UNIVERSITÀ DI PAVIA

DIPARTIMENTO INGEGNERIA CIVILE ARCHITETTURA

Study Course

VIRTUAL REALITY ENGINEERING AND GAME DESIGN FOR ARCHITECTURE AND CULTURAL HERITAGE

Virtual Reality Engineering and Game Design for Architecture and Cultural Heritage

Course Index

- **First Year**

1. History and design of digital culture
    1.A. Virtual worlds and visual history
    1.B. Theory and design for digital culture
2. Digital model production for architecture and gamification
3. Digital light design
4. Graphic and photography for architecture
    4.A. Graphic and image editing
    4.B. Architectural photography
5. Communication by images for video storytelling
6. BIM and digital management of architectural heritage
    6.A. BIM systems and digital asset management
    6.B. BIM and H-BIM modelling
7. Computational models and prototyping
8. Web and multimedia technologies
9. Human computer interaction
10. Elements of critical listening and audio production for images and VR
11. Italian language for foreign students

- **Second year**

12. Methods and models for digital cities
    12.A. Artificial intelligence and advanced modelling for sustainable urban planning
    12.B. Economic urban assessment
13. Virtual architecture design and interaction
14. SFM survey for cultural heritage and architecture
15. Digital heritage intervention
    15.A.Business for digital cultural heritage
    15.B.Digital heritage management
16. Artificial intelligence
17. Computer vision

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

1 History and design of digital culture

Module 1A - Virtual worlds and visual history

Module 1B - Theory and design for digital culture

CLASS NAME

VIRTUAL WORLDS AND VISUAL HISTORY

Prerequisites

Students of this course are required to possess adequate initial preparation in the following knowledge learned during the Bachelor Program of: History and Art history (from antiquity to present) learned during studies conducted in lower and upper secondary schools; Representation and History of Architecture (from antiquity to present).

Training objectives

The course aims to provide the basics of visual culture concerning the evolution of digital technologies. Through theoretical lessons, it aims to analyse the role of new images and new vision devices, critically presenting a history of virtual architectural images, starting from the multifaceted concept of visual culture in the present and in the past. The course tries to investigate how environments, works, and cities were imagined and reproduced, from analogical to digital. The role of the gaze; the depiction of utopias and dystopias; media and devices; the social uses of images; the comparison between real, probable, virtual in architectural and urban representations are just some of the topics dealt with during the course.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The student will acquire the critical skills on:

- Use of an appropriate vocabulary in the description of architectural and artistic phenomena;
- Appropriate relationship between historical context and past architecture;
- Application of historical typologies, architectural language and multimedia language;
- Evaluation and interpretation of data and information acquired in order to formulate an independent judgement on architectural expressions.

During the lessons, images, videos and movies will be shown and commented on to improve student's skill of critical reading skills.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student will acquire knowledge on:

- Meanings of virtual representation in history;
- Modes of representation of imaginary architectures in past eras;
- Techniques and tools of historical representation in the different devices.

Program and content

Virtual World and Visual History is an experimental monographic course. The detailed program and specific course contents will be presented in the Prolusion lecture.
Provisionally, the topics that will be discussed are:

- Introduction to the concepts of "Virtual world", "Visual History", "Real representation vs virtual representation", "Representation of an architectural idea and representation of an architecture not meant to be built;
- Visual culture studies, Pictorial turn and historiography of architecture;
- Idealization of the imaginary model and allegoric ambitions of the virtual as a complement of existence, from Vitruvius to the theorists of the Modern;
- Western models and representations of ideal cities;
- Form and representation of Biblical places from Lost Paradise to Babel Tower;
- Literary narration and visual narration: the "mis-en-scène" and the theatrical set from from the ancient Greek-Roman theater to the "Revolutions" of the twentieth century;
- Architectural "Capriccio": from the Modern age to the Post-modern age;

- Architecture painting, architecture in paintings;
- Architectural inventions and ideal architectures: the paradigms of printed images;
- The charm of distant worlds in time and space;
- Melancholy and Beauty: the places of “invenzione”;
- Illusory spaces and representative fictions of architectural landscape;
- Architectural Competition and Architecture on paper;
- The futuristic dreams from Jules Vernes to Éduard Utudjian;
- The paleo-future, the Future of Tomorrow and pop aesthetics;
- The representation of utopia and dystopia in Eastern and Western World;
- Ideology of vision and Collage from “Tavola degli orrori” to “La città analoga”, to “Roma interrotta” and beyond;
- Virtual worlds between comics and sci-fiction;
- Historical architectures and imaginary worlds in cinema and in TV series;
- The past in the era of digital games, between imagination and historical architectural representation.

Teaching methods

The 6 CFU course is structured on lecture and laboratory. Ex cathedra lessons, in-depth seminars, readings of books, exercises, video and movie viewing.

The frontal lessons are constructed by proposing a sequence of in-depth topics that aim to make the student acquire a critical capacity on the main representative characteristics of virtual architecture and on the connections, in terms of quotations, between digital products and the constructive episodes that characterise the history of architecture. The laboratory activities are configured as a moment of active confrontation between students and lecturer during which ex cathedra lessons, in-depth seminars, book readings, exercises, and the viewing of videos and films will be carried out.

Reference books

M. Savorra, *Virtual Worlds and Visual History*, forthcoming. (The reference book has not yet been published).

Some references will be taken from:

- L. Steil (ed. by), *The Architectural Capriccio. Memory, Fantasy and Invention*, London-New York 2016.
- A. Chapman, *Digital Games as History. How Videogames Represent the Past and Offer Access to Historical Practice*, London- New York 2018.

Other didactic materials of the course will be provided (slides, articles, essays) before the lessons. Each topic will have its own specific bibliography. Besides, for the final examination the student will deal with the topics covered in the course through his own bibliographic itinerary, also based on the choice of a specific topic for an in-depth analysis. In this sense, didactic materials and specific bibliographic indications will be provided, starting from the individual themes and cases illustrated in the detailed program uploaded on the digital platforms provided (Facebook; Unipv; Kiro Unipv, website Unipv etc.).

Learning Evaluation Methods

The final evaluation consists of an oral exam aimed at verifying learning and achievement of the training goals.

Other information

Agenda 2030 Goals: 4. Quality education; 5. Gender equality; 10 To break down inequalities; 11. Sustainable cities and communities.

CLASS NAME

THEORY AND DESIGN FOR DIGITAL CULTURE

Prerequisites

Students are expected to have already developed in their bachelor program:

- An understanding and knowledge of architectural culture through various ages and up to contemporary trends,
- Appropriate skills both in terms of understanding and analysing architectural project and precedents, and in terms of representing them through a variety of media.

Training objectives

The module aims at providing students with appropriate knowledge and key skills to further develop design-oriented activities in the area of digital architectural culture and production.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

- Knowledge of theoretical background to support the digital dimension towards architecture.
- Critical understanding of current trends, and tools available to enable digital dimensions.
- Research skills, including research by design, towards the set-up of a given assignment.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

- Ability to critically analyse architectural precedents.
- Practice-oriented skills towards visual representation of architectural narratives.

