital legacy: large institutions that create digital materials may most sensibly be the ones to manage them in the long term, thus maximising return on their initial investment. But in other contexts, co-operative models for long-term preservation have emerged involving a number of organisations. Both subject specialist and expert centres have emerged offering specific preservation solutions for specific types of digital material.

For some organisations, it may prove more cost-effective to contract all or part of their digital preservation activities to a third party. Whilst it may be advantageous to outsource, it is important to remember responsibility remains with the organisation. Staff will need to be sufficiently aware of digital preservation issues, particularly as they relate to legal, organisational and contractual problems, to manage these third-party contracts effectively.

Any institution which places value on digital resources in general needs to ensure the long-term preservation of digital materials. A significant number of institutions have not only taken that role on for themselves but have offered wider leadership in addressing the practical implications of digital preservation.

Slide 4_ Preservation issues

Digital preservation can often seem daunting at first. It is important to realize than those with existing skills in either information management or information technology within organizations are well placed to build on and apply these skills to digital preservation activities. However, it may require initially learning some new unfamiliar terminology, extending skill sets, and sometimes working in new ways.

Some of the threats to digital materials that we have to consider are:

- Keeping the data
- Keeping the meaning of the data
- Maintaining trust in the data
- Keeping the context of the data and its dependencies
- Acting in a timely manner

- Coping with the data deluge

Slide 5_Organisational issues

While technological issues can be challenging, there are also numerous challenges which relate to organizational issues. These include how digital preservation is organized and delivered, or how those responsibilities change over both time and the lifecycle of digital materials. There are common digital preservation challenges faced across organizations, yet every organizational context will be different. It is vital to ascertain organizational drivers and tailor practical solutions to meet these needs. There is no one size which fits all approaches for digital preservation.

The creation, preservation and access for digital materials are widely distributed. As a result, there is an increasing need to go beyond the confines of individual organizations, or even countries, to maximize the benefits of the technology, address common issues, and to overcome the challenges cost-effectively.

Some of organizational challenges:

- In-house or outsource?
- Collaboration
- Organizational change
- Organizational structures
- Roles and responsibilities
- Selection
- Balancing security and access
- Legal compliance

Slide 6_Resourcing issues

Some of most important resourcing issues:

- Budgets and costs
- Staffing and skills
- Facilities

Budgets and costs

The cost of digital preservation cannot be easily isolated from other organizational expenses, nor should it be. Digital preservation is essentially about preserving access over time and therefore the costs for all parts of the digital life cycle are relevant. In that context even the costs of creating digital materials are integral in so far as they may need to include cost elements which will ultimately facilitate their long-term preservation.

The ability to employ and develop staff with appropriate skills is made more difficult by the speed of technological change and the range of skills needed. It is also limited by resource constraints on organizations which may well need to manage growing traditional collections and digital collections without additional resources.

Slide 7_ Staffing and skills

Digital preservation involves a range of skills and organizational roles. Typically, digital preservation draws on a range of skills which are not normally found in combination. That means larger organizations will likely need to assemble multi-disciplinary teams while in smaller organizations it will be necessary to rely on a distributed team or sources of support. There are three main issues to consider with respect to staffing and skills:

- Firstly, although there have been considerable improvements in recent years, digital preservation teaching often lags behind current best practice or is wholly theoretical within relevant information management programs for new entrants into the profession. So, individuals with practical skills and experience are in high demand and staff can be hard to recruit.
- Secondly, job descriptions can be hard to script, especially when agencies are effectively starting from scratch with a new role. To this end a number of research projects have attempted to describe generic skills needed for digital preservation, using as a basis the assumption that different skills are required at different levels of an organization. Tools like the DigCurv Skills framework allied to the Digital Preservation Coalition's Vacancies section can be very useful when describing new roles.
- Finally, staff working in digital preservation frequently report the need to engage in active career development. Given the expectation that technology and the needs of users develop through time, the staff will need to find ways to have their skills constantly refreshed, such as through specialist briefings and professional.

Slide 8_Facilities

- Storage
- Digital repository systems
- High performance computing
- Digital preservation laboratory

With the typical requirement of replicating preserved data to avoid loss, storage hardware remains amongst the most important digital preservation facilities. Storage technology has changed rapidly over recent decades. Archives widely used media such as CDs or DVDs for long term storage, but the rapid developments in magnetic media have brought fast and reliable storage that has made handheld media redundant. Enterprise storage systems now provide large storage volumes at reasonable cost. While they have finite lifespans, typically of around 4-8 years, they are easy to monitor and then replace when they reach end of life.

Organizations may also wish to consider cloud services to "rent" preservation infrastructure. The flexibility of the cloud allows relatively rapid and low-cost testing and piloting. Cloud services can provide easy, automated replication to multiple locations and access to professionally managed digital storage and integrity checking. Repositories can add access to dedicated tools, procedures, workflow and service agreements, providing a digital repository system tailored for digital preservation requirements via specialist vendors.

Slide 9_ Decision tree

Clearly defined selection policies will enable cost savings in terms of time taken to establish the choice whether or not to select, and also potential costs further down the track of needing to re-assess digital resources which are either no longer accessible or danger of becoming inaccessible.

This Decision Tree may be used as a tool to construct or test such a policy for your organization. The decision process represented in the tree should be addressed by your policy for selection of digital materials for the long-term. Assuming a digital resource is being considered for selection, the questions and choices reflected here will assist the ultimate decision to accept or reject long-term preservation responsibility. The flow of the questions represents a logical order of evaluation. If the response to early questions is not favorable there is little point in accepting preservation responsibility for the resource or continuing its evaluation, for example if the content does not meet your collection policy, then the response to questions on the technical format will be irrelevant. The structure of the tree aims to reflect this process. When a policy is in place, to be effective it must also be:

- Endorsed by senior management
- Actively promulgated throughout the organization
- Reviewed at regular intervals
- Allocated appropriate resource commitment

Slide 10_ Preservation planning

Preservation planning is the function within a digital repository for monitoring changes that may impact on the sustainability of, or access to, the digital material that the repository holds. It should be proactive: both current and forward-looking in terms of acquisitions and trends. Changes might occur within the repository, within the organization in which the repository resides, or external to the repository and organization themselves. Changes might be monitored in the following areas:

- Technology watch
    - packaging
    - storage
    - formats
    - tools
    - environment
    - access mechanisms
- Designated communities
    - needs and expectations of users
    - needs and expectations of producers
    - emerging tools for machine-to-machine access
    - formal feedback from users and producers

The concept of preservation planning is defined within the functional model of the OAIS [2] standard (CCSDS, 2012). This section focuses primarily on the Monitoring components within the OAIS definition. The 'Monitor Technology' and 'Monitor Designated Community' functions of OAIS provide surveys that inform preservation planning activities.

Slide 11_ Metadata and documentation

This lesson provides a brief overview of metadata and documentation, with a focus on the PREMIS digital preservation metadata standard [3]. It draws on the 2nd edition of the DPC Technology Watch Report on Preservation Metadata. The report itself discusses a wider range of issues and practice in greater depth with extensive further reading and advice (Gartner and Lavoie, 2013) [4].

PREMIS (PREservation Metadata: Implementation Strategies) is the international standard for metadata to support the preservation of digital objects and ensure their long-term usability. Developed by an international team, PREMIS is implemented in digital preservation projects around the world, and support for PREMIS is incorporated into a number of commercial and open-source digital preservation tools and systems. The PREMIS Data Dictionary (PREMIS, 2013) is organized around a data model consisting of five entities associated with the digital preservation process:

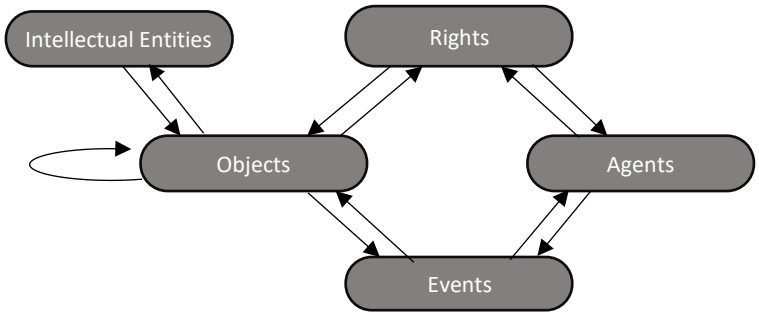

Figure 1. PREMIS – Digital preservation process

- Intellectual Entity - a coherent set of content that is described as a unit: e.g., a book
- Object - a discrete unit of information in digital form, e.g., a PDF file
- Event - a preservation action, e.g., ingest of the PDF file into the repository
- Agent - a person, organization, or software program associated with an Event, e.g., the publisher of a PDF file
- Rights - one or more permissions pertaining to an Object, e.g., permission to make copies of the PDF file for preservation purposes

Slide 12_ Risk and change management

Digital preservation is not simply about risks. It also creates opportunities and by protecting digital materials it means that new or extended values can be derived from them. It can be easy to become overwhelmed with risks, so it is worth being explicit early in the process about what opportunities are being protected or created. There are many things that put your digital resources at risk including changes to your organization or technology. If not managed, these risks will have a significant impact on your ability to carry out your digital preservation activities, wider business functions, or comply with legislation.

To manage digital preservation, you must understand your organization's specific issues and risks. You can do this by undertaking a risk and opportunities assessment. The assessment will highlight specific risks to the continuity of your digital resources, and opportunities that can be realized from mitigating these risks. Experience shows that the risks facing digital resources are subtle and varied. They include, but are not limited to the following:

- Merger, closure, or transfer of functions between organizations.
- Changes in strategic direction or funding and the functions supported by an organization.
- Major changes in individual leaders or experts.
- Outsourcing with no consideration of future preservation needs.
- File format obsolescence meaning that it is expensive or impossible to process data.
- Media obsolescence making it expensive or impossible to recover data.
- Media degradation meaning that data is damaged or changed.
- Loss of contextual information resulting in loss of meaning.
- Breakdown of resource discovery data resulting in difficulty retrieving data.
- Loss of copyright or other legal information resulting in uncertainty over rights and obligations.
- Loss of provenance information or fixity about a document resulting in loss of authenticity.
- Breakdown of the document version control that makes it hard to identify authoritative instances.
- Human error leading to accidental deletion.
- The degree of use. A dark archive is more at risk than one than is heavily used. If digital material is accessed infrequently the impact of failure is less immediately apparent.
- Natural Disasters affecting buildings or infrastructure.

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[3] PREMIS, 2013. Data Dictionary for Preservation Metadata, Version 3.0. Available: http://www.loc.gov/standards/premis/v3/index.html

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Responsible	University of Nis (UNI)
Teacher	Olivera Nikolic, Bata Vasic
Duration (min)	8 min
Slides	12
Version	draft

Slide 1_Who is it for?

This lesson is intended for operational managers (DigCurV Manager Lens) and staff (DigCurV Practitioner Lens) in repositories, publishers and other data creators, as well as third party service providers with the following aims [1]:

- To focus on technical tools and applications that support digital preservation: software, applications, programs and technical services.
- To consider the practical application of preservation techniques and technologies, whether they are relatively small and discrete programs (like DROID) or enterprise-wide solutions that integrate many tools.

This lesson excludes other strategic or policy issues and standards that are sometimes described as tools.

Slide 2_About digital preservation tools

The utility of technical tools for digital preservation depends on the context of their deployment. A community recommendation may be strict, but if it does not align with your specific function or organisational context there is a significant chance that the tool will fail to perform. So before selecting digital preservation tools it is important to consider carefully the technical workflow and institutional setting in which they are embedded. A practical example of this has been presented by Northumberland Estates who developed a straightforward evaluation framework to assess tools in specific contexts.

An alternative way to consider this topic is to review the extent to which any given tool will deliver preservation actions arising from an agreed preservation plan, which in turn derives from a given policy framework.

The following issues are frequently encountered in the process of deploying digital preservation tools. This is not a comprehensive list but consideration of these issues will help sensible and realistic choices.

- Open source versus commercial software

- Enterprise-level solutions versus micro-services
- Describing workflows
- Specifying clear requirements
- Changing and evolving requirements
- Sustainability of tools and community participation

Slide 3_Open source versus commercial software

Some organizations - often in higher education and especially institutional research repositories - are comfortable with the use of open-source software, especially where they have an in-house group of developers. 'Open source' software is where the underlying code is made available for free, enabling a free flow of additions, amendments or development. Other organizations which don't have easy access to developers, tend to have procurement rules that prefer 'off-the shelf' commercial solutions backed by on-going support contracts. The distinction between Open Source versus Commercial software is often over-stated because both influence each other. Nonetheless you may need to consider your organization's norms and culture while you select tools.

Slide 4_Enterprise-level solutions versus micro-services

Some digital preservation tools are designed to offer 'soup to nuts' solutions, meaning that they provide an integrated end-to-end process that enables all (or most) digital preservation functions to be delivered for a whole organisation. In fact, enterprise-level solutions are most often constructed by aggregating individual tools into a single interface. The solution to any given problem might be relatively simple and your organisation may be happy assembling a series of small tools for discrete functions. This encourages rapid progress and is helpful with testing and trialling tools; but it can be hard to maintain over an extended period. In other organisations there is much tighter control over the deployment of software and an expectation that solutions are built across an entire workflow - requiring comprehensive solutions. This can be slower to respond but can be more sustainable in the long term. Before selecting a tool, it is helpful to consider where on this spectrum your organization normally placed.

Slide 5_Describing workflows and specifying clear requirements

A key consideration for tools is their function within overall workflows, so before selecting tools it may be helpful to consider and map out the entire workflow. Being explicit about a workflow can also help identify redundant processes as well major bottlenecks. One frequent challenge is that tools solve a problem in one element of a workflow, only to create a problem elsewhere. In addition, organisations may have multiple workflows, which may have different requirements that are in conflict. Describing a workflow therefore provides a basis for anticipating difficulties and can provide a roadmap for on-going development.

In order to evaluate the usefulness and value to your organisation of the many tools available, having/defining an explicit statement of requirements could help. Tools can be compared and benchmarked transparently and decisions justified accordingly. Properly executed, requirements-gathering activities can involve a range of stakeholders and therefore maximise the potential for alignment and efficiency, achieving wider strategic and organisational objectives.

It is normal for requirements to change through time. Indeed, digital preservation is largely concerned with meeting the challenges associated with inevitable changes in technology. So, it is necessary to monitor and

review tools to ensure that they remain suitable for the purpose and that any changes in requirements are made explicit. A periodic review of the specific requirements is recommended.

Slide 6_ Sustainability of tools and community participation

An important consideration in any decision over the tools you use for digital preservation is the sustainability element. Sustainability in terms of tools may include an active user base, support, and development. For instance, a large user base, both in terms of commercial and open-source providers can be a vital indicator for identifying a viable tool. It is worth noting that a community can change rapidly and for reasons that might not be easily predicted. 'New kids on the block' can quickly become mainstream while large communities can dwindle as quickly as new technologies overtake existing ones. Consequently, it may be necessary to monitor the health of the developer community supporting your tools.

Slide 7_ Sustainability of tools

One of the welcome features of digital preservation in the last two decades has been the rapid development of software, tools and services that enhance and enable digital preservation workflows. As the digital preservation community has grown in size and sophistication so our tools have become more powerful and more refined. This proliferation and increased specialism can also act as a barrier to deployment: especially when tools have been the product of relatively short-lived research projects with limited reach. Consequently, the diversity of tools can seem increasingly bewildering to new users, while the route to market for developers is increasingly complicated.

Tools registries have emerged in recent years as a way to help users find tools that they need. A number of registries now exist that describe digital preservation tools. Depending on the interests of the people behind them, they can also provide detailed descriptions, reviews or comments about tools from the wider community. So, they are not just helpful for users: by allowing experts to review tools and assess their performance, they signpost strengths and weaknesses and provide a basis for future development; by connecting tools to users, they help developers reach a much wider audience and get feedback to improve their tools.