Program and content

The module is organised in two, complementary theoretical sections, components integrated with studio-based activities, as follows:

<u>Architectural theory and culture in the digital era</u>

The module aims at developing students' skills at postgraduate level. Hence, preliminary sessions will be dedicated to:

- Situating Architecture in the digital era
- Architectural responses to technological innovations

<u>(Digital) Architectural narratives and design thinking</u>

Specific focus will be given to architectural narratives developed since the digital era, and their mutual relationship with design thinking and practice

<u>Assignment development and research by design</u>

Once a common ground is established, students will develop their own assignment based on the brief and their own interests.

- Skills and methods to set-up and develop your own research project
- Design-studio based activities, including tutorials, will then allow students to develop their own assignment

Teaching methods

The 6 CFU course is structured on 37 hours of lecture and 23 hours of laboratory time for a total of 60 hours. The module is organised through a variety of teaching activities which include ex-cathedra lectures as well as seminars and practice-based activities in the design studio. Students may be given short assignments to unfold concepts developed through theory lectures. The module brief will be distributed at the beginning of the term and will detail what the main assignment consists of. Students will be supported through tutorials in the development of such tasks.

Reference books

- S. Psarra, *Architecture and Narrative,* Routledge 2009.
- G. Sebestien, C. Pollington, *New Architecture and Technology*, Associated Press, Oxford 2003.
- B. Colomina, *Privacy and publicity: modern architecture as mass media*, Cambridge Mass MIT, London 1994.
- C. Van de Ven, *Space in architecture: the evolution of a new idea in the theory and history of the modern movements*, Van Gorcum, Assen 1980.
- M. Pearce, N. Spiller (eds.), *Architects in Cyberspace* London 1995.
- L. Spuybroek, *NOX Machining Architecture,* London 2004
- K. Oosterhuis, *Hyperbodies. E-motive Architecture*, Birkhauser 2003

Texts for further study

- Ioanni Delsante, *Innovazione tecnologia e architettura*, Santarcangelo di Romagna, 2008 (italian)

Learning Evaluation Methods

The module is based on the idea students will learn throughout the term and via various tools/methods, so the final examination represents only the final stage of such a process. In fact, students will have several opportunities to interact with staff during tutorials but will also be encouraged towards peer-to-peer learning (via group discussions, group presentations and crits). Students will be asked to respond to the proposed brief with their own ‘research project’ and present a final portfolio in both digital and printed versions. The oral discussion will be based on portfolio contents’ as well as on students’ critical understanding of theoretical approaches.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

2 Digital model production for architecture and gamification

CLASS NAME

DIGITAL MODEL PRODUCTION FOR ARCHITECTURE AND GAMIFICATION

Prerequisites

Students are expected to have already developed in their bachelor programm:

- Fundamentals of architectural representation, fundamentals of descriptive and projective geometry. Parallel and central projections, fundamentals of aided design.
- Fundamentals of architectural surveying, knowing how to interpret the relation between shape and measurement. Fundamentals of digital documentation.
- Fundamentals of three-dimensional representation of the built environment, fundamentals of NURBS modelling, fundamentals of Mesh modelling from reality-based processing.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The course aims to provide knowledge useful for analysing, developing and producing three-dimensional models and interactive systems in the field of architectural heritage. Throughout the course, the student will address the topic of digital reproduction of real settings and constructions and explore topics related to processes, methods and tools suitable for developing integrated operational workflows. In this way, the student will be encouraged to consolidate his or her own critical awareness of the topics covered in the course. Through theoretical lectures and practical exercises, the objective of the course is to provide a range of operational possibilities for the creation of three-dimensional digital models, analysing the problems related to the production of renderings, the management of information layers and the development of systems of use and interaction within the developed models. Through this process, the student will be able to combine learning about the subjects of 3D digital work production with a process of building knowledge related to the development of media languages for the virtual narration of architecture. In this way, the student will acquire a solid background in the fundamentals of 3D modelling, digital media integration, and the development of immersive and interactive experiences through virtual communication systems for Cultural Heritage.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student should know:

- Terms and definitions of the 3D modelling language.
- The different types of 3D models, knowing how to recognize the qualities and graphical properties of each.
- The most useful tools for processing digital models for architecture, as well as the language of digital forms for interacting with different 3D modelling software.
- The main forms of visual simulation of history and the most used rendering techniques.
- The methods and techniques for developing systems for interacting with digital models.
- Digital systems dedicated to interactive storytelling of architecture, knowing how to evaluate the limitations, purposes and expressive potential of each.
- The theoretical origins of game-based learning and gamification, developments, main models and application fields.
- The methods of developing a Virtual Reality application, from the modelling stages to the structuring of an interaction system, according to the typical purposes of gamification.

Program and content

The course is organized according to a division of topics into three didactic modules: the first related to digital modelling for the representation of real architecture and environments, the second deals with the topic related to the digital translation of the features of environments, the topic of visual simulation and its historical and technical evolution, and the third related to the possibilities of gamification, with the development of systems of interaction and virtual use of the models, with a focus on the perceptual aspect.

Lectures are combined with practical exercises and laboratory activities to succeed in providing theoretical content and technical skills useful for the development of digital products.

The lectures aim to guide the student on a process of knowledge and critical ability on the nature of the topics covered. During the first module the student will cover the basic content on the different ways of developing NURBS and Mesh models, analysing for each the different advantages and disadvantages with respect to the possible purposes of architectural modelling. Theoretical knowledge is combined with practical modelling activities (E1, E2) with different software useful for the management and development of reality-based and *ex novo* models.

During the second module, the student will address issues related to the spatial analysis of places and settings, to provide him or her with the cognitive basis for the transposition of real environments within the digital scene. In this way, it will be possible for the student to learn the concepts related to visual simulation and its evolution from analogue to digital systems, with an in-depth look at the most modern virtual simulation techniques. The theory will be combined with practical exercises (E3) related to characteristics recognition of environments and their digital translation through real-time rendering systems.

Regarding interaction with models and gamification possibilities for the enjoyment of the models, the course covers an examination of the methods of interaction with virtual spaces through the possibilities of populating the models with varied content and how to access them. The theoretical lectures are deepened by practical exercises related to the development of basic AR and VR applications (E4).

Lecture content list:

Part 1 - Three-dimensional modelling and digital representation for architecture

Course overview. Introduction to the basic concepts of 3D graphics. History of the evolution of three-dimensional modelling: from wooden models to digital models.

- Reality based products and development of environments from scratch. Modes of software interaction and integration of procedures for data optimization. Advantages and disadvantages applied to architectural representation.

Part 2 – Visual Simulation. Duplication of reality between analogy and illusion

Space in the digital scene. Considerations on proportions of shapes and different dimensions perceived in digital space between issues of atmosphere and motion. The construction of a language through the characterization of scenarios. Digital settings and qualification of scene elements between images and corresponding forms.

- Introduction to the topic of visual simulation. Historical evolution of the concept of simulation: from perspective to virtual reality. Techniques for defining the visual rendering of 3D models. Advantages and disadvantages of rendering.

Part 3 – Gamification Techniques: the systems of use and interaction of digital models

Introduction to virtual interaction systems and Gamification. Brief history of video games. Structure and elements that make up a video game. Interaction and narrativity.

- Methods of model interaction and navigation. Platforms for developing interactive environments. Tools for digital enjoyment of models (Virtual Reality, Augmented Reality and Mixed Reality).