Registries are a common way for the digital preservation community to share information. Other types of registries exist such as 'format registries' that outline the performance of given file formats, or 'environment registries' that describe the technology stack necessary to create an execution environment to emulate or virtualize software.

Slide 8_Practical support and guidance

Having considered some of the tools, registries and digital preservation tools that are available to organisations, another question that often arises is what to choose depending on the needs of your organisation. First and foremost, it is important that your selection is aligned to organisational need and strategic direction; the resources and case studies below provide evaluation tools and advice to support successful implementation.

- Community Owned digital Preservation Tool Registry COPTR (http://coptr.digipres.org/Main_Page)
- AV Preserve tools list (https://www.weareavp.com/products/)
- Digital Curation Centre (DCC) tools and services list (http://www.dcc.ac.uk/resources/external/tools-services)

- DCH-RP registry (https://www.dchrp.eu/index.php?en/137/registry-of-services-tools)
- Inventory of FLOSS (Free/libre open-source software) in the cultural heritage domain (https://docs.google.com/spreadsheets/d/1bOoQiXFjGyR3oEubdLdkfCat7V4TsNLnEXGOJWkJ63c/edit#gid=516255520&vpid=D2)

Slide 9_Few words about mentioned tools

COPTR describes useful tools for long term digital preservation and acts primarily as an evaluation tool to help practitioners find what they need to preserve digital data. COPTR aims to collate the knowledge of the digital preservation community on preservation tools in one place. It was initially populated with data from registries run by the COPTR partner organisations, including those maintained by the Digital Curation Centre, the Digital Curation Exchange, National Digital Stewardship Alliance, the Open Preservation Foundation, Preserving digital Objects With Restricted Resources project (POWRR) http://digitalpowrr.niu.edu/.

COPTR captures basic, factual details about a tool, what it does, how to find more information (relevant URLs) and references to user experiences with the tool. The scope is a broad interpretation of the term "digital preservation". In other words, if a tool is useful in performing a digital preservation function such as those described in the OAIS model or the DCC lifecycle model, then it's within scope of this registry.

The DCC is a centre of excellence to support researchers tackling challenges for the preservation and curation of digital resources. To achieve this goal, it offers a number of support and advisory services supported with targeted research and development. The former includes a catalogue of tools and services which categorises tools for researchers and curators.

The Digital Cultural Heritage Roadmap for Preservation (DCH-RP) tools registry collected and described information and knowledge related to tools, technologies and systems that can be applied for the purposes of digital cultural heritage preservation.

Produced by the EU funded Europeana Project, FLOSS inventory lists free open-source software which may be used in the cultural heritage sector. While not limited to digital preservation tools, the inventory does contain information on a variety of tools with digital preservation applications, assessing their purpose, quality of documentation, level of support, license requirements and providing links to project information and source code.

Slide 10_Planning: Fixity and checksums

Fixity

“Fixity, in the preservation sense, means the assurance that a digital file has remained unchanged, i.e., fixed.” (Bailey, 2014). Fixity doesn’t just apply to files, but to any digital object that has a series of bits inside it where that ‘bitstream’ needs to be kept intact with the knowledge that it hasn’t changed. Fixity could be applied to images or videos inside an audio-visual object, to individual files within a zip, to metadata inside an XML structure, to records in a database, or to objects in an object store. However, files are currently the most common way of storing digital materials and fixity of files can established and monitored through the use of checksums.

Checksums

A checksum on a file is a 'digital fingerprint' whereby even the smallest change to the file will cause the checksum to change completely. Checksums are typically created using cryptographic techniques and can be generated using a range of readily available and open-source tools. It is important to note that whilst checksums can be used to detect if the contents of a file have changed, they do not tell you where in the file that the change has occurred.

Checksums have three main functions:

1. To show that a file has been correctly received from a content owner or source and then transferred successfully to preservation storage
2. show that file fixity has been maintained when that file is being stored.
3. To make the users know that the file has been correctly retrieved from storage and delivered to them.

This allows a 'chain of custody' to be established between those who produce or supply the digital materials, those responsible for its on-going storage, and those who need to use the digital material that has been stored. In the OAIS reference model (ISO, 2012) [2] these are the producers, the OAIS itself is the repository, and the consumers.

Slide 11_More about checksums

Checksums are ideal for detecting if unwanted changes to digital materials occurred. However, sometimes the digital materials will be changed deliberately, for example if a file format is migrated. This causes the checksum to change. This requires new checksums to be established after the migration which become the way of checking data integrity of the new file going forward.

Checksums can be stored in a variety of ways, for example within a PREMIS record, in a database, or within a 'manifest' that accompanies the files in a storage system.

There are several different checksum algorithms, e.g., MD5 and SHA-256 that can be used to generate checksums of increasing strength. The 'stronger' the algorithm the harder it is to deliberately change a file in a way that goes undetected. This can be important for applications where there is a need to demonstrate resistance to malicious corruption or alteration of digital materials, for example where evidential weight and legal admissibility is important. However, if checksums are being used to detect accidental loss or damage to files, for example due to a storage failure, then MD5 is sufficient and has the advantage of being well supported in tools and is quick to calculate.

List of useful software with links is given below:

- **AVPreserve Fixity Tool** (http://www.avpreserve.com/tools/fixity/)
- **MD5** (https://tools.ietf.org/html/rfc1321)
- **SHA-1** (http://csrc.nist.gov/publications/fips/fips180-4/fips-180-4.pdf)
- **SHA-256** (https://csrc.nist.gov/csrc/media/projects/cryptographic-standards-and-guidelines/documents/examples/sha256.pdf)
- **Md5deep** and **Hashdeep** (http://coptr.digipres.org/Md5deep_and_hashdeep)
- **md5sum** (http://coptr.digipres.org/Md5sum_Unix_command)

Slide 12_The table

We recommend four levels in which digital preservation can be supported through file fixity and data integrity techniques. Many of the benefits of fixity checking can only be achieved if there are multiple copies of the digital materials, for example allowing repair if integrity of one of the copies has been lost.

Table 1. The four levels of Activities and corresponding risks and achievements

Level	Activity	Risks addressed and benefits achieved
1	• Check a file fixity if it has been provided with the content. • Create fixity info if it wasn't provided with the content.	• Corrupted or incorrect digital materials are not knowingly stored. • Authenticity of the digital materials can be asserted. • Baseline fixity established so unwanted data changes have potential to be detected.
2	• Check fixity on all ingests • Use write-blockers when working with original media • Virus-check high risk content.	• No digital material of unconfirmed integrity can enter preservation storage. Evidential weight supported for authenticity. • Assurance can be given to all content providers that their content has been safely received. Original media is protected. • No malicious content can enter preservation storage.
3	• Check fixity of content held on preservation storage systems at regular intervals. • Maintain logs of fixity info and supply audit on demand. • Ability to detect corrupt data. • Virus-check all content.	• Protection from wide range of data corruption and loss events. Problems with storage are detected earlier. • Data corruption or loss does not go undetected due to 'silent errors' or 'undetected failures. Digital materials are not in a state of 'unknown' integrity. • Ongoing evidential weight can be given for the corect digital materials.
4	• Check fixity of all content in response to specific events or activities • Ability to replace/repair corrupted data • Ensure that no one has access to all copies..	• Failure modes that threaten digital materials are proactively countered. All copies of digital materials are actively maintained. • Assurance to users of the integrity and authenticity of digital materials being accessed. • Effectiveness of preservation approach can be measured and demonstrated. • Compliance with standards, e.g., ISO 16363 Audit and certification of trustworthy digital repositories.

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AREA D

DIGITAL ACCESS: UNIVERSAL DESIGN AND VIRTUAL EXPERIENCES

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

MODULE 6

COMMUNICATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

AREA D
MODULE 6: COMMUNICATION OF CH

6.1 Managing of websites

Responsible	Lusófona University
Teacher	Ricardo Geraldes
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

Good morning/afternoon, welcome to this lesson on the topic Managing of websites. Within this sub-module we are going to explore two different sides of the same coin - how museums manage their website and what contents are reasonable to offer. This is a very complex issue, and especially in relation to the pace digitalization is developing and advancing. In the previous lessons you have been introduced to different kinds of technology - Virtual Reality, Augmented Reality and Mixed Reality. These are good examples of how digital development is increasing and offering new opportunities to communicate CH.

Slide 2_Website and museums

These examples are good because they offer great opportunities for museums to communicate, to disseminate and to explore new ways to share their assets and thus provide new ways to people access information. One of the most common means of doing this - disseminating information/knowledge - is to organize, establish and maintain a website.
Simply said, a website is a collection of publicly accessible information - publicly is a keyword, because once a website is online it is generally accessible for everyone - and this is also an intended issue! Pieces of information are posted in different interlinked (web) pages. Mostly they share a single domain name. This is relevant to indicate where this information belongs to.
Website has arisen to a most common and primary source of information. We all do this; through search machines we look for information. We will now look together for some examples of websites of museums.

Slide 3_Introduction to tools

A brief introduction on tools available that support the construction and management of websites. The objective is to is provide an overview on possibilities.
There are different tools to design, develop and make the sites public. Before this discussion, it is important to define some terms to be used:

- World Wide Web - refers to all websites/sites that are publicly accessible
- “Web presence” or simply “site” is the presence in the www
- A "site" consists of several webpages that are interlinked

- Languages HTML, CSS, etc.

Slide 4_First step: sketching and developing a good strategy

Advancements in digital technologies make almost endless the possibilities of web design - new software programmes enable an easy and rapid construction of a web-presence. What-You-See-Is-What-You-Get programmes help to develop a site without technical knowledge.
However, these programmes actually only "translate and carry" the information making it accessible to everyone, everywhere and in the same way. Therefore, before creating a website, there are issues that need to be clarified and shared with all people involved in the project.
This is called sketching - it is the analogue and offline planning and designing of the website, addressing the following question sets:

- The first set of questions is fundamental: What was the purpose or goal of the site? Who is the targeted audience? What is/are the content(s) to be made public?
- The second set of questions refers to the usability of the site: How can the content(s) be transmitted to reach the targeted audience? What is the navigation going to look like? This step is called assembling a sitemap.
- After identifying goal(s) and audience(s), and sitemap, we can think about the design of the site: What is my final design going to look like? This step encompasses the technical solution to be decided, for example defining institutional information, building frames, selecting a colour scheme

Slide 9_ Keeping the contents and communication channels alive

Filling the website with the right content is vital when creating a new site or organising a dissemination campaign. This calls for checking with regular site visits, the website, the contents and the way they are being displayed. Proactive updates ensure that the audience is getting your most current data and customer service messages - the combination of using "formal" communication channels (press releases, newsletters and catalogues), other channels can be used, such as videoconferencing, audio conferencing, text message, instant messaging and posts in social media, and direct channel with visitors - like a live chat.

Slide 5_ Features of a good website

The most What-You-See-Is-What-You-Get programmes provide a good support for creating a website. If we look at different web-presence of museums, can we discover common issues? How is the navigation? How easy can the information be found? For sure these can be individual and unique - but creativity should not hinder - as the defined goals.
To the most appreciated and used features, according to Bartindale et al. (2011), are the search and content manipulation, which facilitate the further use of content, like enabling image saving, printing, re-sizing and other image manipulation features.

Slide 6_ Interactions

ICT advancements enable the use of variegated kinds of software and programmes. Make use of them to keep the targeted audience alive. The possibility to build interactive actions on the website opens a new way of communicating contents - being creative in this way can bring people to several experiences. This encourages costumers to explore your potentialities and services, and on the flip side, this adds value for your assets. New developments allow the use of texts and hypertexts, images, videos, animations, etc. and the use social media channels. This can enrich the experiences the customers have.

Slide 7_ Positioning the website on the internet

Once the website is established, the next step is the so-called web positioning. This means, from a strategic point of view, to make the website known and used - in other words we need to find a way that the site gets noticed online. Usually, there are companies that offer this kind of service - it is action of highlighting and make the website visible. The issue of positioning is a recurring task, every time the site is updated, new exhibition is inaugurated, etc. an information update should be posted. This enables the targeted audience

to stay up-to-date with your latest releases. Positioning also aims at capturing potential traffic and turning customers - into recurrent users. A way to conceive a positioning campaign is to decide which will be your *keywords, hashtags, tags* and *categories* which are some of the most powerful tools one can use to get your content noticed online.

Slide 8_ Evaluating the usability of the website

Monistrol, Rovira, Codinaa, (2006) propose methodology for evaluating the museums' websites. In this proposal, the links have a special importance because they are relatively good and easy to collect indicators. Mostly this methodology checks the popularity of the website. Also, the general methods of evaluation of web sites include some parameter for quantitative data - traffic.

Slide 10_Keeping the information alive and update

The website has become the most important means of communication. Almost all museums, besides offering quality content, have discovered the possibilities of "customer" acquisition and utility of their websites. A website should therefore always be up to date in terms of content, functionality and design.
From time to time the website should be checked - is the information displayed updated, relevant and current? The best is to keep the communication channels alive with regular, proactive updates.

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Videos links

AREA D
MODULE 6: CH COMMUNICATION

6.2 Virtual exhibition

Responsible	Lusófona University
Teacher	NN
Duration (min)	8
Slides	
Version	draft

Slide 1_ Slide 1_Introduction

Good morning/afternoon, welcome to the second session on the use of digital technology to enhance the visitor experience and increase the museum networking, creating engagement and expanding the visitor spectrum. In this session we address the concept of virtual exhibition - "to go to the museum never leaving my home." In this session we will discuss the concepts and terms used in the context of Virtual Exhibitions - the technical issues and possibilities are part of module 7. Our focus today is on a single form of virtual reality, known as a virtual tour - and in the case of a museum - a virtual exhibition.

Slide 2_ Slide 2_Virtual exhibition - opening new doors

Museums have long recognised that digital technology advancements are opening new ways of not only interacting with people, but they also open innovative ways to present and display the museum assets. Virtual exhibition is a web-based application that enables creators to build exhibitions using different technologies - and combining these with each other. These technologies will be discussed in different lectures - our goal in this session is to understand and discuss the strengths and weaknesses that the virtual technology can offer.

Slide 3_ Slide 3_Visiting museums from my couch

Virtual Reality, Augmented Reality and 3-D tours are becoming more and more a way that CH sector is putting in place to increase the accessibility to the assets - and to increase the visitors' experience. We can visit together today and now several museums around the world without leaving our couches. In few seconds we can move from a visit to the Guggenheim Museum in New York, to a virtual tour of the National Tile Museum in Lisbon. From or desktop or mobile devices, we can travel from discovering incredible impressionist works of art in New York to a virtual tour to Lisbon before the 1755 earthquake - to a gone time and place that does not exist anymore.

Another example of using virtual tours is accessing assets that are otherwise not available. For example, the virtual tour of the Tile Museum offers additionally an added value as it shows examples of the use of tiles that are not in the museum, like churches and manor houses, or spaces that are not usually open to visit, such as sacristies in some churches.

Beside these, there other advantages, such as no need to buy tickets, no queuing necessary, enjoying the asset alone.

Slide 4_ Slide 4_Google Arts & Culture collection

One of the most known platforms to start a virtual tour in museums and art galleries around the world is offered by Google Arts & Culture's collection. The added value of the Google platform is to be a central point - so a user can avoid the own search for a cultural asset. But not all museums and galleries are included in Google Arts & Culture's collection, many offer online visits and virtual tours on their own website. Here everyone can find the path to most known museums, such as the British Museum, Uffizi in Florence, Van Gogh Museum in Amsterdam, etc. Other museums also share their virtual tours via social media, such as Facebook or Instagram.
According to Google Arts & Culture, over 2,000 leading museums and archives are partnered with the Google Cultural Institute, offering the largest platform for this kind of collections. Here a user can filter searches using different parameters, such as country, artists, dates, historical events, museums, art movement.