Exercise content list:

E1. Introduction to the use of 3D NURBS modelling software. From vector drawing to three-dimensional model: modelling techniques using Rhinoceros software. From primitive models to the development of complex models.
E2. Introduction to the use of 3D Mesh modelling software. Digital sculpting operations on high-poly mesh and construction of digital landscape through an additive or subtractive mechanism (Blender software).
E3. Feature analysis of symbolic environments. Introduction to rendering engines (Lumion, Twinmotion) and scene animation techniques.
E4. Development of an AR application (Unity 3D). Introduction to the use of software for the use of digital models (Unreal Engine 4.0).

Description of laboratory activities

During laboratory sessions, students will work in the classroom on in-depth theoretical knowledge and practical applications related to model development and different techniques for sharing and interacting on digital environments for architectural representation using open source softwares (such as Unreal Engine or Unity). The course will annually propose a monographic theme that each student will develop during laboratory hours. The theme will cover the creation of a 3D model of an architectural system and the creation of a way to enjoy it through different virtual reality solutions.

Teaching methods

The 6 CFU course is structured on lecture, exercise and laboratory. The lectures are constructed by offering a sequence of in-depth topics that address the main problems of 3D model representation and development, illustrating examples and comparing different workflows. The exercises are focused on verifying the learning of the course content, proposing a course of exercises aimed at verifying the actual knowledge of the skills acquired. The laboratory activities are configured as a moment of active discussion between students and professor during which they develop their modelling work that will be presented in the exam.

Reference books

Module 1 - Three-dimensional modelling and digital representation for architecture

- F. Melendez, *Drawing from the Model: Fundamentals of Digital Drawing, 3D Modeling, and Visual Programming in Architectural Design*, London 2019.

Module 2 – Visual Simulation. Duplication of reality between analogy and illusion

- Ch. Norberg-Schulz, *Genius Loci: towards a phenomenology of architecture*, New York 1979.
- P. Fuery, K. Fuery, *Visual Cultures and Critical Theory,* New York 2003.
- R. Arnheim, *Art and visual perception. A psychology of the creative eye/New version.* Berkley, 2004

Module 3 – Gamification Techniques: the systems of use and interaction of digital models

- M. Ioannides, N. Magnenat-Thalmann, G. Papagiannakis, *Mixed Reality and Gamification for Cultural Heritage*, New York 2017.
- E. Champion, *Critical Gaming: Interactive History and Virtual Heritage*, London 2015.
- S. M. La Valle, *Virtual Reality*, Cambridge 2017.

Handbooks and guides

- T. Shannon, *Unreal Engine 4 for Design Visualization: Developing Stunning Interactive Visualizations, Animations, and Renderings*, Boston 2018.
- R. Wells, *Unity 2020 By Example: A project-based guide to building 2D, 3D, augmented reality, and virtual reality games from scratch* (3rd Edition), Birmingham 2020.

- J. M. Blain, *The Complete guide to Blender graphics: computer modeling & animation*, London 2021.

Learning Evaluation Mehods

Checking of acquired knowledge will take place through the exercises to be developed by the student during the course. These are articulated in such a way as to review the topics covered during the lectures constituting practical moments of verification and comparison of the skills acquired. The course laboratory is designed as a moment of open work in which students will interface with the professor through a learning-by-doing process.
The course contemplates in the exercises a series of small tests to verify the knowledge acquired, representing a moment of comparison with what has been deepened in the laboratory hours. The monograph topic assigned to each student will provide a way to develop a product that the student will submit in the exam.
The examination is held through a presentation by the student of the work done during the lab, presenting his or her modelling project, and through an oral examination of the skills acquired.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

3 Digital Light Design

CLASS NAME

DIGITAL LIGHT DESIGN

Prerequisites

Students have to be able to use techniques and tools of the design of architectural and building artefacts and, with regard to aspects of lighting engineering, to have basic knowledge of systems acquired during the bachelor degree.
Students are expected to have already developed in their bachelor programm:

- Basic knowledge of optics
- Basic knowledge of principles of architectural representation
- Fundamentals of compositional aspects inherent in the design of architectural spaces.

Training objectives

The course provides the development of technical-scientific skills inherent to the design of lighting systems and the development of digital simulations through the use of Virtual Reality. Within the course the student will face a series of lectures dealing with the principles of lighting engineering applied to several case studies in order to foster the development of critical and design skills on lighting systems. The different lighting sources applied to different contexts and environments required a knowledge of the lighting system properties (colour, intensity, brightening and dimension of the lighting spot) to favour situations of visual comfort, according to the national and international regulations requirements.
Through the development of virtual spaces, the course will focus on the simulation of lighting systems using specific softwares to simulate the digital light. The development of renderings and simulations will initiate a dialogue between students and lecturers on the role of light within digital settings and on the various problems related to lighting. The light will be understood as a material that composes architectural space. The course includes an in-depth study of the light as a generator of spaces and languages for architecture. The course will address the theme of video mapping as a tool for the regeneration, reinvention and enhancement of urban spaces and cultural heritage.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

By the end of the course the student should know:

- The use of digital tools for the simulation of lighting fixtures.
- The technical regulations related to the lighting design of spaces.
- The methods and tools for a correct design of space lighting systems.
- How light propagates in real space and in digital space.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

Students will know and learn the tools used in the field of lighting design; they will be able to apply the knowledge acquired in the design of real and virtual space, using tools that are useful and able to enhance environments.
Students will learn real time video processing and 2D and 3D projection mapping techniques using open-source or University-licensed educational software (e.g. Isadora and MadMapper), while studying the historical and contemporary use of projection in performance, architecture and visual art. By the end of the course the student should know:

- Design a real and digital lighting system.
- Elaborate digital models for the simulation of lighting bodies.
- Program models for video mapping.
- Elaborate technical reports using languages proper to lighting engineering.

Program and content

The course is structured in three parts that address the problem of light and its design. The course explores the technical and artistic aspects of mapping and designing projections to articulate environmental and architectural space. Focusing on the theme of projected media environments, students will develop a project that has a physical and emotional impact on the viewer, either as a large-scale installation or performance or as an integrated element of architecture. Students will learn real-time video processing and 2D and 3D projection mapping techniques using open-source or licensed educational software, while studying the historical and contemporary use of projection in performance, architecture and visual art.

Part 1 Fundamentals of lighting engineering

- Physical characteristics of light and photometric quantities.
- Types of light sources and their application in different architectural environments.
- Standards for visual comfort in closed and open environments.
- Photometric quantities, units of measurement and the relationship between them. Illuminance from point, linear and extended sources. Radiometry, photometry, colorimetry.
- Natural lighting and colour rendering.
- Light sources and control systems: luminaires.
- Introduction to light design.

Part 2 - Designing light within digital spaces

- Light as a material component for the design of architectural space
- Overview of software for the simulation of lighting systems.
- Setting up light sources.
- Light in motion.
- Visual comfort in digital environments.

Part 3 - From digital to real: video mapping and light as a language for architecture

- Introduction to video mapping technique.
- Lighting and video mapping for cultural heritage
- Overview of existing video mapping software (e.g. Resolume Arena).
- Creative content and case studies to test the techniques learned on different surfaces.
- Design and planning of a video mapping installation using different spaces or models.