Slide 5_ Slide 5_Virtual tours

Virtual tours allow different options of visiting a museum or an exhibition; visitors can take self-guided, room-by-room tours, or select single exhibits and areas within the museum. Visitors can also access selected collections and stroll through past exhibits that are no longer on display.
Usually, the virtual tours are preceded by an explanation and some tips on how to navigate within the museum rooms and around art works. An interesting feature are zooming possibilities that offer a close-up view of a particular object or exhibit panel. For some objects there are even seamless 360º panoramic views displaying all its facets. Zooming in is another interesting feature that stitching together individual pictures create very high resolution gigapixel images.
As explained in the next Module there are different types of virtual experiences, each one requiring different equipment to build the tour and to appreciate the results, the main types are: Non-immersive, Semi-immersive, and Fully immersive virtual reality. The main features are the increasing grade of interaction and realistic experience within the virtual world.

Slide 6_ The pandemic and virtual tours

Virtual tours, as a quick response to a suddenly still stand in the global tourism industry. Many museums, art galleries were forced to cease any physical activity. Several institutions began conducting live events (virtual tours) in real time. Members of the staff organised and streamed periodically real time tours as a way to stay connected with visitors in hazardous or emergency situations - as the Covid-19 pandemic. To this example, Frank Lloyd Wright Foundation, the Vatican Museums, can be cited as they responded to restrictions by releasing virtual tours and streaming live events. These experiences, emerged in exceptional conditions have been enhanced now, as digital technology has allowed excellent results to a great extent. The advancement of technologies with several new inventions allied to an increasing people's exposure to the basic interaction paradigms – make people feel familiar with technology use, for instance, the use of Street View featured within Google Maps.

Slide 7_ Visit requirements

We will dedicate this session to the "user" side. Usually, such tours have been tested and should work on all common devices, browsers, and operating systems (using a desktop computer with Windows, Mac, Linux or a mobile device such as an iPhone, iPad, or Android), the functionality and appearance may however vary as it will adjust automatically to accommodate the most visitors. Apart from this positive view, other authors find the effort to create and make available to be (too) high, slow, and of limited value (Laubheimer, 2020). According to this author, one negative issue, is that these virtual tours are often not interactive.
As discussed in the previous session (4.1.1), besides the need to develop a museum website, studies suggest the importance of content manipulation features to repeat visits.

Slide 8_ User experiences

For sure, a virtual tour does not compare or is a substitute to being able to experience live - but it allows a visitor to experience a certain location remotely. And from the museum side to share their resources with a broader world.
Visiting the Guggenheim or the Tile Museum from home is not the same as experiencing the atmosphere and enjoying the architecture in loco, but on the flip side, virtual tours can offer an uninhibited, uninterrupted, intimate view of the assets. This can be a unique experience; users enjoy exhibits from famed artists in renowned museums from across the world – all from the comfort of home and get intimate views that an actual site visit does not offer. Being in the Sistine Chapel will not enable a visitor to see so close the in fresco painted ceiling by Michelangelo. This means that a user can discover new knowledge.
Interesting is the fact that many virtual tours pose the question on what the users think of the tour and how the experience can be improved. In the session 4.5 the user experiences in virtual/digital tours and museums will be discussed.

Slide 9_ Slide 8_ Navigation, wayfinding and user friendliness

Laubheimer (2020) also noted a quick dissipation of delight in visiting virtual tours. *While many of the visually impressive elicited a substantial wow factor in study participants, the initial delight quickly subsided*. And this was most prominent on leisure tours, further the author, in art galleries and museums. The research revealed that the excitement tended to be longer when using 360° videos or photos offered substantial narrative (either literal audio voiceovers or written text) reflected at key contextual moments.
Future studies are needed to explore the importance of interactivity and further offer to visitors. Their evaluation will expand research into factors contributing to the return visits to museum websites and decisions to visit physical collections.
Another factor considered essential to increase virtual visits is the easy navigation possibility - an online user should intuitively navigate through the rooms - as she/he would do in physical visits. Therefore, the wayfinding through the museum or exhibition should be easy to "find" and use.

Slide 10_ Are virtual tours mere great spectacle of technicality?

The research done to understand the reaction of users to virtual tours revealed indeed that, for many users, technology is advancing too fast, getting too complex and technically not to be followed. Some authors think as shown in slide 7 that virtual tours need a high effort and mostly satisfy more the producers than the users. This is a question that has to be seriously pondered, as authors claim, there is a call for suppressing misconceptions that virtual tours are competitors or substitutes for actual site visits. In fact, many authors claim that virtual tours should be used to enhance real visits and not replace them.
This calls for putting the experience of the users in the forefront when creating a virtual tour.
Indeed, information tailored to the user - about each site and asset should be included in the tours.

Slide 11_ Virtual tours in the future

Virtual tours are going to be more useful if they are supported with further information - many claim that a voiceover is very useful and easy to be implemented. In addition, virtual tours start directly transporting the user to the tour, whereas they should be combined with an introduction (via video for example) providing background and describing what the visit includes. It seems to be useful to provide a quick introduction with more cognitive observations on the tour and context before starting interactive "travel".
Some authors claim that adding sound (audio) explanations to the virtual tours is more convenient than reading. This means that virtual tours should support different languages. This seems to be relevant for the case of the known museums, as speaking or understanding English is not given everywhere. Another issue that is often commented is the use of too technical language. Historical or archaeological terms may be difficult to understand.

Slide 12_ Virtual tours in the future

The studies of El-Said & Azis (2022) and Laubheimer (2020) used show that consistency and interaction are issues that have to be improved in the future. Consistency refers to developing a virtual tour in a way that provides the targeted audience with a consistent experience, rather than one that varies with each tour guide and tour group. This also refers the wayfinding and navigation through the tour space.
Interactivity in a digital space, means enabling users to engage with the environment in a similar way as if they were there. This issue also encompasses selecting a self-paced timing. So that users are able to visit the different sites at their leisure.
Interactivity is a field where there is in principle still great need for research - on more exact understanding of the status quo, appropriate measures to increase it. In lesson 8.6, the ways to track user experience will be discussed.

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Laubheimer, P. (August 30, 2020). Virtual Tours: High Interaction Cost, Moderate Usefulness. Nielsen Norman Group. https://www.nngroup.com/articles/virtual-tours/

Videos links (Virtual tours)

Museu Nacional do Azulejo (National Tile Museum), Lisbon
https://artsandculture.google.com/story/gAWhceMYFOAfIA

Museu Nacional dos Coches / National Coach Museum, Lisbon
https://my.matterport.com/show/?m=crADZwGeEXF

British Museum, London
https://britishmuseum.withgoogle.com/

Uffizi Gallery, Florence
https://www.uffizi.it/en

Guggenheim Museum, New York
https://artsandculture.google.com/partner/solomon-r-guggenheim-museum

AREA D
MODULE 6: CH COMMUNICATION

6.3 Video Production and Podcasts for museums

Responsible	University of Lusofona
Teacher	Ricardo Geraldes
Duration (min)	8
Slides	9
Version	draft

Slide 1_Introduction

Good morning/afternoon, we welcome you all to this lesson on the topic of **Video Production and Podcast for Museums**. The main focus of this lesson is to provide a context on two specific media – Video and Podcasts, as to give the best technical use in the context of museums. These two techniques, that broaden the museums ecosystem, are fundamental to the way culture heritage can reach new audiences. The constant evolution and proliferation of Informational and Communication Technologies (ICT) have created a variety of new possibilities, concerning the way culture heritage is managed, and also in the way that it is shared with the public. Videos and Podcasts are two privileged ways to help an ever-evolving society regarding culture heritage reception.

Slide 2_ Expanded Museums

In the age of technological apparatus, the museum, as a physical space, is not a one-way place, just waiting to be visited. The experience may however start before entering the building. The portable audio player was one of the first technologies that made museums expanded, in the way art and all historical objects can be perceived. Nowadays, with the proliferation of handheld technologies museums are faced with the challenge to rethink the audience expectations. Nowadays, a visitor can reconfigure his or her own specific needs according to the medium at hand, allowing the visitors to contribute to the museum in several ways: interpretations; interactivity; metrics; and so on. Museums are themselves expanded throughout technologies, but also by the way all visitors participate in meaning making and the creation of contents.

Slide 3_Introduction to video production

A brief introduction on video production, allowing an overview of the possibilities of video production in museums context. What is the right equipment? Why is it important to learn video techniques? And what is the right terminology? These are some of the questions posed when learning about video production. Great ideas do not guarantee great outcomes. And it is not enough to just simply show what is going on in front of the camera. The way you frame and light the subject will influence how your audience responds. It is needed to choose the proper framing (images) and sound, to convey an idea in an interesting and appealing way.

Slide 4_What is Video production?

Producing a video does not imply that you need to have the most expensive equipment. Or the need to hire a professional team. Video techniques that are popular amongst professional videographers have now become available to beginners too. Affordable cameras and software have allowed anyone to put their creativity into action in video production. Whether a museum is concerned in developing videos or interactive video lessons, there is no lack of production tools to help. But still, there's much more than pointing a camera at something. All successful production arises from a *know-how* groundwork: knowing how to handle the camera properly (hold-in-hand or tripod) and the end results of the various controls; knowing how to use the equipment effectively; developing skills underlying good camerawork and sound-design; knowing how to express ideas compellingly; and knowing how to organize systematically, applying practical planning, preparation and production.

Slide 5_ Video production - learning the basics

It is not a fundamental issue to know every function of how the equipment works, but it is important to know its capabilities in order to achieve the most reliable results. First, one needs to explore, properly, what the camera allows you to do. Knowing how to operate your camera will let you apply your creativity more productively. Getting to know your equipment is essential. Once knowing your equipment, the next phase is to create a storyboard.

Slide 6_ Video production – storyboard

After getting to know your video tools, it is best to pre-plan your shots. Through moving images storytelling can be a great instrument for museums to engage current audiences and attract new ones. It all starts by making a storyboard. So, what is a storyboard? A storyboard is a tool that sketches all the scenes that is about to elaborate the video. First step is to plan your video by creating an objective, provide a key message, define the length of the video and finally delineating the channels where you want to promote your video. The second step is to visualize the script with a storyboard, for example, determine the order of the sequences in your video. The next step is to add script or additional notes to the shots your sketched. And finally revise the work before considering your video finished. So, the proper investment in video production can allow good outcomes and increase the museum outreach outside its physical place.

Slide 7_ Video production – museums context

Since its creation, museums have been in a state of endless transformation. Living in the age of information and augment reality through a variety of screens, videos are a great way to get noticed and also increase digital metrics and human traffic to every museum. Therefore, adding video to the museum marketing is definitely an excellent choice. Following are a few ways to add value to the museum marketing plan. Providing videos to the museum website is one obvious way to do this, allowing the audience to know in depth the contents of the museum: upcoming events or new exhibitions; adding a video to the About page, providing an overview of the organization and compelling features; information videos on specific exhibits or artefacts, going beyond simple descriptions; or using video to present a plan visit, allowing a kind of must-see list. Another aspect of video outcomes, in the museum context, is the encouragement of user-generated video content, which means that visitors participate in creating and sharing their own video contents. Not least important is the email marketing, where the video is used through emails, giving and aesthetics advantage over other newsletters. Finally, live-stream videos on social media. Giving a chance to show, for example, the *behind the scenes* of the museum, or a specific exhibit or artefact.

Slide 8_What is a Podcast

A podcast is a digital file that can be downloaded and listened to or viewed when desired. The benefit of podcasting is that allows listeners to be up-to-date with news and developments of the museums

programme, it also give the possibility to reach new audiences and gives a closer relationship with the audiences. Another aspect is that podcasts are generally free. In short, it is portable and on demand. The use of podcasting in museum interactivity and shared information has enormous potential in terms of sharing many forms of communication in an attractive and asynchronous way.

Slide 9_What is a Podcast – museums context

For museum professionals, podcasting, which can be launched from a small budget, has been one of the first tools to expand museums to reach a broader audience. While Podcasting is a wide and varying experience, it can be divided into one of three formats: conversional, which is the most common format, and basically is a podcast of informal style, with a solo host to a roundtable discussion; the narrative nonfiction, which is a long-form narrative, that covers everything that relates to a true event or topic in a narrative style; and finally, there's the scripted fiction, where stories are embellished. Regarding museums podcasts, the informal style is the most adequate. So, determining whether to show descriptive or elaborative material is a difficult choice, as different types of information will differently influence the visitor's aesthetic experience. In short, podcasts, not being a novelty in museums, help to engage with a variety of public, and they also help the public to engage with museums more readily. Podcasts can entertain, by operating a scripted fiction narrative, but mostly they educate, giving light onto less known areas of knowledge.

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AREA D
MODULE 6: CH COMMUNICATION

6.4 Digital Accessibility and Inclusion

Responsible	University of Lusofona
Teacher	Ricardo Geraldes
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

Good morning/afternoon, we welcome you all to this lesson on the topic of **Digital Accessibility and Inclusion**. The main focus of this lesson is to provide a helpful context and proper solutions (skills and practical knowledge) in digital accessibility, usability and design of digital structures exhibits, for the main purpose of digital inclusion, ensuring access for everyone. This is also based on the importance of developing digital literacy skills, from and for all stakeholders, in the landscape of culture heritage. Museums today see the digital world as a new frontier that is not only inevitable, but also challenging. Professional teams thus need to develop curatorial and information management skills of a new kind, enabling accessibility and inclusive solutions, regarding all of the structures and layers (physical and conceptual) that constitute museums (from mobility, sign language interpretation, to communication and content warnings, to audio description, to touch tours, etc.). With this in mind, the culture sector will need to employ a dynamic that incorporates managerial, commercial, and social practices and qualities in order to create added value and avoid being a seemingly unproductive expense.

Slide 2_Information Curators – a context on providing digital accessibility and inclusion

Information curators, as individuals that organize and manage information and services, in order to fulfil information-user needs[1], focus on organizing, and disseminating information and processes relevant to a topic or area of special interest. However, today's information curator for museums should be equipped with conceptual tools but also leadership skills that contemplate a deep social awareness. This notion of cultural leadership will need to include a framework of educational context and economic fostering, in the areas of museology, policy management, critical text creation, and marketing. Information Curation practices and Knowledge Management concepts are the necessary answers to the challenges that museums face nowadays, regarding digital accessibility and inclusion. For that matter, next, two concepts will be introduced that can help us establish a more inclusive structure and digital accessibility. Information Architecture and Content Architecture.

Slide 3_ Information Architecture and Content Architecture

In the Information Age, led mainly by speed (and show), an optimization of information and knowledge are indispensable, both individually and organizationally. The challenge posed by information exacerbation, in the face of the need for contextual "personalization" in the elaboration of knowledge, circumscribes both qualitative and quantitative requirements and information relevance. Information Curators carry out a permanent analysis of the sectors they intend to dynamize, and elaborate studies of the information ecosystem, using marketing tools and organizational and behavioural management. For that matter we will introduce the concepts of Information Architecture (IA) and Content Architecture (CA). According to the book *Information Architecture: For Web and Beyond* (2015) IA is considered to be "(…) a design discipline that is focused on making information findable and understandable. (…) IA allows us to think about problems through two important perspectives: that information products and services are perceived by people as *places made of language*, and that these information environments can be *organized* for *optimum find ability and understandability*" (Arango et al., 2015, p. 29). So, it is understood that digital accessibility and inclusion is a *place made of language*, that, incorporating IA will help people understand their space, and, in this way find what is being looked for in the museums or on-line platforms. And as a complement to IA, CA will help organize and classify the components of a particular content in order to make it more effective, reusable, and *understandable*, regarding digital accessibility and inclusion.