Teaching methods

The 6 CFU course is structured on lecture, exercise and laboratory. The lectures are constructed by offering a sequence of in-depth topics that address the main problems of light analysis, simulation and design. The exercises are aimed at familiarising the student with software and tools through the development of problems related to the lighting of digital spaces and the different perception that such lighting can generate in the user of such architectures. The laboratory activities will focus on the development of one's own lighting project on a digital architecture, developing static and dynamic proposals of light sources.

Reference books

- M. D. Egan. *Concepts in Architecture Lighting*, New York 1983.
- H. Köster, *Dynamic daylighting architecture, Basics, Systems, Projects*, Basel-Boston 2004.

- D. Maniello, *Augmented Reality in Public Spaces. Basic techniques for video mapping*. Vol.I., Brienza 2014.
- L. Lanier, *Aesthetic 3D Lighting: History, Theory, and Application*, London 2018.
- Illuminating Engineering Society, *IES Lighting Handbook* (various editions, publishers, years.)

Texts for further study

- Regulation (CE) n. 244/2009.
- Regulation (UE) n. 1194/2012.
- Guideline 2010/30/CE.

Learning Evaluation Methods

At the end of the course, the student will take an oral examination aimed at verifying the knowledge acquired during the lessons. In the exam, the student will present their own lighting project, which will be assessed. The laboratory activities and exercises will contribute to providing a constant dialogue between students and lecturers, facilitating the mechanics of learning and comparison. The development of a practical exercise will enable technical skills to be acquired through the principles of learning-by-doing.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

4 Graphic and photography for architecture

Module 4A - Graphic and Image Editing

Module 4B - Architectural Photography

CLASS NAME

GRAPHIC AND IMAGE EDITING

Prerequisites

Students enrolled in this course are required to have appropriate basic knowledge of the Drawing of architecture and composition disciplines acquired in the Bachelor programm. In particular, the student should possess knowledge of:

- Basic descriptive geometry (orthogonal, axonometric, and perspective projections).
- Freehand drawing.
- Notions of the main artistic techniques both chromatic and graphic.
- Image processing, and vector graphics software (Autodesk AutoCAD, Adobe Photoshop).

Training objectives

The course teaches how to plan, analyse, design, and create visual solutions to communication problems using images.
The course will address the topic of digital storytelling through images. Theoretical lectures will cover the meaning and use of Graphics from antiquity to the current day. During laboratory activities, the student will experiment with tools and languages to elaborate their own communicative message through image editing.
The aim of the course is to provide the student with a range of digital communication possibilities, thanks to which he/she will be able to analyse and respond to problems related to the field of typography, the Internet web, marketing, and advertising graphics.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

At the end of the course the student should know:

- History of Graphic Design and digital image processing.
- Ways and tools for narrating a digital communicative message.
- Tools for producing and processing a digital image.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student should know:

- Use appropriate vocabulary and language properties to describe the history of Graphic and Digital Visual Communication.
- Acquire critical sense and independence in evaluating the effectiveness of a communicative message.
- Correctly apply image editing tools and techniques to produce an effective visual message.
- Develop a digital narrative from which to develop valid outputs for multiple areas of visual communication.
- Manage 2D graphics programs.
- Manage the creative and development process of a graphic product.

Program and content

The course addresses the History of Graphics and how it can be applied in the field of digital communication. Enrolees will study Drawing as a communicative tool and as a basis for the production and processing of digital images. The course will cover the importance of mark-making and the use of colour in hand drawing, digital drawing, illustrations, and photographic images. These

operations will be carried out both on historical or existing images and on images produced within the course. The focus of the course is to provide an understanding of the value and use of such systems for visual communication. The course aims to provide the tools for the elaboration of digital products capable of interacting with corporate graphics.
The lectures are divided between theory and practice, to enable students to acquire the necessary notions to be able to critically analyse and describe a visual product.
The course will cover: the basic contents for image editing using dedicated software (Open source software or educational licences); the contents to produce 2D graphics Open source software or educational licences); and the contents for publishing and page layout (Open source software or educational licences), analysing for each the different advantages and disadvantages with respect to the possible purposes of architectural communication. During the lectures, paper media (sheets of different formats for freehand drawing, then digitised) and digital media (Pcs and graphics tablets) will be used to also enable an integrated hybrid approach between freehand and digital drawing.

List of lesson contents

- Overview of the history of Graphic Design and Visual Communication.
- Digital communication in products (lettering, signage, graphic design, visual design, web design, etc.).
- Digital images, characteristics, and critical analysis of the digital image (format, quality, use).
- The tools, software, and Apps for digital image production (drawing and photography).
- Sign and digital drawing, techniques, and software for drawing digitally.
- Colour theory in the digital field.
- The 2D Digital Drawing, modes, and purposes of communication.
- Digital image editing (drawing and photography).
- The structure of a communicative message.
- Storytelling. Analysis of comics and illustration for narrating a visual message.
- Digital formats, layout for web and print.
- The digital product for printing. Typography fundamentals (fonts, formats, products).
- Layout software.
- The portfolio.

Description of lab activities

During the laboratory hours, students will work in the classroom on the deepening of practical knowledge related to the development of digital graphic products.

- The 2D vector drawing (Open-source software or educational licences).
- The raster drawing and editing of 2D images (Open-source software or educational licences).
- The storytelling and portfolio.
- The graphic layout for printing.
- The graphic layout for the web.

Teaching methods

The 3 CFU course is structured on theoretical lecture and laboratory activities. Each theoretical lecture is combined with a practical laboratory activity, subject to evaluation, to be carried out in the classroom during laboratory hours. Individual work activities are planned outside the classroom, especially about theoretical study aimed at filling any knowledge gaps in the basic disciplines.

Reference books

- J. Albers, *Interaction of Color*, New Haven 2013.
- M. Bierut, *How to use graphic design to sell things*, London-New York 2015.
- E. Lupton, J. Cole Phillips, *Graphic Design*, New York 2015.

Learning Evaluation Methods

During the course, the student will develop practical laboratory tests to verify the knowledge acquired. The tests cover the topics discussed during the lectures, constituting practical moments of testing and comparing acquired skills. A test will be given for each topic covered. In this way, the student will be able to check his understanding from time to time, also comparing himself with the expert staff present in the classroom, according to a "learning by doing" method of teaching. Practical tests in the laboratory will be used to develop, step by step, thematic portions of a macro-topic. Upon completion of the individual laboratory activities, the student will bring his or her product as monographic examination material.
For the exam, the student will prepare a presentation of what they have accomplished during the lab, showing their graphic design and product communication project, and will take an oral examination on the acquired skills.

Other information

-

CLASS NAME

ARCHITECTURAL PHOTOGRAPHY

Prerequisites

Students are expected to have already developed in their bachelor programm:

- Basic knowledge of representation of architectural space and the typological, morphology and material understanding of the built environment.
- Basic knowledge of digital image management software.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

Ever since the invention of photography, architecture has been a notable subject for photographers and likewise, photography has played an important role in the way architecture is communicated and perceived. Every picture has a meaning, it not only represents the visual aesthetics and materiality but also how space is perceived without physically being in it, thus it has the capability to convey feelings and emotions.
The photographic representation of architectural space is understood as a critical mode of spatial, morphological, and typological understanding of the built space, both in relation to the surrounding landscape and in relation to the structuring and articulation of the interior space.
The course aims to provide tools and skills for the critical reading and the autonomous realisation of photographic images of architecture, both outdoor and indoor, with a level of autonomy adequate to realise independently a photographic documentation focused on specific purposes.
The course will address topics related to techniques and equipment, giving meanwhile importance to space, materiality, details, and form

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course students shall know:

- Critically understand photographical representation of architecture.
- Manage instruments and tool for plan, develop and post-process photography architecture.
- Integrate compositional skills with the understanding of typological, morphological, and material aspects of the building.