Slide 4_ Inclusive Museums and Digital Accessibility

When one talks about inclusion, equity or diversity and digital accessibility in museums, a list of groups starts to appear. But mainly, we are talking about socioeconomically disadvantage people, and people with physical or cognitive disabilities. Having some organizations add "accessibility" in their structures or initiatives, it doesn't always result in the inclusion of disable visitors (or staff, for that matters). What can be done to correct this? One thing to start is to know your stakeholders, and match the museum intent's with the visitor's intent's. And by first addressing this premise it will yield not only accessibility and inclusion, but also different outcomes, including innovation. "Conversations about disability often rely on the idea of accessibility as a set of particular, preset interventions, but accessibility requires great flexibility. It demands a malleable infrastructure that fits, in real time, with the needs of the community. (…) Accessibility is a promise, not a guarantee. It´s a speculative practice" (Lazard, 2019, p.10). Nonetheless, some solutions are almost obvious, in a way of assuring all institutions to *think* accessibility for disabled participants of all communities, and that's to employ (more) disabled people.

[1] Retrieved from https://www.igi-global.com/dictionary/information-curators/14593.

Slide 5_Inclusive Museums - *hard and soft architecture of accessibility*

This part of the lesson will pinpoint some recommendations on the physical part of museums, that we could refer as *hard and soft architecture of accessibility* (12).

- **Sign Language Interpretation**: multiple tools and resources to provide Sign Language interpretation in every event, according to the digital and media resources. That may include hiring interpreters.
- **Audio Description**: audio description implies the narration of visual contents, increasing accessibility for the blind and visually impaired. Providing a real-time narration of the events, exhibits or a particular artefact.
- **Communication Access Real-Time Translation**: real-time speech-to-text caption system that can be used for live broadcast online or remote events.
- **Childcare**: Providing assistance for parents, caregivers, and children, from facilities of baby-changing stations, to playrooms.
- **Closed Captioning**: facilitates access for deaf and hearing impaired, which includes text-based transcription of dialogue and descriptions of sounds, and music.
- **Communication**: taking into account a variety of people with psychological, developmental, and/or cognitive disabilities, it is important to hold space and awareness for varied communication designs. Allowing language accessibility for everyone.
- **Content warnings**: this will facilitate access for people with psychological disabilities.
- **Image Captions for Web Accessibility:** a screen reader is frequently used with text-to-speech or text-to-Braille software increasing accessibility for the blind and vision-impaired, but also for illiterate people.
- **Mobility**: taking into account a wide range of people with different mobility issues. From automated entrances, wheelchairs, and people pushing strollers, will allow a space to become more accessible.

Slide 6_ Digital Accessibility - Assistive Technology

By Digital Accessibility, we refer to ensure access to the museums' website or other kinds of digital platforms.

- **Visual impaired**: use of screen readers, accompanied by a braille display; zoom and text enlargement.
- **Physical:** sticky keys, for a better sense of touch; one-handed keyboards; Eye-tracking; Voice-driven interfaces; scanning software.
- **Cognitive and Verbal:** augmentative and alternative communication (AAC) which can be from facial expressions, body language or sign language, to symbol boards, choice cards or keyboards and alphabet charts.
- **Sensory Rooms:** sensory rooms for sensory stimulation and calming. These particular spaces normally have specific objects that will help autistic people to regulate sensory input and stimulation.

Slide 7_Web Accessibility

Perceivable; **Operable**; **Understandable**; **Robust**; **Conformance**; these are the four main principles into assuring the foundation for web accessibility, following the guidelines of the Web Accessibility Initiative (WAI), proposed by the World Wide Web Consortium. Assuring these recommendations museums will expand their accessibility by creating a digital structure that gives web contents more user-friendly for people with mobility disabilities or health problems.

Slide 8_Web Recommendations

These are some recommendations for Internet

- WordPress;
- Install Chrome Color Contrast Extension;
- Use the website at 200% zoom to test;
- Install WAVE Extension – allows web content for accessibility within the browser;

Slide 9_Media and Mobile Accessibility

Guaranteeing that all the media used within the museums' digital products are accessible in addition to all the platforms, here some points to consider.

- Captions
- Alt Text
- Visual descriptions
- PDFs
- Interactive tour app
- Images with description
- Add captions and transcripts
- Hashtags

Slide 10_ Inclusive Museums and Digital Accessibility, what's next

As we have been showing, accessibility and inclusion is not just about automatic doors, elevators and escalators, or even bathroom specifics, or technological apparatus, it's the articulation between these *hard and soft architectures of accessibility* and people. Accessibility and inclusion, in the context of museums, have, nowadays and clearly in the future, a very strong technological component. Technology plays thus an important role in the management of all resources, both human and cultural content. But, as we already proposed earlier, hiring disabled people can be a great solution, for it will push form the inside, the changes that are requested from the outside audience. What's next? The Semantic Web is a good candidate, as an example that can be used in the future to provide, organize, and even hint new forms of accessibility and inclusion: "The Semantic Web is a Web of actionable information – information derived from data through a semantic theory for interpreting the symbols. The semantic theory provides an account of "meaning" in which the logical connection of terms establishes interoperability between systems" (Berners-Lee, Hall, Shadbolt 2006, p.96). Therefore, the interoperability generated by the Web Semantic will definitely offer an arrangement of digital accessibility with inclusion as teleological stance.

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Video links

https://www.youtube.com/watch?v=9n9KacDbpzw

Links

https://www.w3.org/

MODULE 7

VIRTUALIZATION

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

AREA D
MODULE 7: VIRTUALIZATION

7.1 Virtual Reality

Responsible	The Cyprus Institute (CyI)
Teacher	
Duration (min)	8
Slides	10
Version	draft

Slide 1_Introduction

Good morning/afternoon, welcome to the first lesson of the module 'Virtualization'. Within this module we are going to explore Virtual Reality, Augmented Reality and Mixed Reality. Today we will speak about Virtual Reality – the main concepts, technologies and key applications for VR in Cultural Heritage. We will talk through and understand the strengths and weaknesses that this technology can offer to the CH sector.

Slide 2_What is Virtual Reality?

Virtual Reality is the use of computer technology to create a simulated environment and place the user inside a three-dimensional experience that enables them to explore and interact with that virtual surrounding. This is the definition that we are going to explore more closely. Essentially VR puts the user inside an experience. For example, this can be interactive, immersive or in the form of a 360-degree video such as a virtual tour where you can add many features to help visitors explore a museum virtually.

Slide 3_Forms of Virtual Reality

Virtual reality is fast growing beyond entertainment and gaming and can now be an important tool in education, science, cultural heritage and more. Instead of just viewing a screen the user feels totally immersed within the 3D world and can even interact with it. VR basically creates an experience that 'fools' the eyes and brain in the way they form visuals. This can be achieved with in 3 forms: non-immersive, semi-immersive and full immersive (or a mixture of the three).

Slide 4_Non-Immersive VR

This is the most common version of VR and features a computer-generated virtual environment however the user remains aware and controlled by their physical environment. A prime example of this would be video games. You can control characters and activities during a game but the virtual environment is not directly interacting with you.

Slide 5_Semi-immersive VR

This experience is partially based in a virtual environment. Examples of this type of VR can be found for education and training purposes. It can use a computer screen or a projector to create a virtual environment with which the user can interact with but other than your visual cues you will have no physical sensations to enhance the experience. Semi-immersive VR utilises projector and very powerful computers.

Examples of semi-immersive VR can be seen in flight simulators used for training where you can have a projection system and monitor that will set up the desired environment e.g. The cockpit but the viewer will not need to wear any head gear and is still aware of the surrounding world. Semi-immersive VR in museums is beneficial because it can accommodate large number of users at the same time – think of 4D cinema experiences or simulators both of which can be found at some larger museums and institutions.

Slide 6_Fully-Immersive VR

This type of VR creates the most realistic experience and uses sights, sound and sometimes smell to make the environment as realistic as possible. Special equipment such as VR glasses, gloves, body detectors and sense detectors are required to create this realistic experience.

EXAMPLE: Beyond the Castle

Beyond the Castle is an interactive virtual reality experience that allows you to assume the role of a medieval archer, shooting arrows from the ancient Falcon Tower.

This experience includes an integrated itinerary with a guide who takes you to the Falcon Tower, where the visitor-player, wearing special visors, become the protagonists of an interactive "hyper reality" experience.

EXAMPLE:

'Birdly' is an example of 'at the moment' fully immersive VR – it includes a headset and headphones and the user is laying down on a platform that is controlled by the individual to simulate 'bird wings' and the sense of flying. The movement inside the virtual environment is fully controlled by the user, who can change their posture and move their arms around to 'fly' inside the virtual world.

Slide 7_VR in Museums and CH Sites - Examples

VR can help museums bring objects and artefacts into context, for example by showing them in their original setting through a VR experience. VR can add an extra layer to a museum and give further insight about certain areas or objects.

Virtual Tour – * During COVID-19 many museums developed virtual tours of either their specific exhibits or tours of the entire museums. These tours were essentially a 360-degree view of the space that visitors can explore and click on the objects to gain more information.

Slide 8_Examples Cont.

VR through a headset in museums – * The Natural History Museum in Paris installed a permanent exhibition that deals with evolution. Visitors are fully immersed in a journey where they can explore links between species and view various creatures up close that have been now made extinct.

The Natural History Museum in London took this opportunity to give visitors a glimpse of some of its rarest specimens allowing users through the VR experience to handle and resize the objects while Sir David Attenborough teaches you the important facts of you are viewing.

Slide 9_Strengths

Benefits include making museums more accessible to people with mobility issues who can still enjoy the museums from the comfort of their homes. Visitors can access museums that are on the other side of the world without having to travel to them, however some believe this will stop people traveling or attending museums in person. VR is not meant to be used to replace museums or the real-life objects but a medium that can be used to enhance the museum experience and inclusive for all visitors. It also provides a way that can recreate lost heritage sites and preserve heritage sites for future generations (due to conflict, looting or the passage of time). It is also engaging and makes the experience fun, entertaining and unique for all visitors.

Slide 10_Challenges

An obvious challenge to VR technology and its use in museums, is the cost. Not all museums or CH sites will have the budgets to create VR environments for their exhibits. Management and design of VR is also pricey as it requires specialised training and personnel that will not be available for everyone – replacing broken head pieces for example can add to the increasing costs. Auckland War Memorial Museum had 15 broken headsets in just a couple weeks of installing a VR experience. This will add to the already high cost of installing such features in museums. Another challenge or limitation to look at would be one that has become more increasingly relevant due to COVID-19 is the hygiene of the headsets, should they exist. The hardware would be worn by several people throughout the course of one single day. This can then lead to museums needed extra staff or volunteers having the clean the equipment after every use. Additionally, some users can find their first experience of VR unsettling or even nausea-inducing. This is because of the disconnect between your physical body and the virtual world that your mind is immersed in. Symptoms can include headaches, eyestrain, disorientation, vertigo and even vomiting.

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AREA D
MODULE 7: VIRTUALIZATION

7.2. Augmented & Mixed Reality

Responsible	The Cyprus Institute (CyI)
Teacher	
Duration (min)	8
Slides	15
Version	draft

Slide 1_Introduction & Definition

Good morning/afternoon, welcome to the second lesson of the module 'Virtualization'. Within this lesson we are going to explore Augmented Reality and Mixed Reality - the main concepts, technologies and key applications that can be used in Cultural Heritage. We will talk through and understand the strengths and weaknesses that this technology can offer to the CH sector.

Slice 2_Introduction

We have already looked at Virtual Reality and today we will continue with Augmented Reality and Mixed Reality so we can easily see the similarities and differences.

What is AR? As a definition to 'augment' something is to make it greater by adding to it. This is essentially what AR does to an already existing real-life environment.

Augmented Reality is a system that combines real and virtual content to enhance an environment without completely replacing it. In general, there are 3 popular techniques that are used to achieve this which we will look at in detail in the next slides.

The most common application where you may have seen AR being used is if you have ever used Snapchat filter or Pokémon Go. These are two very well-known and popular examples of augmented reality.

Slice 3_Introduction Cont. - Main Concepts

On the other hand, Mixed Reality is a relatively new technology in the immersive world and is technology that blends VR and AR - blend of physical and digital worlds that combines interactions with the physical world and 3D environments. It aims to merge the real world and the virtual world to create a more immersive experience than ever. More than one person can participate and collaborate on a task, think of it as a much broader virtual reality where it pushes the limits to work towards achieving unrestricted, limitless environments.

There are 2 main concepts when it comes to AR: Marker-based AR and Marker less- based AR which is further divided into 4 areas.

Mixed reality however starts with the real world and virtual objects are overlaid just as in AR but here they can be interacted with. So as a user you remain in the real world and digital content is added to it. Can be seen as an advancement of AR.

Let's begin with marker-based AR.

Slide 4_Marker-based AR

This type uses a visual marker and is the standard type of AR people think of when they hear augmented reality. A very common example of this would be a two-dimensional QR code which a phone camera can recognize and will respond with the visual effects. This is also the type of AR one sees when using Snapchat filters. Marker-based AR relies heavily on cameras whether this be on a phone or a tablet and is continually scanning for the marker in a real-life environment. When the camera is not focused on a specific spot the virtual objects will not be shown properly. Marker-based AR systems are made up of cameras, image capturing, image processing and rendering. Benefits are that it is relatively easy and budget-friendly to implement given the fact that so many people will have a phone with a camera that they can use. On the other hand, a drawback is that sometimes to experience the AR users have to download an app on their smartphones so it isn't instantaneous.

Slide 5_Markerless-based AR (further divided into 4 areas)

This type refers to software that do not need a camera to recognise a marker but instead places 3d objects in the real-life environment by examining the features present in real-time. It uses the hardware of any smartphone such as camera, GPS, digital compass and accelerometer to work efficiently. It uses Simultaneous Localization and Mapping otherwise known as (SLAM) to understand the surrounding environment and the AR content can be displayed on top of the user's physical real-life view and can be observed from any angle and position. Imagine you are holding a tablet and whichever direction you move it in the specific AR content is displayed.

Slide 6_Projection-based AR

This Project light on a flat surface to create 3D imagery. For example, the use of holograms.

Slide 7_Location-based AR

The content is fixed to a specific physical space. So, when your device is fixed on a specific location it superimposes the digital imagery. The best example of this type to understand would be Pokémon GO application.

Slide 8_Overlay-based AR

Or Superimposition. Replaces the un-augmented view of an object with an enhanced virtual image of the same item completed with other visual perspectives. For example, a product can be placed in the real-life environment, you can see how it looks within a room, change its colour and arrangement.

Slide 9_Contour-based AR

Or outlining AR outlines the silhouettes of objects and simulate a realistic human interaction. Utilizes object recognition for better understanding the current environment it is in. For example, it might be used to develop a safe-driving application for low visibility situations.

Slide 10_ Accessibility

At the moment AR is more accessible due to the fact that it does not require a headset which is a reason why mixed reality is more expensive.

This type of digital application can be used in archaeology and cultural heritage sites to project views of ancient locations over todays ruins to enhance the visitors experience by allowing them to see what the site was like in its prime.

Slide 11_Hardware for Mixed Reality

As AR does not require headset, MR is all about the headsets!

Several companies are working on mixed reality technology including Microsoft's HoloLens, Lenovo Explorer, Samsung Odyssey. Microsoft HoloLens for example has a see-through display – the user can see the physical environment while wearing the headset. MR devices are equipped with sensors which are crucial for tracking the user's movements and cameras which take cues from the environment.

Slide 12_Differences between VR and AR

To blend everything we have seen together, we will look at the main differences between VR and AR. VR is an all-enveloping artificial immersive environment, whereas AR enhances the user's real-world environments with digital overlays that can incorporate artificial objects.

Basically, VR creates synthetic environments where user's actions can impact what occurs within those environments. AR views the real world directly via a device such as a camera for example, and inputs or overlays still graphics, audio or video. VR creates a new world whereas AR adds to existing real world.

Slide 13_Applications (AR)

Augmented Reality can be used in museums, galleries and heritage sites to add another layer of information to artefacts or exhibits. The National Gallery in London found a way to make their most popular paintings even more accessible to people. Members of the general public can use a mobile app to scan QR codes found on a busy London street which will show them the painting in question and provide images and information about that specific painting.