Program and contents

The course is organised in 4 main topics, each structured in 3 or 4 hours of frontal lessons:

- Fundamentals of architecture photography, from concept to post-production.
- Historical evolution of architectural photography between aesthetics, language, and representation.
- Outdoor architecture photography: methods, techniques, and interpretative tools.
- Indoor architecture photography: methods, techniques, and interpretative tools.

The course will also offer 23 hours applied laboratory where students will be asked to develop a personal portfolio, applying to real contest the topics of theoretical lessons. The laboratory will

include photography sessions, and critical readings of the students' work, and will produce a final photo exhibition.

Teaching methods

The 3 CFU course is structured on lecture and laboratory. Each theoretical lecture is combined with a practical laboratory activity, subject to evaluation, to be carried out in the classroom during laboratory hours.

Reference books and literature

- M. Harris, *Professional Architectural Photography*, Focal Press 2001.
- A. Hausberg, *Construction and Design Manual, Architectural Photography*, Dom Publishers, Berlin 2012
- A. Schulz, *Architectural Photography, 3rd Edition: Composition, Capture, and Digital Image Processing*, Rocky Nook ed., San Rafael 2015.
- J. Ewing, *Follow the sun: A Field Guide to Architectural Photography in the Digital Age*, Routledge, London 2016.
- G. Basilico, *Metropoli*, SKIRA, Losanna 2020.

Learning test

The module is based on the idea students will learn throughout the term and via various tools/methods, so the final examination represents only the final stage of such a process. In fact, students will have several opportunities to interact with staff during tutorials, and exercises but will also be encouraged towards peer-to-peer learning (via group discussions and group presentations). Students will be asked to deliver a final portfolio including the results of laboratory activities. The oral discussion will be based on these results as well as on students' critical understanding of theoretical approaches.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

5 Communication by Images for Video Storytelling

CLASS NAME

COMMUNICATION BY IMAGES FOR VIDEO STORYTELLING

Prerequisites

This is a basic course in multimedia application development and is a natural continuation of the course in “Graphic And Image Editing” Prerequisites: skills in freehand drawing of architecture and composition disciplines acquired in the Bachelor programm.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

By the end of the course, the student should know the main tools for managing a multimedia product in terms of acquisition and file processing.
He/she should be familiar with video capture techniques and have a sensitivity about the management of video products in terms of spatial and temporal analysis of the visual message.
The student will acquire a basic knowledge to develop a multimedia product reflecting particular architectural narratives. The drawing becomes a fundamental element in the development of an image-based narrative process. The narrative of architecture is structured through sequences of drawings considering a narrative progression, in a temporal order, intended to qualify a storyboard. The drawing of architecture confers critical capabilities in prefiguring spaces, scenarios and architectural compositions.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student should know:

- Develop a storyboard for the creation of a video sequence.
- Manage a video shooting medium and handle the different types of input and output files.
- Adjust the video components affecting a media file.
- Have knowledge of using video editing software.

Program and content

This course covers the fundamentals of digital storytelling and video editing for defining digital and multimedia products related to architecture. From the analysis of the digital video image, the course addresses storytelling and scripting of the visual message by analyzing the timing, pace, and mechanics of visual communication.
Students will learn about the techniques of editing and graphic composition of a short film, develop technical and creative skills, and apply theoretical concepts in a practical way to drawings and 3D models of architecture.
The course introduces the basic theoretical concepts and technical tools for audiovisual product development, with the aim of providing an overview of creative media. The first part of the course covers the fundamentals of picture storytelling theory and analysis of the main aspects of screenwriting and digital storytelling production. The second part includes the production of a short film. Students will employ video cameras, stabilizers, lighting, and major video editing software. The discipline introduces both theoretically and practically the basic principles behind editing. The student develops a visual storytelling project after alternating between lectures and laboratory activities. In this way, he/she explores a variety of processes, both experimental and established, employed in the development of a screenplay, and deepens his/her knowledge of audio-visual storytelling. Drawing becomes the discipline through which to control time. The student will be able to concretize orientation skills in the operation of multimedia products through the development of creative experiences.

List of lesson contents:

- From idea to storytelling, drawing as support for time management.
- Defining a script from objectives to 'idea, structure, and layout.
- Drawing and linear storytelling in animation composition.
- Software and workflow for an understanding of post-production processes.

Description of lab activities

The course enables the development of technical and operational skills hand in hand with artistic and creative expression through the constant practical application of theoretical concepts. Students complete their communication skills through direct comparisons with teaching staff.
The course will provide students with a range of cross-disciplinary skills necessary to generate video and film products useful for promoting architectural projects or narrating existing architecture.
Lab activities will involve the creation of a short video. Students will be required to produce a storyboard, capturing the images and footage, and will have to compose elements of graphics, text, drawings, and 3D models into a short video.

Teaching methods

The 3 CFU course is structured frontal lessons and laboratory.
Theoretical lessons include the projection of videos, the commentary of the different scenes, the analyses of the relationship between visual message, filmic time, and architectural scenes. The student will know examples of abstractions and interpretations of architectural space through the main techniques of video use of space. During the laboratory activity, the student will produce a video, through the development of a short storyboard and the acquisition of videos with different types of cameras (possibly provided by the educational laboratories).
The student will use the laboratory hours to create his own video project and assemble the shooting scenes with the support of the sound component, developed during the “Sound And Multimedia Compositions” course.

Reference books

- M. Hanson, *The end of Celluloid. Film Features in the Digital Age*, Mies 2004.
- D. Bordwel, *The way Hollywood Tells It. Story and Style in Modern Movies*, Berkley-Los Angeles-London 2006.
- A. Cameron, *Modular Narratives in Contemporary Cinema*, New York 2008.
- C. Beach, *A Hidden History of Film Style*, Los Angeles 2015.

Learning Evaluation Methods

During the course, students will carry out practical tests to verify knowledge.
Students will have moments of dialogue and individual review with the teaching staff.
During the exam, students will talk about the developed multimedia project according to three different points of view:

- The story of the idea, through the storyboard.
- The story of the making of the video, of the different shooting and editing techniques.
- The product, the short film made.

The commission will discuss and comment on three points, asking questions about the theoretical contents of the lessons. For the exam, the student will prepare a presentation of what they have accomplished during the lab, showing their graphic design and product communication project, and will take an oral examination on the acquired skills.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

6 BIM and Digital Management of Architectural Heritage

Module 6A – BIM Systems and Digital Asset Management

Module 6B – BIM and H-BIM Modelling

CLASS NAME

BIM SYSTEMS AND DIGITAL ASSET MANAGEMENT

Prerequisites

To conduct the course, students are required to possess adequate knowledge in the field of digital modelling design acquired in the Bachelor programm. In particular: theoretical knowledge on architectural representation; methods of critical analysis and expressive synthesis of architecture and its context; architectural survey bases and the relationship between geometry and measurement; knowledge of Autodesk AutoCAD software (basic level).