There are many elements to consider when thinking of using AR in museums – such as how can it bring people together? You do not want to end up introducing something than can have visitors glued to their phones individually and make the experience more 'isolating'. Another consideration is making the technology easy to use so that visitors of all ages are able to participate in the experience. Also, curators have to consider that AR is a way to enhance or 'add' to the already existing painting, exhibit, artefact and not try and alter it or change it or change the impact it is meant to have on the visitor.

Slide 14_Applications (MR)

Mixed Reality could eventually be inserted in several areas of our daily lives. It could be used in any area from business to education. Mixed reality means essentially you can interact and manipulate both physical and virtual items and environments using next-generation sensing and imaging. HoloLens was also used in a trial/study at the Cairo Museum where visitors put on the headset and are guided through the museum by a hologram of King Tutankhamun as a tour guide. Such

applications can make museums more interactive and boost visitors who will want to try out this new technology. It can also make learning more efficient for visitors who are visual learners.

Slice 15_Challenges of Mixed Reality and Conclusion

MR technology is still in its infancy, the devices are currently limited and expensive. If we look at all three 'realities' we have explored, we can come to the conclusion that MR is the most expensive. One HoloLens can cost upwards of $3,500 and a large museum such as the Cairo Museum mentioned previously, would need quite a few devices to give a larger number of people the experience of this type of museum tour. New cost-effective devices are being developed but this is still a pricey alternative to some of the other technologies we have looked at. As most people already use a smartphone or a tablet AR seems to be the least pricey option in terms of 'realities'. In the following lessons of this module, you will explore in more detail mobile applications and wearable devices applications.

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AREA D

MODULE 7: VIRTUALIZATION

7.3 Applications on the Web

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Iva Vasic
Duration (min)	8
Slides	13
Version	draft

Slide 1_Introduction

Digital representation of cultural heritage has emerged in recent years and digital content became widespread online. Fast data streaming, an increase in web server storage, and an improvement in state-of-the-art techniques for digitization enabled museums and visitors to interact in the virtual Web environment and to perceive the digital content from different perspectives.

For instance, many museums and other art/cultural organizations have invested in the development of featured digital applications with appealing storytelling and their online dissemination to engage the audience in featured cultural heritage projects. In this regard, it is worth mentioning the Europeana project, which formed specific media archiving and metadata standardization rules for cultural heritage institutions and sole users to follow.

Slide 2_Workflow

A general workflow for creating a digital museum includes:

- content production that was described in the previous lessons,
- content management, and
- content visualization and interaction.

Slide 3_Important aspects for Web-based museums

Visualization systems must be able to handle important aspects in the context of digital preservation, such as user profiles, security, and ease of access to digital content. [1]

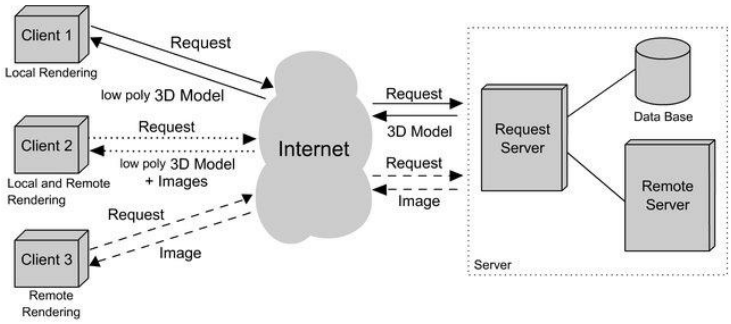

Figure 1 - Architecture used in the visualization system of the three-dimensional (3D) Virtual Museum [1]

According to the Augmented Representation of Cultural Objects (ARCO) system development that incorporates participatory design principles [2], four aspects must be assessed:

- Domain suitability
- Technical usability
- User acceptability and
- Sense of Presence

Slide 4_Social media impact on museum's aims

According to ICOM, the standard fundamentals of a museum are acquisition, conservation, interpretation, exhibition, and communication [3]. An important aspect to be considered is the feedback, a mean for the conversation between museums and the audience that should be analysed to improve user experience. The web environment is especially suitable for achieving this task.

Slide 5_Types of content

Several types of content that are often included in the virtual cultural heritage include:

- 360-degree panoramic images
- 360-degree panoramic videos
- Two-dimensional high-quality paintings and
- Three-dimensional models including both meshes and point clouds

The above-mentioned content can be further enriched with different kinds of interactive elements including pop-ups, static media, and buttons amongst others.

Slide 6_ Case studies

The following slides will include some of the important case studies on the usage of digital cultural heritage on the Web.

Slide 7_ Case Study – Google Arts and Culture

One of the leaders in the field of digitization, management, and publishing of cultural heritage collections online is Google Arts and Culture platform (GAC). It is a non-profit platform under Google Cultural Institute, providing online exhibitions and museum collections for users, and sharing technical tools with cultural institutions across the globe [4]. By digitizing art collections and creating a supportive structure that can hold all information in one place, Google's digital technologies and the hyper-communicative characteristics of the internet support the open access of art collections and cultural organizations [5].

Slide 8_ Case Study – Louvre Museum – Database

The Collections database consists of entries for more than 480,000 works in the Louvre Museum and National Museum Eugène-Delacroix. Updated on a daily basis, it is a result of the continuous research and documentation efforts carried out by teams of experts from both museums.

The Louvre's collections site offers several research tools: a full-text search engine; advanced search form; features that filter search results according to date of creation, collection the work belongs to, where the work is located, category of work, artist/maker; themed albums; and an interactive map to find works on display in the museum [6].

Figure 2 – Interactive map of the museum [6]

Slide 9_ Case Study – Louvre Museum – Virtual Web Tours

Several exhibitions of "Petit Galerie" are accessible through the virtual tours on the official website of Louvre Museum [7]:

- "From Afar: Travelling Materials and Objects" aims to tell the tale of the world and its peoples by describing exchanges between distant worlds – exchanges often far more ancient than the explorations of the 16th century.
- "The advent of the artist" takes a closer look at the transition from the typically anonymous craftsman of the classical period to the artist of the Renaissance, featuring works by Delacroix, Rembrandt, Tintoretto and more.
- "The body in movement" explores one of the performing arts: dance and how the artists used different materials and techniques to represent the movement.
- "Founding Myths: From Hercules to Darth Vader" investigates how illustrators, sculptors, painters, puppeteers, filmmakers, and musicians around the world have drawn inspiration from myths, given them form, and brought them to life.

Slide 10_ Case Study - The Civic Art Gallery "F. Podesti" in Ancona - History

The Civic Art Gallery "F. Podesti" in Ancona is a reference in the cultural scene of the capital of the Marche region since the establishment in 1884. The building that now houses his collection is the historic Palazzo Bosdari. It is preserved as it was constructed in 1400 and renovated in early 1660, with strong mannerist accent.

The project started as a permanent experimentation laboratory that will allow working on the virtual tour with the goal of strengthening and adding tools that improve the relationship between the audience and the museum [8].

Slide 11_ Case Study - The Civic Art Gallery "F. Podesti" in Ancona - Project

The virtual tour was developed in Pano2VR software and allows the user to move throughout different rooms thanks to the interactive map of the museum or directly selecting a work of interest. In each room, an introductory text to the paintings on display is automatically presented, and by clicking on them it is possible to recall information, high-resolution images, and 3D models (Figure 3).

Figure 3 – Virtual tour of the Civic Art Gallery "F. Podesti" in Ancona [9]

The project focused on several important subjects:

- Accessibility: the study and implementation of specific mediation tools such as highly readable texts, descriptive audio, and narrative designed for different typologies are envisaged.
- Entertainment: a schedule will be defined connected to the use of the virtual space characterized by guided tours and exhibitions, with exhibitions of works that would hardly have been exhibited in the real dimension.
- Use: proposals aimed at the exploration of individual works will be integrated with the addition of thematic files. For example, the aspects related to the restoration would offer the possibility of investigating the material reality of the paintings.

Slide 12_ Virtual tour of Civic Art Gallery of Ascoli - Workflow

The developed application presents a case study of the virtual museum with 84 panoramas and various descriptive features such as information about the artifacts, 3D models, and high-resolution paintings representations, as well as building information [10]. The workflow of the virtualization process is depicted in the following figure.

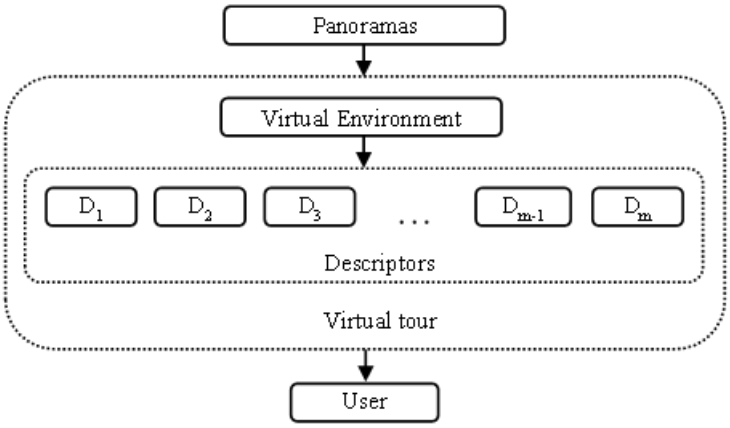

Figure 4 - VR visualization process flow where D1, D2,…, Dm are the functions whose arguments are obtained from the interactive input (interactions from users) [10]

Slide 13_ Virtual tour of Civic Art Gallery of Ascoli - Project

An intuitive interface that consists of visually comprehensive buttons is designed for different groups of people including even the staff of the museum. Interactive elements such as buttons, menus, and interactive popups are incorporated in the executable web application within the used software tool functionality and improved by inserting the additional JavaScript codes that additionally ensure the rich user experience and also the availability of user behaviour tracking, measurement, and useful statistical analysis [11]. The following figure illustrates some of the interactive functionalities of the virtual application including at the same time the richness of perceptual historical and artistic details.

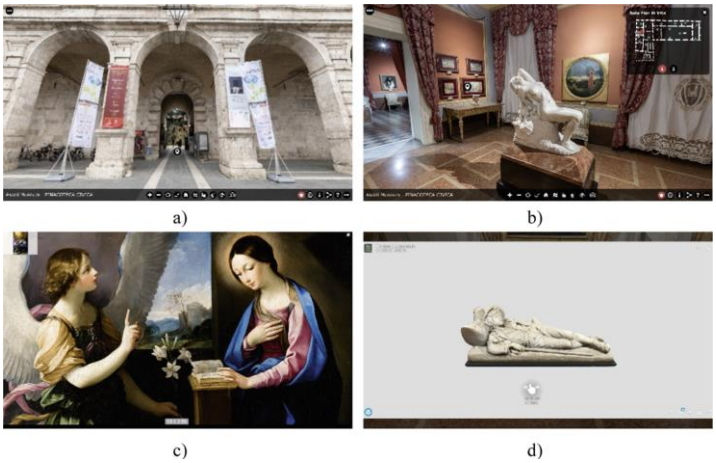

Figure 5 - The virtual tour interface of Civic Art Gallery: a) the main entrance, b) Sala Fior di Vita, c) HD painting "Annunciazione", d) interactive 3D model "Pastorello" [10]

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AREA D

MODULE 7: VIRTUALIZATION

7.4 Mobile applications

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Chiara Mariotti
Duration (min)	8
Slides	15
Version	draft

Slide 1_Introduction

Good morning and welcome to this lesson from the module "Virtualization" within the MOOC "Supporting the Digital Transformation of Museums. The DCBox approach." The topic we are going to discuss concerns the digital accessibility to cultural contents focussing on mobile applications.

Slide 2_Goal

The goal of this lesson is to highlight the role and added value of mobile applications compared to other types of applications, precisely because they are active and available both online and on site. This condition strengthens the close link between *user / digital content / physical container*, which is often an historical architecture or site, thus it is itself a subject to be investigated and interacted with.

Slide 3_Structure

To make the potential of such technologies in accessing cultural heritage as explicit as possible, we will analyse 3 virtuous experiences, selected for the different ways in which mobile digital tools have been designed, developed, and customized with respect to the features of contexts and cultural contents for users.

Slide 4_Case 1: Casa Batlló (description)

The first experience is that of Casa Batlló in Barcelona (Spain), which is one of the most famous architectures by Antoni Gaudí, known as the greatest exponent of Catalan modernism. Following the request of a wealthy textile industrialist, D. Josep Batlló y Casanovas, Gaudí transformed a modest existing building into one of his most original works, which was inscribed on the UNESCO World Heritage List in 2005. Since the late 1990s, Casa Batlló has been open to the public and now hosts the Casa Batlló museum, which receives an average of 3,000 visitors per day. Currently, the museum rooms are empty, as the ancient furniture has been removed, so the visit is heavily focused on the architecture of the house.

Slide 5_Case 1: Casa Batlló (mobile app & technology)

The digital upgrade proposed by the museum provides an enhanced experience for visitors allowing them to see both the current and original state of the building, including furniture and characters in period clothing, and adding more visual and sound effects. The result is a mobile augmented guide based on an innovative combination of traditional (or direct) and indirect Augmented Reality (AR) with the aim to overcome some criticalities in using AR, such as the inability to add artificial markers on the walls, the presence of small and crowded rooms, as well as the limited computational capacity of smartphones.

Slide 6_Case 1: Casa Batlló (technical aspects)

The application uses traditional AR to augment some specific assets, as well as a physical model of the museum, which is located in one of its rooms, while indirect AR to augment the museum rooms after the off-line virtualization of the real environment with the use of an authoring tool. An additional novelty lies in experiencing indirect AR indoors, as opposed to outdoors where it is widely documented in literature. The app automatically switches between one or the other kind of augmentation, depending on user location, which is retrieved by using Bluetooth technology.

Slide 7_Case 1: Casa Batlló (technical aspects)

Contents conveyed through indirect AR are a sequence of "augmented cubes", a kind of virtual cubic shape model that includes visual information as a blend of real images and static virtual models and dynamic virtual content. By combining real and virtual objects, very complex scenes are obtained that show old furniture, photographs or home lines no longer available in the museum, while the real objects are the walls and ceilings of the rooms. Moreover, Gaudí's design is full of symbolism, as it is reminiscent of animals or natural forms. To highlight this symbolism, the guide includes animations that, starting from the shape of a real objects, morph into the natural objects that inspired them. Additionally, each augmented scene is supported by audio (through headphones) that provides visitors with a brief history of the room and the augmented elements.

Slide 8_Case 1: Casa Batlló (results)

The main benefits of this mixed direct and indirect AR solution are:

- a customizable field of view, which is not restricted by the mobile device camera optics
- the absence of artificial markers on the walls, solved by image tracking
- no critical issues related to lighting conditions (natural or artificial) and to visitor occlusions
- static multimedia content is merged off-line and transformed (with the authoring tool) into data suitable for real time management on smartphones without loss of content; dynamic multimedia content, rendered in real time in the mobile application, blends seamlessly with the static content thanks to the extension of cube maps.

Such benefits were confirmed by usability tests conducted in April 2013 on the first version of the mobile application; these tests were also fundamental to improve the application to its current state.

Slide 9_Case 2: Archaeological Museum and site in Segni (description)

The second case is that of the Archaeological Museum and Site in Segni, Rome (Italy). Like many ancient cities, Segni boasts an impressive cultural heritage, but two factors affect its attractiveness: the layering of the remains, which makes it complex for non-experts to understand the archaeological site spread across the contemporary landscape, and the tourist flows that converge mostly on the capital as opposed to smaller decentralized areas.

Slide 10_Case 2: Archaeological Museum and site in Segni (mobile app & technology)

To overcome these critical issues, an interactive online guide for smartphones, tablets, or pcs was developed, called #SegniArcheologia. The goal is to extend the visit of the Archaeological Museum of Segni to its territory, literally moving the museum out of its physical location and taking the visitor to 6 outdoor points of interest within the Archaeological Site. The CNR, the Italian National Research Center, and in particular the Institute of Cultural Heritage Sciences supported the construction of contents by ensuring its scientific quality. The web-app is based on an open framework called ATON that offers flexible solutions to create apps for interactive content enjoyment (exploration, annotation, semantic querying). The interactive guide can be accessed on site or along urban visitor routes via information poles using QRcodes.