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The course deals with overcoming design and planning challenges in cultural heritage knowledge, conservation and management process in a lifecycle perspective, focusing on H-BIM based approach, which will be analysed as a necessary tool during both the design and the management phase, as well as during the proper intervention phase. Having access to the right information at the right time has been and remains a pervasive problem during operations and maintenance (O&M) and thus hinders an asset owner's ability to ensure their facilities performance is being optimised. Typically, asset managers are often confronted with 'As-built' documentation that is prepared using Computer-Aided-Design (CAD) and is often incomplete, erroneous and/or redundant, which adversely impacts an asset's integrity and productivity during O&M. The aim of the course is to give an overview concerning the development of structured and innovative methodologies for the management of cultural heritage by means of HBIM models digital twins, the management of scheduled planned conservation strategy and the setting up of a BIM-oriented Asset Management platform.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course students shall know

- Which kind of information may be included within a H-BIM model;
- How integrate an H-BIM model within the diagnostic/design/management process;
- How to manage H-BIM model in perspective of innovative digital asset management tools.

Program and content

The BIM methodology can be a bridge between archival documentation, architectural survey and digital model, proving to be an effective tool as a semantic data archive, consisting not only of geometrically correct elements but also of alphanumeric and digital attributes (texts, multimedia files, URL links, etc.). The HBIM models are understood as data hubs that in the documentary field, can represent the historical artefacts taking into account the past and the present as a result of constructive transformations, enlargements and changes of use in a wide time span. HBIM models can be constructed from three-dimensional data derived from digital surveying techniques, such as laser scanner and photogrammetry. The process, called reverse engineering, no longer has the goal of translating geometric survey into two-dimensional plans, elevations and sections, but rather is a starting point for three-dimensional modelling, striving to move from solid to parametric objects, described geometrically and semantically.
The course is organized in 6 topics as following:

- Digital asset management: a global overview.
- BIM models for cultural heritage: a support for knowledge integration within the decision process.

- BIM models for cultural heritage and planned conservation: multi-dimensional models.
- BIM models for cultural heritage as a support tool during the construction site activities.
- BIM models and innovative data acquisition techniques.
- H-BIM models and digital twins.

Teaching methods

The 6 CFU course is structured on lecture and exercise.

Reference books

- R. Letellier, *Recording, Documentation, and Information Management for the Conservation of Heritage Places*, Los Angeles 2007.
- J. L. Pedersoli, C. Antomarchi, S. Michalski, *A Guide to Risk Management of Cultural Heritage*, Roma 2016.
- E. C. Giovannini, *Virtual reconstruction information management*, 2017.
- N. Bruno, *From Survey To Analysis for Cultural Heritage Management: a New Proposal for Database Design in Bim*, Parma 2017.
- F. Chiabrando, V. Donato, M. Lo Turco, C. Santagati, *Cultural heritage documentation, analysis and management using building information modelling: State of the art and perspectives*, [online] 2018.
- S. Bruno, A. Musicco, F. Fatiguso, G.R. Dell'Osso, *The Role of 4D Historic Building Information Modelling and Management in the Analysis of Constructive Evolution and Decay Condition within the Refurbishment Process. International Journal of Architectural Heritage*, [online] 2019.
- R. Garozzo, M. Lo Turco, C. Santagati, *Information Models to Manage Complexity for an Integrated Knowledge Project.* Roma 2019.

Other specific bibliography will be selected from archives of several index of publication, organisations, and associations, which are active in education and research in the field of Computer-aided architectural design (CAAD) of which main references among many others are:

- Cumulative index of publications about computer aided architectural design. http://papers.cumincad.org
- Association for Computer Aided Design in Architecture. http://acadia.org
- Association for Computer Aided Architectural Design Research in Asia. https://www.caadria.org
- Association for Education and Research in Computer Aided Architectural Design in Europe http://ecaade.org

Learning Evaluation Methods

The module is based on the idea students will learn throughout the term and via various tools/methods, so the final examination represents only the final stage of such a process. In fact, students will have several opportunities to interact with staff during tutorials, and exercises but will also be encouraged towards peer-to-peer learning (via group discussions, group presentations and crits). Students will be asked to deliver a final report including the results of tutorials and exercise work. The oral discussion will be based on these results as well as on students' critical understanding of theoretical approaches.

Other information

-

CLASS NAME

BIM AND H-BIM MODELLING

Prerequisites

To conduct the course, students are required to possess adequate knowledge in the field of digital modelling design. In particular: theoretical knowledge on architectural representation; methods of critical analysis and expressive synthesis of architecture and its context; architectural survey bases and the relationship between geometry and measurement; knowledge of Autodesk AutoCAD software (basic level).

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

At the end of the course the student must know the different communication and representation methods on parametric modelling platforms. The student must be able to formulate a shared project and to manage the digital files produced during the workflow. The student will be able to relate to the geometric shapes of architecture through parametric modelling and will know the main hierarchies of approximation and definition of levels of detail for the development of a BIM model.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student must know:

- Work on parametric modelling software.
- Define the parametric families of a built-in digital information system.
- Create a scan-to-BIM model.

Program and content

The course deals with the issues of BIM modelling applied to Cultural Heritage, for the digitization of built heritage, management and computer-aided design. The course aims to provide the tools and methodologies for the management and critical reading of the data obtained from digital survey, including the use of these data within the HBIM digital parametric modelling procedures.
The training methodology includes lectures alternating with practical exercises and laboratory activities, approaching a case study in a concrete and operational way.

List of lesson contents

- Parametric modelling HBIM: concepts, methods and evolution of digital databases.

The lesson introduces the topic of parametric modelling and scan-to-BIM methods applied to the built architectural heritage. Through an excursus on the types of digital databases and modelling techniques, an updated framework is provided on the protocols and systems of information representation.

- Integrated survey methodologies for the documentation of the architectural heritage.
- Typological classifications for three-dimensional information representation: information categories of the parametric model for Cultural Heritage.
- Scan-to-BIM procedures Management of the point cloud data and parametric modelling strategies.

The lesson deals with the issue of managing point cloud digital data from Autodesk Recap to Autodesk Revit. (*Data import/export, segmentation techniques and data point cloud visualisation, rcs project structuring associated with Revit, point cloud management in Revit*).

- Procedures Scan-to-BIM web based digital platforms and archives and collaborative modelling workflows.

Description of laboratory activities
During the laboratory hours, students will work in the classroom on a specific case study assigned for the deepening of practical knowledge related to the development of the parametric digital model project and the different collaborative modelling techniques for architectural representation.

Teaching methods

The 3 CFU course is structured on frontal lessons and laboratory. The lectures include lessons related to the use of software and the main complexities of modelling and development of a shared modelling workflow. The laboratory activities, on the other hand, concern the development of a practical test in which the acquired knowledge is practically developed and consolidated.

Reference books

Manuals and guides

- C. Eastman, P. Teicholz, R. Sacks, K. Liston, *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors.* 2nd Edition, Hoboken 2011.
- P.F. Aubin, *Revit Essentials for Architecture: 2021 and beyond*, 2021.
- P.F. Aubin, *Renaissance Revit: Creating Classical Architecture with Modern Software,* 2021.

Recommended texts

- M. Murphy, *Historic Building Information Modelling (HBIM) For Recording and Documenting Classical Architecture in Dublin 1700 to 1830*, Trinity College Dublin, 2012.
- C. Bolognesi, A. Villa (eds.), *From Building Information Modelling to Mixed Reality*, Cham 2021.

Learning Evaluation Methods

The verification of the acquired knowledge will concern the delivery of an HBIM project developed on a real case study, assigned during the course. The lectures of the course are structured to guide the student during the practical activities. The laboratory hours are used as practical moments of verification and comparison about the acquired skills. The workshop of the course is conceived as a moment of open work, in which students will interact with the teaching staff through a learning-by-doing process.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

7 Computational Models and Prototyping

CLASS NAME

COMPUTATIONAL MODELS AND PROTOTYPING

Prerequisites

The course proposes a specialisation path focusing on the creation of numerical models for structural analysis and prototyping. The methodological-operational aspects of mathematics and building science and being able to use this knowledge to interpret and describe problems in architecture and construction learned during the bachelor programme.
Students should also have preferrable background on the following disciplines:

- Base of mechanics.
- Heat transfer.
- Properties of materials

Training objectives

The course intends to provide an insight on the creation of virtual models suitable to carry out advanced numerical simulations. Concerning the additive manufacturing processes, the course aims to identify the most appropriate technology for different prototyping activities.
Students will learn basic principles of numerical modelling, by means of theoretical and practical lessons, through case studies dealing with the production of specific prototypes through 3D printing technologies.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The course will provide basic theoretical elements for the understanding of the fundamental concepts underlying 3D printing processes and non-linear numerical simulations. The main additive manufacturing technologies will be described and general indications will be given for the choice of the specific technology and main process parameters for given applications. Particular attention will be paid to the Fused Deposition Modelling and Selective Laser Melting processes and their main related problems will be illustrated, such as thermal distortions and geometrical accuracy. The most common commercial computing environments and numerical techniques to solve the equations governing additive manufacturing processes will be described as well.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

The aim of the course is to prepare future professionals able to deal with numerical-driven approaches for the selection of the most appropriate additive manufacturing technique for prototyping applications. Such professionals will have a background on additive manufacturing techniques and on commercial codes to simulate the processes and predict the overall result.

Program and content

Theoretical lessons according to the following scheme:

- Introduction to additive manufacturing technologies
- SLM technology
- FDM technology
- Main slicing parameters for FDM processes
- Generation of the G-code
- Introduction to the finite element method
- Solution of non-linear thermal problems
- Elastic and plastic constitutive models
- Solution of mechanical problems with elastoplastic materials

- SLM and FDM process simulation: weakly coupled thermomechanical problems, mesh, assumptions and lumped models

Hours of practice:

- Introduction to STL file management software (Educational Licence software such as Autodesk Netfabb)
- FDM: slicing software (Open source software such as Slic3r - Cura) and choice of process parameters
- FDM: gcode generation and analysis
- SLM: object orientation and support design (Educational Licence software such as Autodesk Netfabb)
- FDM process simulation (Educational Licence software such as Ansys): case study of interest
- SLM process simulation (Educational Licence software such as Ansys - Amphyon): case study of interest

Teaching methods

The 6 CFU course is structured on lecture and exercise. The course will include both theoretical and practical lessons. Practical lessons will involve the use of commercial software and numerical simulation codes.

Reference books

Slide and in-depth material provided by the teacher.
Some reference texts:

- I. Gibson, *Additive Manufacturing Technologies*, Cham 2021.

Texts for further study

- F.Auricchio, S. Marconi, G. Alaimo, *Materiali per la stampa 3D: possibilità attuali e prospettive future,* in Stampa 3D di C. Galli e A. Zama, Bologna, 2014 (italian)

Learning Evaluation Methods

The learning assessment will include a practical test with exercises and the development of a project (possibly carried out in small groups).

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

8 Web and multimedia technologies

CLASS NAME

WEB AND MULTIMEDIA TECHNOLOGIES

Prerequisites

Basic knowledge of Internet technologies (client/server architectures, protocols, etc.).

Training objectives

The student must be able to:
- Understand the theoretical and practical bases of web technologies and of on-line and off-line multimedia;
- Apply web and multimedia technologies to build static, dynamic, and interactive websites;
- Critically select the best web and multimedia technologies depending on the application contexts.

Program and content

- On-line/off-line Multimedia:
  - Images and graphics: color, bitmap graphics (global/local/pixel-level editing), vector (object-oriented) graphics, overview of graphic formats (characteristics, use), graphics for the Web (requirements, tools);
  - Digital audio: characteristics, formats, use;
  - Digital animation: bitmap animation, vector animation;
  - Digital video: formats, non-linear editing, requirements for the Web;
- Elements of off-line Multimedia.
- World Wide Web:
  - HTML language;
  - Cascading Style Sheets (CSS);
  - XML technologies;
  - Client-side interaction (JavaScript, Java);
  - Server-side interaction (CGI programs and application servers);
  - Content Management Systems (CMS);
  - Web 2.0;
  - Semantic Web;
  - Some HTML/CSS/JavaScript templates and frameworks;
  - Elements of Web Styling, Usability, Accessibility, and Information Architecture.
- Advanced forms of interaction in Multimedia:
  - Mobile technologies;
  - Elements of (immersive/non-immersive) virtual reality, augmented reality, telepresence, and perceptual interfaces.

Teaching methods

The course is structured into theory lectures and practical classes.

Reference books

Mainly slides and links to on-line material.

Learning Evaluation Methods

Written test composed of open questions and exercises (optionally followed by an oral exam) and project (implementation of a dynamic website).

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

9 Human computer interaction

CLASS NAME
HUMAN COMPUTER INTERACTION

Prerequisites

Training objectives

Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. This course includes both theoretical material and practical approaches to designing user interfaces. In the lectures, the two will be combined.

Program and content

- Introduction to HCI
- The human
- Input-output channels, human memory, thinking: reasoning and problem solving
- Accessibility techniques
- The interaction
- Models of interaction, ergonomics, interaction styles, elements of the WIMP-interface, interactivity
- Paradigms for interaction
- Interaction design basics
- The process of design, user focus, navigation design, screen design and layout
- Usability engineering
- Design rules
- Usability priciples, guidelines, standards, design patterns
- Evaluation techniques, through expert analysis and through user participation

Teaching methods

The course is structured into theory lectures.

Reference books

Textbook: "Human-Computer Interaction" (3rd Edition). Prentice Hall. By A. Dix, J. E. Finlay, G. D. Abowd and R. Beale. ISBN: 0130461091 ISBN-13: 9780130461094

Learning Evaluation Methods

Written exam at the end off the course: short “open” questions. Attending 75% of lessons: optional project (adds 1-3 points) Optional ten-minutes powerpoint presentations during the lessons (1 point)

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

10 Elements of critical listening and audio production for images and VR

CLASS NAME

ELEMENTS OF CRITICAL LISTENING AND AUDIO PRODUCTION FOR IMAGES AND VR

Prerequisites

Students are required to be familiar with personal computers, formats of audio file and basic concepts of acoustics. Previous experience in the use of professional audio hardware (microphones, recorders) and software (linear and non linear Digital Audio Workstations) are welcome but not necessary.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The course aims to provide the theoretical and practical skills necessary to consciously approach the production of sound materials for contemporary multimedia environments. Great attention will be paid to the relevance of critical listening and the ability to analyse and understand the potential role played by sound within traditional and current multimedia contexts. Alongside the theoretical approach to the topic, students will be introduced to the use of professional audio hardware and software. The context of the construction of traditional narratives, based on linear audiovisual materials, as well as that of non linear media, will be explored, with particular regard to game and virtual reality audio. Various approaches to sound spatialization will be presented (mono, stereo, Dolby Surround, Dolby Atmos, Ambisonics).