Slide 11_Case 2: Archaeological Museum and site in Segni (technical aspects)

Storytelling about the city, its personalities and monuments occurs in a geo-localized way, starting with 360° panoramas, and it is customized, according to the visitor's interest, both online and on site. In mobile use, each user can use their own smartphone. The narrative exploits different content (sound, video, images, text and 3D models). The technologies used are Augmented and Mixed Reality. Thanks to the Extended Matrix approach, it is possible to document not only archaeological remains in their current state of conservation but also reconstructive hypotheses; at the same time, all information that supports the reconstructive

hypotheses semantically enriches 3D models. The result is an immersive space that can be freely interrogated by the user.

Slide 12_Case 2: Archaeological Museum and site in Segni (results)

The #SegniArcheologia web-app allows:

- to enrich the visit by strengthening the link between the museum and the historic city
- to improve the understanding of the archaeological site, especially in the mobile use thanks to the direct comparison with the architectural remains
- to increase the attractiveness of the area with alternative cultural and tourist routes.

In addition, the digital tool (User eXperience Design) received a follow-up design phase of User eXperience Evaluation to estimate the effectiveness of the app through testing and interviewing users, and the feedback are very satisfactory.

Slide 13_Case 3: The Galla Placidia Line (description)

The third case is about a museum context very different from the previous ones, mainly because the museum as a physical building does not exist. This is the military landscape of the Galla Placidia Line, a defense system consisting mainly of bunkers that runs 130 km along the Adriatic coast (from Pesaro to the Po River delta), built by the German army during World War II to fear a landing by Allied forces. Today, this fortified line represents an incomplete heritage because many bunkers were demolished due to Peace Treaties, a dissonant legacy because it conveys a controversial memory, but also completely hidden because the structures have been absorbed into the contemporary landscape of the coast.

Slide 14_Case 3: The Galla Placidia Line (mobile app & technology)

An ongoing project, called "The Galla Placidia Line", which involves the Università Politecnia delle Marche, is dealing with the enhancement and storytelling of this Dissonant Heritage. Among the project strategic actions is a web-app to map and geo-locate bunkers, and to support tourist routes by pointing out hidden bunkers to walkers. The application is available from both pc and smartphones. It uses GPS technology, and will soon use beacons to send alerts to users walking along the coast. Although this application is less advanced in technology than the previous ones, it shows us the potential of mobile applications for digital accessibility to cultural heritage content that could not be reported in any other way.

Slide 15_Conclusions

Starting from these experiences, it is possible to extract some reflections on the role of mobile applications for accessing cultural contents in museums, considering their various forms: a museum-architecture (Casa Batlló), a museum-archaeological site (Segni), a museum-landscape (La Linea Galla Placidia).

These reflections concern the importance of designing specific content for different forms of heritage, but above all the added value that mobile applications can offer by stressing the close relationship between content and container. In fact, if well designed, each of these apps should encourage on site visit by providing, for example, additional content during the physical one.

In this way, the visiting experience can be totally virtual, if special causes require it (as it was during the pandemic) or, preferably, on-site but enriched with additional semantic content.

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Case 2: Archaeological Museum and Site in Segni (Italy)

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AREA D

MODULE 7: VIRTUALIZATION

7.5 Wearable devices

Responsible	Università Politecnica delle Marche
Teacher	Ramona Quattrini
Duration (min)	8
Slides	12
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome the last lesson of the "Virtualization" module. As in the previous ones I'm going to introduce you to some of the best practices, particularly focusing on the applications for wearable devices.

Slide 2_what's a wearable device?

You daily interact with computers and mobile phones, and you know exactly how they function, but maybe you are not quite familiar with the use of wearable devices (visors and smartglasses, just to have an instance). They allow you to have some immersive experiences which enables even more sophisticated features and level of engagement. The Immersive Virtual Reality (iVR) and Mixed reality (MR), that you have learn about in the first part of this module, are the main implemented technologies in the following cases.

Slide 3_case I: Studiolo del Duca (description)

For the first one we come back to the Ducal Palace of Urbino, in one of the most interesting rooms: the "Studiolo del Duca". This work was developed by our research group, at Università Politecnica delle Marche. The Studiolo is located on the first floor of the Palace, anciently the residence of the Montefeltro family and now the main museum in the Marche Region.

One fascinating feature is that the Studiolo reflected Duke's personality and intimate ideals and housed his most precious objects, as well. This very small study has an irregular floor plan while its walls are decorated with upper and lower fasciae. The upper part contains twenty-eight portraits of Illustrious Men, such as intellectuals, religious, great thinkers, among others. The lower fascia has a continuum of wooden intarsia creating the illusion of dilated space. The decorations include books, scientific instruments and other objects, images representing the duke's enterprises.

Slide 4_ case I: Studiolo del Duca (iVR app & technology)

Due to the small size of the Studiolo, room access is often limited, and the visitors' stream make difficult its enjoyment. The iVR application proposes a platform capable of integrating the virtual model and cultural and historiographical contents, thereby generating an Interactive Thematic Virtual Environment (ITVE) narrating the meanings associated with the images present in the Studiolo.

There are two reasons why this solution is effective for the case study:

-the first is that it is small and can be virtually explored without simulation of movement;

-the second involves the numerous allegorical decorative elements that are difficult to understand without specific in-depth knowledge of history and renaissance arts, which in this case are explained using the interactive tools provided in the virtual environment.

Slide 5_ case I: Studiolo del Duca (technical aspect)

Interaction and explanation of the points of interest take places thanks to two different content types: written and oral. The controller can be used to visualize icons that show a caption which the user can read while looking at the selected element.
The development of the application for Htc Vive was performed in the game engine Unity. The usage of this platform will be presented more in-depth in the following activity.
In addition, I'd like to report that, due to the study's geometric peculiarities, the generation of the digital replica was very challenging and required integrated acquisitions that you can study in the article in the references slot of this lesson.
This study demonstrates how digital technology can radically transform and modernize the structure of museums and exhibitions so that their Cultural Heritage contents can travel from galleries and historical buildings to everyone's houses.

Slide 6_ case II: A night in the Forum (description)

In the second case, we will discuss about video games. Not a common video game but, as it's called, a "serious game". A serious game is a game designed for a primary purpose other than pure entertainment. "A Night in the Forum" videogame was published in the Sony PlayStation store, for the PS VR headset, co-designed by a research institution [CNR ISPC], in cooperation with "Forum of Augustus Museum" in Rome. It was the final result of the REVEAL EU project, whose goal was to identify strategies and tools to develop educational titles.

Slide 7_ case II: A night in the Forum (The videogame)

"A night in the forum" represents a particular type of video game called 'Environmental Narrative Videogame (EEN)' which uses real scenarios acquired in the field, reconstructed following the archaeological sources. The game takes place in an archaeological site: the Forum of Augustus in Rome (you already studied this architecture in the Module 2 where the 3d modelling process was presented). The scenario presents a 3D model of the archaeological site as it is today (introductory scene) and also a 3d model of its reconstruction during the 1st century AD, which includes many architectures, statues and roman infrastructures. The plot consists of a tourist that, while visiting this archaeological site in a guided tour, remains behind and doesn't notice that he is locked inside. While he's looking around, he finds an object on the stairs of a building. It is a shiny helmet and when he picks it up, he is taken back in time, where he has to play the part of the forum's guardian and carry out all assigned tasks and get the place ready for the new opening at the sun rising, to come back to its time.

Slide 8_ case II: A night in the Forum (technical aspects)

In order to enable all users (expert and non-expert) to play, the gameplay was designed to be as simple as possible. The games are played through a first-person perspective in virtual reality. The players use their heads to focus on areas of interest in order to perform actions. When they focus their view on a target area or object, one of several icons is displayed to the player.

The process of archaeological sites and museums' gamification certainly represents an innovative approach that cultural institutions are increasingly adopting. The production of "serious games" are considered as strategic digital marketing tools to promote cultural heritage and tourism in addition to their traditional "learning by playing" function.

Slide 9_Mixed Reality (description)

These last two cases concern iVR applications that occlude your view to present a fully immersive digital experience. But what about an immersive experience that enhances your museum's visit with 3d holograms and video stream and still makes you able to see the physical world? This is what Mixed Reality does and it represents a novelty in the Digital Cultural Heritage scenario.

For example, in the slide you can see an automotive museum, you can go in deep about this case study thanks to the proposed bibliography.

Slide 10_ Castel del Monte Fortress

"Castel del Monte", fortress from the 13th century and UNESCO Heritage, is a virtuous case of a so-called "Holomuseum". The project is developed by Hevolus Innovation in collaboration Microsoft and aims to offer visitors more engaging experiences by means of the Microsoft's headset Hololens. Some remarkable features are the Federico II's avatar that guide you through the rooms and the presence of many 3d reconstruction of some architectural elements such as chimneys and capitals.

Slide 11_ Ducal Palace – Sala degli Angeli

I'd like to mention another last case which concerns, again, the Ducal Palace of Urbino and, in particular, the Hall of the Angels, one of the biggest and most interesting rooms.

Slide 12_ Ducal Palace – Sala degli Angeli

Two MR applications have been developed by our research team. One for museum management addressed for experts and technicians, the other for artworks' enjoyment by non-experts users.

Slide 13_ Ducal Palace – Sala degli Angeli

As you can see in the tests conducted in lab, the MR management APP proposes a series of panels, which can be displayed once the reference object is framed, allowing the comparison of the hypothetical environmental room's conditions with the thermo-hygrometric parameters of the object.

The second APP offers a series of panels placed below the painting where the short story inspired by the illustrations is featured. Through buttons, in addition to the simple audio-visual narration, the scene is corroborated by the creation of 3D models which include the architecture, furniture and characters of the painting.

Slide 14_ Ducal Palace – Sala degli Angeli

Both the experiences are developed for Microsoft Hololens2 and use Mixed reality technology.

As main features, all data coming from HBIM and from inverse perspective modeling procedures that you faced in module 3.

Slide 14_Conclusions

In conclusion, we've just seen 4 virtuous cases where two XR technologies are implemented. The first (the immersive VR (for HtC Vive or PS VR) is a proven tool with a high level of readiness that provides, usually, remote experiences. The second one, the MR for Hololens, is an innovative and promising technology that offers a number of remarkable possibilities for museums' on-site enjoyment but still not very common due to the lower tech acceptance.

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A Night In The Forum Trailer
https://www.youtube.com/watch?v=9AvCQexNbrU&ab_channel=sofiapescarin

Castel del Monte diventa un HoloMuseum
https://www.youtube.com/watch?v=QuwA9qpG5dA&t=91s&ab_channel=MicrosoftItalia

Petersen Automotive Museum: a HoloLens experience
https://www.youtube.com/watch?v=DdM786eiIa8&t=5s&ab_channel=Microsoft

MODULE 8

NEW FRONTIERS IN CH

DC BOX
DIGITAL CURATOR TRAINING TOOL BOX

AREA D

MODULE 8: NEW FRONTIERS OF CH

8.1 Introduction to AI

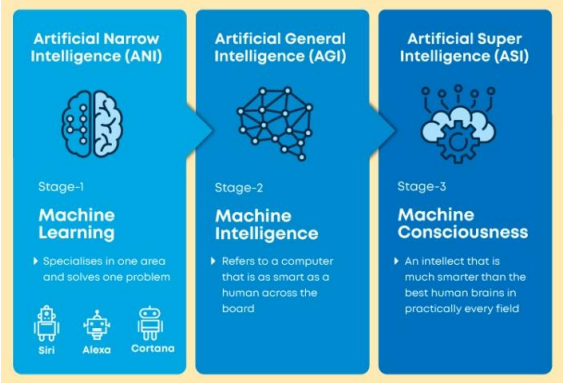
Responsible	University of Nis (UNI), Università Politecnica delle Marche (UNIVPM)
Teacher	Stanisa Peric,
Duration (min)	8 min
Slides	
Version	draft

Slide 1_Basic definition of AI

In computing terms, artificial intelligence (AI) is a concept that enables a machine to understand and solve complicated problems similarly to how we humans do [1]. For instance, we accomplish the assignment, make mistakes, and learn from them. Similar to humans, artificial intelligence also has to work on an issue, solve it, and learn from it while making mistakes in order to enhance itself. Or, to put it another way, let us imagine this as a game of chess between two friends. Any poor decision reduces your chances of success. As a result, after each game you lose against a friend, you try to recall the mistakes you did and use that information to improve your performance going forward. Over time, you get more accurate and your chances of succeeding or finding the solution increase substantially. This is the underlying concept which is very similar to how the AI is supposed to work.

Slide 2_Types of AI

AI technologies can be categorised by their capacity to mimic human characteristics, the used technology, real-world applications, and the theory of mind. All AI systems, both real and hypothetical, can be classified into one of three groups based on these characteristics [2]: Artificial narrow intelligence (ANI), which has a narrow range of abilities; Artificial general intelligence (AGI), which is on par with human capabilities; or Artificial super intelligence (ASI), which is more capable than a human.



Slide 3_ Artificial Narrow Intelligence

Artificial Narrow Intelligence (ANI), also known as Narrow AI or Weak AI, is a type of Artificial Intelligence focused on one single narrow task, so it possesses a narrow-range of abilities. ANI is something most of us interact with on a daily basis. The main applications used today with this type of AI are Google Assistant, Google Translate, Siri, Cortana, or Alexa. They are all machine intelligence that use Natural Language Processing (NLP). NLP is mostly used in chatbots and other similar applications. By understanding speech and text in natural language they are programmed to interact with humans in a personalized, natural way.

Slide 4_ Artificial General Intelligence

When we talk about Artificial General Intelligence (AGI) we refer to a type of AI that is about as capable as a human. However, AGI is still an emerging field. Since the human brain is the model to creating General Intelligence, it seems unlike that it will be developed relatively soon because there is lack of a comprehensive knowledge of the functionality of the human brain.

Slide 5_ Artificial Super Intelligence

Artificial Super Intelligence (ASI) is way into the future. To reach this point and to be called an ASI, an AI will need to surpass humans in any task and field. The ASI type is achieved when AI is more capable than a human. This type of AI will be able to perform extraordinary tasks well at things such as arts, decision making, and emotional relationships. These characteristics now play a role in separating machines from people, or, things that are thought to be exclusively human.

Slide 6_Perception and Knowledge representation

Research in the field of artificial intelligence is mainly focused on the following tasks (which humans perform successfully):

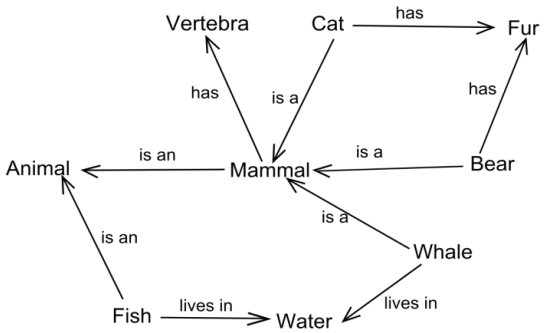
- **Perception** - the ability of a computer system to interpret information from sensors (microphone, camera, lidar) in a way similar to how humans use their senses to gain knowledge about the world around them. Applications: autonomous vehicle navigation, facial recognition, object recognition (computer vision), speech recognition (machine hearing).

- **Knowledge representation** - representation of information about the world around you in a form that the computer can later use to solve complex problems. Examples of knowledge presentation are given in the following two slides:

Slide 7_Logical representation and Semantic networks

Logical representation - knowledge is presented in the form of precisely defined logical statements that have precisely defined syntax and semantics, which leads to simple application of logical reasoning. Logical representation can be in the form of statement logic or predicate logic.

Semantic networks - knowledge is represented in the form of graphs whose nodes represent objects, and the lines represent semantic relations between them.



[4]

Slide 8_Frame and Rule-based representations

Frame - knowledge is represented by the structure of records that describe objects. They consist of a set of object properties and their values.

Slot	Value	Type
ALEX	_	(This Frame)
NAME	Alex	(key value)
ISA	Boy	(parent frame)
SEX	Male	(inheritance value)
AGE	IF-NEEDED: Subtract(current,BIRTHDATE);	(procedural attachment)
HOME	100 Main St.	(instance value)
BIRTHDATE	8/4/2000	(instance value)
FAVORITE_FOOD	Spaghetti	(instance value)
CLIMBS	Trees	(instance value)
BODY_TYPE	Wiry	(instance value)
NUM_LEGS	1	(exception)

[5]

Rule-based representations - knowledge is stored in the form of a set of rules created by experts, usually in the form of "if-then" rules.

IF (at the bus stop AND the bus arrives) THEN (get on the bus)

IF (on the bus AND a paid ticket AND a free seat) THEN (sit in a free seat)

IF (on the bus AND unpaid ticket) THEN (buy ticket)

IF (bus reaches destination) THEN (get off bus)

Slide 9_

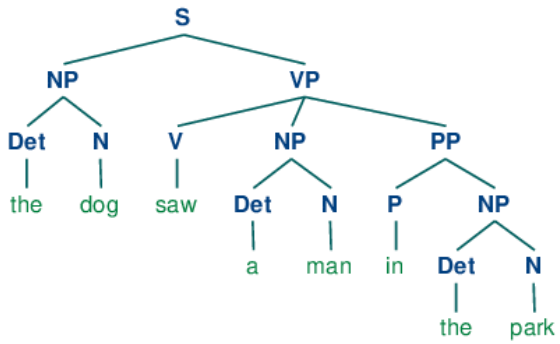
- **Reasoning and problem solving** - reasoning represents the generation of logical conclusions and predictions from available knowledge using logical reasoning techniques (induction, deduction) as well as the ability to react to changes by using existing knowledge to solve new and unknown problems. Problem solving in the sense of VI is a systematic search within the allowed actions to achieve a given goal.

- **Movement and manipulation of objects** - AI is indispensable in today's robotics, where the main goal is to create an intelligent robot, capable of movement and manipulation of objects, which can perform tasks based on its own experience, without being previously programmed for it. Robotics is based on the control theory, where the movement of the object (robot) is based on the information obtained from the created feedback loops.

Slide 10_Natural Language Processing

- **NLP - Natural Language Processing** - the ability of computers to understand, interpret and manipulate natural human language, both in spoken and written form. In the beginning (until the early nineties), symbolic methods prevailed, while today statistical methods of machine learning are mostly used (frequency of occurrence of words in a certain mutual correlation, searching by keywords, looking for patterns in texts), and in recent years especially deep neural networks.

For syntax analysis, syntax trees are generated that describe the structure of the sentence according to some formal grammar (N-noun, V-verb, A-adjective, D-determiner, NP-noun phrase, VP-verb phrase, AP-adjective phrase, S-sentence)

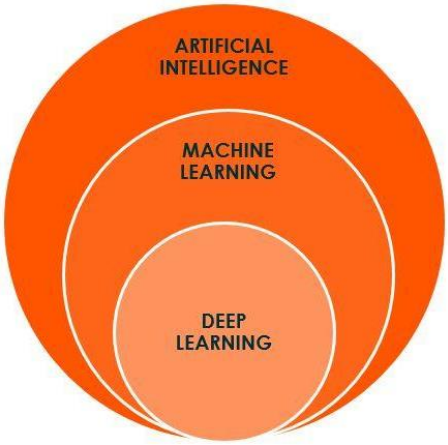


[6]

NLP solves problems such as: speech recognition, generating natural speech, answering questions posed in natural language, finding information in texts as well as machine translation, with the tendency to create systems capable of independently collecting knowledge from written sources.

Slide 11_Connections between AI, ML and DL

While machine learning (ML), deep learning (DL), and artificial intelligence (AI) are frequently used interchangeably, there are some significant distinctions. A set of concentric circles can be used to represent the relationship. ML is a subtopic of AI, which is the larger subject that covers the entire area of research. DL is a further refinement of ML and represents the most cutting edge of AI applications that are being used today.



[7]

Slide 12_ Use cases and applications of AI

Recently, museums are utilizing Artificial Intelligence technology to engage audiences and personalize visitors' experience. Chatbot is a software robot that interacts with human by personalizing the tour and interacting with audiences through intelligent customer service [8].
Chatbot Dot, the Akron Art Museum's digital tour guide
Practical realization, A cultural heritage framework using a Deep Learning based Chatbot for supporting tourist journey
There are a lot of applications in the cultural heritage domain, but most of them use technologies that belong to some specific field (NLP, computer vision, ML, DL, etc.) rather than AI in general.

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AREA D

MODULE 8: NEW FRONTIERS OF CH

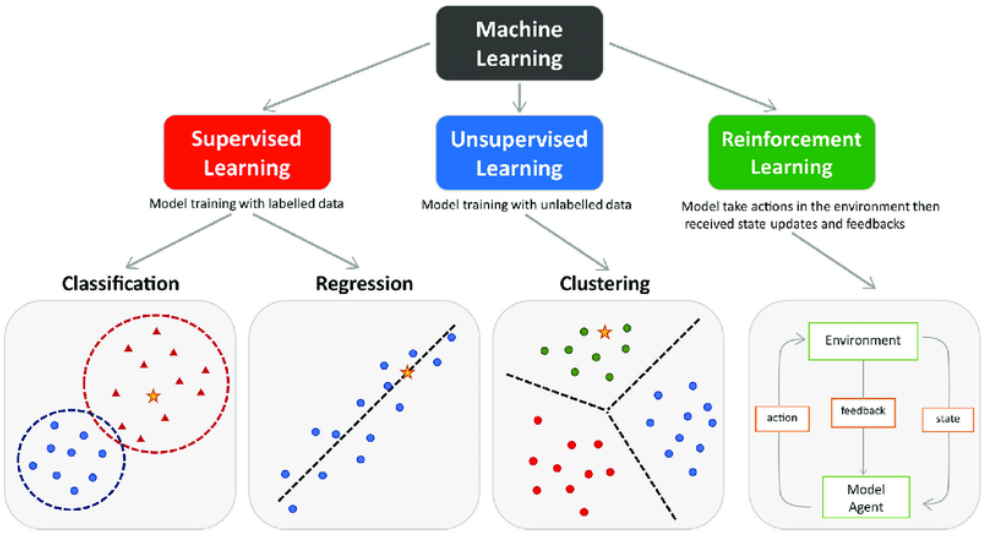
8.2 Machine Learning

Responsible	University of Nis (UNI), Università Politecnica delle Marche (UNIVPM)
Teacher	Stanisa Peric,
Duration (min)	8 min
Slides	
Version	draft

Slide 1_Core principle

Artificial intelligence makes judgments by putting particular algorithms into practice. They enable us to distinguish between fundamental and in-depth experience-based knowledge. Machine Learning is a part of Artificial Intelligence (AI) and computer science, which centers around the utilization of information and calculations to mimic the way that people learn, bit by bit working on its precision. Machine learning algorithms build mathematical models based on input samples (training data) to make predictions or decisions even though they are not explicitly programmed to do so.

Slide 2_Three types of Machine Learning



[1]

Slide 3_Supervised learning

Supervised learning - a mathematical model is formed on the basis of a set of data (training data) that contains both inputs and desired outputs (input-output pairs), where the goal is to find a function that maps inputs to outputs in the best way, so that it can later be used to predict the output and for new, previously unseen inputs (which were not part of the training data) - to perform generalization. Organizations may address a wide range of real problems at a massive scale with the help of supervised learning, such as classifying spam in a different folder from inbox.

Slide 4_Supervised learning - example

For example, we have a known data set with two variables: input - number of years and output - shoe size:

Years (Input)	**Shoe size (Output)**
Milan - 5	29
Goran - 8	34
Marko - 11	39
Ivan - 17	42

The goal - to predict the number of shoes for Darko who is 10 years old.

Slide 5_Supervised learning forms

Supervised learning can take two forms: **classification** (outputs are limited to a finite set of values, so the algorithm determines to which category some input data falls) and **regression** (outputs can have any numerical value from a certain range). Supervised machine learning methods: Linear Regression, Logistic Regression, K-Nearest Neighbors, Decision Tree, Random Forest, Neural Network, Method Support Vector Machine, Naive Bayes.

Slide 6_Unsupervised learning

Unsupervised learning - commonly referred to as unsupervised machine learning, analyses and groups unlabelled datasets using machine learning algorithms. These algorithms identify hidden patterns or data clusters without the assistance of a human. It is the best option for exploratory data analysis, cross-selling tactics, consumer segmentation, and picture identification because of its capacity to find similarities and differences in information.

Slide 7_Reinforcement learning

Reinforcement learning - behavioural machine learning model similar to supervised learning, but the algorithm isn't trained using sample data. In Reinforcement learning, an AI algorithm faces a game-like circumstance. The PC utilizes experimentation to find an answer for the issue. To get the machine to do what the software engineer needs, the computerized reasoning gets rewards or punishments for its activities, and it tends to maximize the total reward.

Slide 8_Use cases and applications of ML

Machine learning, a technology that learns, categorizes, and makes predictions based on existing data, is the subset of AI that powers "computer vision". This technology, which is called "machine learning for visitation pattern prediction and experience evaluation," can also gather information from the actual interactions that visitors have as well as from all the various digital touchpoints along the way, including the web, social media, ticketing, and mobile apps, among others.
Exploring ML in Museums

Slide 9_Use cases and applications of ML

The use of computer vision for museum collections is one of the most promising technologies [2]. The phrase "computer vision for museum collections" refers to data analysis of collection characteristics such as colour, form, line and space orientation, light, and even facial recognition. The system may connect collections based on such variables, enabling curators to be more imaginative and explore additional possibilities.

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AREA D

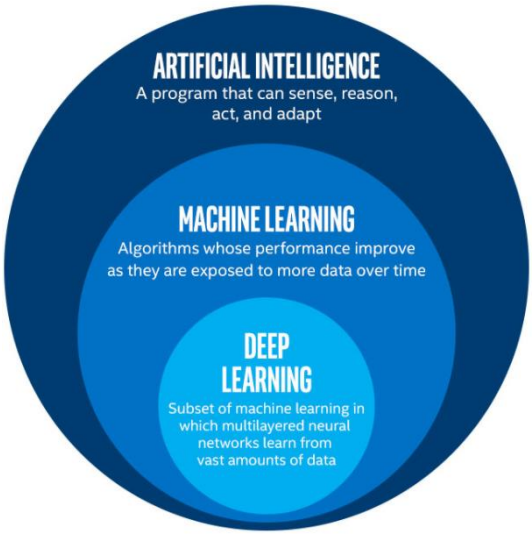
MODULE 8: NEW FRONTIERS OF CH

8.3 Deep learning

Responsible	University of Nis (UNI), Università Politecnica delle Marche (UNIVPM)
Teacher	Stanisa Peric,
Duration (min)	8 min
Slides	
Version	draft

Slide 1_Main concept

As we already mentioned, machine learning, deep learning, and neural networks are all sub-fields of artificial intelligence. As a matter of fact, deep learning is a sub-field of machine learning inspired by the structure and function of the brain called neural networks.



[1]

Slide 2_Working principle

Deep learning uses multiple layers of neurons between the input and output of the network. A multi-layered architecture enables the extraction of higher-level features from raw input data. For example, in image processing, the first layers can identify edges, higher contours, and even higher human-relevant shapes, such as letters or faces. Deep learning has drastically improved the performance of many AI applications including computer vision, speech recognition, image classification...
Deep learning most often uses convolutional and recurrent neural networks for its layers.

Slide 3_Artificial Neural Networks (ANN)

One of the most exciting advancements of the previous decade is Artificial Neural Networks, the fundamental piece of deep learning algorithms, the front line of artificial intelligence. Neural networks are inspired by the architecture of neurons in the human brain. The role of a neuron is to accept inputs from other neurons that, if activated, send a weighted vote whether the target neuron should be activated or not. Learning the network involves adjusting those weights based on training data. The most common training technique is the backpropagation algorithm. Modern neural networks have the ability to model complex relationships between inputs and outputs and look for patterns in data.

Slide 4_Convolutional Neural Networks (CNN)

A convolutional neural network, or CNN, is designed to handle organized data, such as images. Convolutional neural networks are widely used in computer vision and have advanced for some visual applications including image classification. They have also found success in natural language processing for text grouping.
Convolutional neural networks are actually skilled at picking out patterns in the picture data, such as lines, angles, circles, or even eyes and faces. Convolutional neural networks are incredibly effective for computer vision tasks thanks to this property. CNN do not require any pre-handling, unlike earlier computer vision algorithms, and can function directly on raw picture input.

Slide 5_Recurrent Neural Networks (RNN)

Recurrent neural networks (RNN) are the best in the class algorithm for sequential data and are utilized by Apple's Siri and Google's voice search. The main algorithm recollects its inputs because of internal memory, making it impeccably appropriate for AI issues that include sequential data. It is one of the algorithms in the background of the stunning accomplishments in deep learning in recent years.

Slide 6_Recurrent Neural Networks (RNN)

Recurrent neural networks (RNN) are a kind of Neural Network where the outputs from the previous neuron are taken care of as input to the current neuron. In most neural networks, the inputs and outputs are not dependent on one another. However, in situations where it is needed to anticipate the following expression of a sentence, the past words are required, and thus there is a need to remember the past terms. Consequently, RNN appeared, which settled this issue with the assistance of a Hidden Layer. The principle and most crucial component of RNN is the Hidden state, which recalls some data about succession. RNN has a "memory" which recalls all data concerning what has been determined.

Slide 7_ Use cases and applications of DL

The Neural Network/Deep Learning is also changing the museum experiences and it can be used in archival research activities [2]. In addition, a deep learning system can be used for deciphering ancient languages (restoring ancient text, decoding epigraphic marks, extracting layout from Cuneiform tablets, etc.). Besides that, the Neural Network has the potential to alter how artists produce their work. An application of using Generative Adversarial Networks (GANs) is the exhibition "Memories of Passerby I" and a prototype "Generist Maps" made by Met, Microsoft, and MIT [3].

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AREA D

MODULE 8: NEW FRONTIERS IN CH

7.4 The role of Artificial Intelligence in the Heritage Sciences dimension

Responsible	Università Politecnica delle Marche (UNIVPM)
Teacher	Roberto Pierdicca
Duration (min)	8
Slides	12
Version	draft

Slide 1_Introduction

Good morning, good afternoon and welcome to this lesson of the module “AI in Cultural Heritage domain” within the the DCbox MOOCs. We are going to talk about the introduction in this field of Artificial Intelligence approaches, and in particular those algorithms designed for the interpretation of complex data, i.e. images or point clouds, in order to reduce the human intervention in specific tasks.

Slide 2_AI and CH

Given the tremendous improvement of computing capabilities and the large availability of more and more complex digital data, the surge of automatization has become paramount. The introduction of such methods, however, requires a delicate discussion over their use in this field. The European Commission is striving to define guidelines and protocols for a proper use of AI, in these slides you can see the main findings of the Research for CULT Committee - The Use of Artificial Intelligence in the Cultural and Creative Sectors.

Slide 3_Digitalization

On its counterpart, as we have seen during this course, the digitization process is producing - thanks to the introduction of cutting edge geomatic techniques - datasets that need to be managed in a proper way and, as recently formalized the report study of the EU commission “Study on quality in 3D digitisation of tangible cultural heritage”.

Slide 4_ GeoAI

The integration of AI approaches in geomatics has developed into the concept of geospatial artificial intelligence (GeoAI), which is a new paradigm for knowledge discovery and beyond. The attractive feature of AI is its ability to identify relevant patterns within complex, nonlinear data without the need for any a priori mechanistic understanding of the geomatics processes. Heterogeneous data, textual, 2D and 3D can benefit from the application of learning-based methods, and in the following slides three CH related-projects will be reported where AI has been extensively exploited.

Slide 5_Ontology definition and training set

In this first example, we explain the semantic segmentation of 3D point clouds. The first step is the definition of classes, namely the typology of object the neural network is claimed to recognize, given a specific ontology. This step is fundamental for the training step. Indeed, to allow a Deep Convoloutional Neural Network to interpret unordered and unstructured data, as point clouds are, the first activity is data labelling, to provide the algorithm with a sufficient number of training samples. For this project, a specific benchmark dataset has been created with multifaceted architecture, coming from both TLS and photogrammetry.

Slide 6_Processing

After the acquisition and creation of 3D point clouds with the consequent annotation of single objects, testing of hyperparameters (optimization) and features (selection) within the DNN is necessary, so that the system can be optimized. Once the attribution of classes to objects with similar features has been done, evaluation with state-of art DL framework performances was done with standards metrics (F1 Score, Precision, Recall, OA, IoU).

Slide 7_Results

The results show how the network was able to recognize the main class categories previously defined, with an overall accuracy of around the 80%. Notwithstanding, even if the overall performances can be considered more than satisfactory, it is fair to say that single classes are often misclassified or even not recognized at all. The main reasons, common in the CH sphere, are twofold: on the one hand, data are unique even when belonging to the same class. On the other, training samples are missing, like in the case of windows and/or minor elements which reduce the generalization potential of the DCNN.

Slide 8_Explainability

Another important aspect, which should be considered when dealing with semantic segmentation, is the data interpretation. In other words, there is a lack of clarification frameworks that allow non expert users to understand the results of the automatic computation. The method proposed in these slides is based on GRAD-CAM, a very well-known method of data interoperability that has been exploited for the point cloud data. As is visible from the pictures, the system highlights (in red) those points that are responsible for errors, since their features are too complex, or the inner layers of the network are not able to select. Future efforts in the scientific community are dedicated to this very important method.

Slide 9_2D data segmentation

The second example that is reported in these slides is related to the automatic processing of ancient mosaic. Generally, the approach of expert archaeologists is that of manually digitizing the data coming from high resolution orthomosaic. As explained before, the use of AI-based systems can be the solution to reduce the human intervention.

Slide 10_Mosaic segmentation

Even in this case, the training phase is essential, since the final result of the segmentation is strictly dependent on the quality of the labelled data. Mosaics are manly composed of tesserae, and to provide the insiders with vector data, the segmentation is performed. The U-Net neural network, properly trained with synthetic dataset produced by an expert system, gives as output excellent performances in terms of accuracy; the

results have been compared with state-of-the-art benchmark dataset, proving the high reliability of such method. In the future, the application of an ontology-driven approach will be developed, with the aim not only to digitize the tesserae, but also to provide a semantic to the figures represented by the mosaic itself.

Slide 11_Fighiting the illicit traffic of cultural goods

The third example is the exploitation of AI for the detection of illicit traffic on the web of cultural properties. It is well known, in fact, and proved by the UNESCO red list, that social media are often used to exchange, illegally, archaeological findings. The project here presented, SIGNIFICANCE, moves towards this direction, by scraping the web and social media to extract useful information from the images and detect illicit trading of goods. The approach of the project is based on social media intelligence approaches, which are based on semantic segmentation of textual and visual features that, matched with the police's database, can help detecting such trade.

Slide 12_Human behaviour understanding in museum environments

The fourth and last example is related to the wide domain of behavioral patterns detection within cultural environments, and in particular museums. It is well known that, given the latest achievements in space sensing techniques (like Wi-Fi, UWB, Bluetooth and many more), tracking humans moving in indoor space has become a paramount task to better manage spaces, exhibition and arrangements. In this case, the slide shows a System, called Me.Mus, which exploits vision and wireless tracking systems to determine the human path and attempt to predict them. The Deep Learning network, properly trained with manually labelled data, is able to understand patterns of trajectories, beside understanding the main features of the museum's public. The future research lines are oriented towards a personalized experience, based on human preferences and needs.

Slide 13_next steps

In this lesson we have witnessed to some examples on how semantic segmentation can be used in the field of CH, and in particular for the interpretation, protection and conservation of artefacts digitally replicated. These methods are still under investigation and their use in the daily practice is still far, but the premises and the good results obtained make the community confident that the research path is paved.

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AREA D

MODULE 8: NEW FRONTIERS OF CH

about8.5 Evaluation questionnaires for museum experience

Responsible	University of Nis (UNI)
Teacher	Andjela Djordjevic
Duration (min)	8 min
Slides	13
Version	draft

Slide 1_Introduction

Good afternoon and welcome. Today we are going to talk about virtual museums and the ways to track user experience of a virtual tour. We will talk about assessment questionnaires and their underlying concept. Afterwards, we will explain and define terms such as level of engagement, level of readiness and usability test. Finally, we will mention some of the key applications of AI and XR for user experience evaluation.

Slide 2_

There are two ways of experiencing digital tours in a museum: physically, in the museum , and online. The outburst of coronavirus dramatically encouraged an improvement of museums' online digital services. During the pandemic, a vast majority of museums increased their online presence. It is clear that no matter whether the tour is held in a physical museum setting or online, the feedback is one of the most important things for the improvement of the experience itself and creating value for the end users.

Slide 3_Evaluation of virtual tours

The evaluation of how users respond to digital experiences represents an essential part of the digitization process. Through some assessment questionnaires, it is possible to examine many experience dimensions. A questionnaire is one of the most frequently used tools to collect information from a respondent and use it for further evaluation.

Slide 4_Types of questionnaires

There are several types of questionnaires based on the tools used to get data. Those are telephone questionnaires, in-house questionnaires, mail questionnaires, online questionnaires and mobile questionnaires. Telephone questionnaires are relatively quick to conduct but are expensive and collect fewer responses than other types. One should bear in mind that the there is a high chance that the sample does not represent broad population. In-house questionnaire is a type of questionnaire which is carried out in

person, usually in some form of an interview. The main advantage is that it collects in depth data, but it is quite slow to conduct and expensive. It can take place in respondents' home or workplace. Mail Questionnaires are mostly outdated. The questionnaire is sent via e-mail, so there is a chance that the potential respondent will simply ignore it. Online questionnaires are time efficient and economic, which is their main advantage. The main disadvantage is that there is a chance the respondent would ignore it. One of the ways of preventing this would be by motivating the digital museum visitors to fill in the questionnaire by offering them some discounts for real tours in the physical museum. Lastly, mobile questionnaire is a type of questionnaires which are usually filled in via mobile application.

Slide 5_

If a questionnaire is completed by the respondent themselves, it belongs to the group of self-completion questionnaires. On the other hand, if a questionnaire is in a form of an interview and the respondent's answers are filled in by an interviewer, it classifies as a facilitated questionnaire. Self-completion questionnaires are structured and generally used to collect quantitative data. They are thoroughly planned, present a quick way to conduct data, but they are not very flexible. A facilitated questionnaire can be used to collect qualitative data since they can have a flexible structure and not limit the respondent's answers, still, collecting data this way might take up a lot of time.

Slide 6_Types of questions

As for the questions used in the process of evaluation, they could belong to one of the two main groups: open-ended questions and closed ended questions. Open-ended questions give the respondent an opportunity to answer using their own words and ideas. This type of questions provides certain flexibility and gives a great response variety. Still, one of the main disadvantages of open-ended questions is the amount of time and work needed analyse the results. Also, there is a greater chance that a respondent will skip an open-ended question than a closed ended one. An example of a closed ended question is presented in the slide. As you can see, the respondent does not have an opportunity to come up with their own answer but has to choose from several predefined answers.

Slide 7_ Types of closed ended questions

There are several subtypes of closed ended questions: dichotomous questions, multiple-choice questions, scaling questions and pictoral questions. Dichotomous questions consist of two possible choices and are usually "yes/no" questions. On the other hand, multiple-choice questions give the respondent an opportunity to choose one or several options from the given list. The concept of pictoral questions is similar to multiple choice questions, but the answers are presented in pictures. Finally, scaling questions give respondent an opportunity to rate their experience on a scale.

Slide 8_How to define questions?

In order to design a good quality questionnaire, questions should be defined thoroughly. According to *Tip Sheet on Question Wording* by Harvard University Program on Survey Research: "The ideal question accomplishes three goals: It measures the underlying concept it is intended to tap; it doesn't measure other concepts and it means the same to all respondents.

Slide 9_

In *Tip Sheet on Question Wordin*g, several rules that could help with the question definition are given. Firstly, strictly technical terms, as well as jargon, should be avoided since they could potentially confuse the respondent. All the phrases used in the questionnaire should be easily understood. Secondly, the terms should be precise, and, ideally, should have the same specific meaning to anyone filling in the questionnaire.

The questions should be defined specifically in order to get specific answers. It is important to avoid complex sentences. A reference frame should be provided since all the respondents ought to be answering questions about the same time and place. If rating scale is used, it is supposed to be ordinal, and it should be clear to all the respondents whether each point of the scale has higher or lower value than the other. Questions should measure only one thing, and not more. Also, answer choices for multiple-answer questions should anticipate all possibilities. Finally, questions using leading, emotional, or evocative language should be avoided.

Slide 10_Digital Museum evaluation questionnaire

Having everything previously stated in mind, *Art Museum Digital Impact Evaluation Toolkit* contains some useful pieces of advice when designing an evaluation questionnaire for a digital museum. According to it, several aspects should be considered. Firstly, background information on the respondents (for example demographics, motivations and visitation frequency) should be collected. Second aspect to be considered is digital experience, meaning prior digital engagement and timing of interactive experience if the tour is held in a physical museum. The questionnaire should also examine visitors' relationship with the theme and knowledge on the theme of the exhibition, as well as their attitude toward the digitalisation process and the virtualisation of museums. In the end, information about visitors' overall experience and impact should be acquired.

Slide 11_

Visitors of a virtual tour could fill in the questionnaire online, via mobile application or in a written form, depending on whether the tour is taking place online, on the mobile application or in the museum. If the questionnaire is given in paper form, it should be made in such a way that answers could be easily transferred into digital form, which means to have mostly closed multiple-answer questions that could be easily scanned and saved in a digital format.

Slide 12_ Activity: Design an evaluation questionnaire

Now that you are familiar with the concept of designing evaluation questionnaires, your task would be to design and conduct a simple survey about virtual tour or museum application. You will find useful literature on the links presented in the slide.

Slide 13_ Ending slide

That would be all, thank you for your attention.

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Slide 1_Introduction

8.6 ICT for tracking behaviour

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Duration (min)	8 min
Slides	13
Version	draft

In the last years, especially after the COVID outbreak when people had to stay home and couldn't physically visit museums, it became incredibly important to ensure that the visitors of online virtual tours could have a the most genuine museum experience as possible . In order to provide and enable that kind of the experience, it is important to have an insight into users' behaviour during the virtual tour and find out how to improve user experience based on the collected information on their behaviour. The table on the slide presents evaluation scales for virtual reality developed by Sutcliffe and Gault in 2004, and evaluation scales for virtual tours developed by Kabassi et al. in 2019. If you look at the second column, you can see that the factors to be considered are natural engagement, compatibility with the user's task and the domain, realistic feedback, the natural expression of action, close coordination of action and representation, clear turn-taking, sense of presence, faithful viewpoints, navigation and orientation support, clear entry and exit points, consistent departures and support for learning. The information on user behaviour can be acquired using information and communication technologies. Firstly, we will define three important terms: level of engagement, level of readiness and usability test.

Slide 2_Level of engagement

In order to find out whether users find value in a certain product, user engagement should be measured. O 'Brien et al. gives the following definition of user engagement "User engagement (UE) is a quality of user experience characterized by the depth of an actor's cognitive, temporal, affective and behavioural investment when interacting with a digital system".

Slide 3_

Engagement could be measured through 6 psychological levels: acknowledgement, exploration, action, identification, integration, enlisting. The first level of engagement is acknowledgement. This level implies that the users visit the website or follow social media accounts of the museum. If the users are spending

more time on the website, or download and test the app, it they share or react to content posted on the social media, etc., then those users reached the second level of engagement and are exploring the digital content of the museum. The third level of engagement is action: for example, if the users sign up to the product. When the users form an emotional connection and identify with a product, they have reached the fourth level of engagement. If the product is frequently used and becomes a part of the users' daily life, then the fifth level of engagement - integration, is achieved. At last, the sixth level of engagement – enlisting is achieved if the users subscribe and commit to the product.

Slide 4_Level of readiness

The Level of readiness represents a maturity level of a service or product. The term technology readiness level or short - TRL was coined by NASA. The following levels of readiness are defined: level 1 where basic principles are observed, level 2 is achieved when technology concept is formulated, level 3 considers experimental proof of concept, level 4 is achieved when technology is validated in lab, level 5 is reached when technology is validated in relevant environment (industrially relevant environment in the case of key enabling technologies), level 6: technology is demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies), level 7 refers to system prototype demonstration in operational environment, level 8 – system is complete and qualified and finally level 9 is achieved – when actual system proven in operational environment.

Slide 5_Usability test

The term usability refers to how effectively, efficiently, and easily users operate and perform different tasks on a system. Usability testing is a technique which evaluates user experience and gives direct input on the way in which the system is used real users. It is a very efficient tool for identifying where the users are struggling while using the system. That way, the system can be further improved to provide better user experience and maximize the ease of use.

Slide 6_User behaviour evaluation using AI and XR

A sophisticated evaluation of user behaviour can be achieved by using Artificial Intelligence (AI) and eXtended Reality (XR) technologies. The main benefit of analysing user behaviour by employing AI and XR technologies is the opportunity to further improve the digital museum application, and therefore user experience. In order to track user behaviour during a virtual tour of the museum, AI technology could be implemented and used for eye tracking, mouse tracking, tracking of keyboard input, etc. depending on whether the tour is held online or in the physical museum. All of these techniques can be applied in usability analysis. For those who are interested, an interesting case study for the virtual museum analysis can be found in the paper "Virtualization and Vice Versa: A new procedural model of the reverse virtualization for the user behaviour tracking in the virtual museum", where the reverse virtualization process was applied in order to track user behaviour. Now we will explain two of the previously mentioned techniques used to acquire information on user experience: eye tracking and mouse tracking.

Slide 7_Eye tracking

Eye tracking is a useful tool which can provide both qualitative and quantitative feedback on user behaviour. It can be used to track the location of the user's gaze. This technique gets information on whether some parts of a webpage have been skipped, glanced at, or read. Therefore, eye gazing can give an

insight into user's attention level. Still, it requires special equipment in order to achieve an adequate data acquisition.

Slide 8_Mouse tracking

The studies have shown that there is a high possibility that the position of the user's gaze is related to the position of their cursor on the screen. Therefore, there is a high chance that mouse tracking, which records mouse clicks, scrolls and movements, would provide accurate enough information on user's eye movement during the tour. This information could be used to discover which objects caught most of the attention, which parts of the museums were visited the most, as well as most frequently used paths. The greatest benefit of using mouse tracking compared to eye tracking to collect information is its lower cost, simpler implementation and the fact that it is a passive form of study. It is not uncommon that the users usually are blissfully unaware of their mouse patterns being tracked. Those users tend to behave more naturally and, therefore, the collected information is more accurate.

Slide 9_

An even higher level of virtual tour experience would be achieved if more sophisticated UX information acquisition was provided through Human-Computer Intelligent Interaction (HCII). Gesture, facial expression and emotion recognition could be implemented and used in virtual tours. We can conclude that by implementing these technologies, intelligent system of the museum would be able to provide much better interactive experience and enhance the overall quality of a virtual tour experience.

Slide 10_ Ending slide

That would be all, thank you for your attention.

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