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

By the end of the course, the student should be able to:

- understand and analyse the role of sound in existing audio and multimedia products;
- apply a critical listening approach to existing audio tracks: differentiation of sound sources, spatial location and sound layering, basic recognition of the most common typologies of signal modification tools (compression, EQ, distortion, delay ecc.);
- correctly choose and use suitable audio recording tools in the most common contexts;
- understand pros and cons, as well as applications, of the main solutions for the sound spatialization;
- use linear and non-linear sound production software at a basic level;
- develop the basic concepts for sound design in existing linear multimedia products and realisation of a cue sheet;
- manage adaptive audio in games and VR using FMOD, within the Unity environment.

Program and content

In traditional and innovative multimedia narratives related to architecture and cultural heritage, the sound component can play a crucial role in the construction of perceived realism and in emotional and sensorial environment shaping. Likewise, poorly designed or produced audio can deprive an otherwise worthy visual product of any perception of quality, realism and attractiveness.This course covers the theoretical and practical fundamentals of contemporary audio production for linear and non linear media, alternating lectures and classroom exercises. It starts with an introduction to sound acoustics and digitization, psychoacoustics and sound in multimedia products, critical listening for audio and audiovisual pre-existing artefacts. The remaining part of the course is divided into three macro areas, addressed both from a theoretical and practical point of view: production and reproduction of sound materials, linear audio in audiovisual production, and non linear audio in game and virtual reality production.

The specific topics are divided by area as follows:

- **Production and reproduction of sound materials**

- recording of ambient sounds using microphones and digital recorders;
- sound manipulation in samplers;
- sound generation using synthesiser;
- sound and virtual spaces: from mono to immersive audio;
- basics of mixing in mono, stereo, surround and immersive formats.

- **Linear audio in audiovisual production**
  - multimedia analysis: from movies and music videos to new media;
  - linear audio in audiovisual production;
  - sonorization of a short audiovisual product.
- **Non linear audio in game and virtual reality production**
  - introduction to game scoring and virtual reality audio;
  - non-linear audio in VR production;
  - sonorization of a VR environment using FMOD and Unity 3d.

Description of lab activities
During lab activities the students will be required to record and manipulate sounds, produce sounds using synthesisers, sonorize a short linear audiovisual product and a VR environment. The technical and operational skills will always be complemented by a particular attention to the ability to critically understand the cultural and production contexts, and the destination of the product. During the practical activities the professors will be present in the classroom, and available to students for discussion and support. Students will be able, if they wish, to continue the practical activities independently and outside the lesson hours. Specific indications will be given regarding the use of commonly available devices (such as smartphones) and free or demo software.

Teaching methods

The 3 CFU course is structured on frontal lessons and laboratory.
Frontal classes include the audio and audiovisual excerpts to be commented and analysed thoroughly, with a specific focus on sound as a semantic component of multimedia. Software for audio manipulation, analysis and annotation will be presented, as well as the main physical and digital tools for ambient recording, editing and sound synthesis.
Laboratories and frontal classes will be interspersed during the course, so as to offer immediate application of abstract concepts and analytical methodologies and to exercise students in various situations of audio editing, recording, and sound design for multimedia. Collective projects and work groups will be suggested as a way to foster peer learning processes and develop a problem-solving attitude to audio production, possibly also in parallel with the activities of the COMMUNICATION BY IMAGES FOR VIDEO STORYTELLING lab.

Reference books

- D. Baxter, Immersive Sound Production: A Practical Guide, New York, Focal Press, 2022.
- M. Enns, Understanding Game Scoring. The Evolution of Compositional Practice for and through Gaming, New York, Routledge, 2022.
- F. Everest, K. Pohlmann, The Master Handbook of Acoustics, New York, McGraw-Hill, 2014.
- D. Kulezic-Wilson, Liz Greene (eds.), The Palgrave Handbook of Sound Design and Music in Screen Media: Integrated Soundtracks, London, Palgrave Macmillan, 2016.
- W. Moylan, Understanding and Crafting the Mix. The Art of Recording, New York, Focal Press 2022.
- C. Robinson, Game Audio with FMOD and Unity, New York, Focal Press 2019.
- M. Senior, Recording Secrets for the Small Studio, New York, Routledge, 2014.
- C. Robinson, Game Audio with FMOD and Unity, New York, Focal Press 2019.
- S. Schütze, A. Irwin-Schütze, New Realities in Audio. A Practical Guide for VR, AR, MR and 360 Video, New York, CRC Press 2018.

- B.K. Shepard, Refining Sound: A Practical Guide to Synthesis and Synthesisers, Oxford, Oxford University Press, 2013.

Learning Evaluation Methods

Grading of the students will take into account their result and participation in the teaching and practical activities carried out during the lab, as well as by assessing their overall knowledge of the main topics presented on the basis of a final discussion of a selected bibliography related to audio production, editing, and sound design for multimedia.
The commission will discuss and comment with each individual student the analysis and critical evaluation on-the-spot of a short audio or audiovisual excerpt, their knowledge of linear editing for traditional media, and of non-linear editing and sound design for 3D and gaming applications.

Other information

--

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

11 Italian language for foreign students

CLASS NAME

ITALIAN LANGUAGE FOR FOREIGN STUDENTS

Prerequisites

Training objectives

Students will be able to:
1.understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type.
2. introduce themselves and others and can ask and answer questions about personal details such as where they live, people they know and things they have.
3. interact in a simple way provided the other person talks slowly and clearly and is prepared to help.

Program and content

Communicative functions: introducing oneself, affirming, denying, asking and saying your telephone number, expressing tastes, introducing and describing someone, asking and giving directions to move around a city, indicating something or someone, asking for personal information, offering, accepting and refusing something, asking and saying the time, describing a city, talking about family, daily activities, and free time, finding out about someone's daily schedules, finding out about someone's plans, making a proposal, accepting and declining an invitation, expressing uncertainty , asking and saying the quantity, making arrangements, expressing tastes, interacting in stores, making a request and responding, giving orders and instructions, describing places and activities, describing object' location in a space.
Lexicon: greetings, expressions with essere e avere, expressions of time, professions, numbers, adjectives to describe nationality, people, food, places, and buildings in a city, means of transportation, musical instruments, food and drink, family, parts of the day, days of the week, adverbs and expressions of frequency and time, free time activities and places, expressions indicating quantity, shops, words to place objects in a space.
Grammar: present indicative of regular, irregular, and reflexive verbs, imperative, passato prossimo and past participle of regular verbs, definite and indefinite articles, gender and number of nouns and adjectives, simple and articulated prepositions, coordinating conjunctions, possessive adjectives, third person direct pronouns and indirect pronouns, piacere, c'è/ci sono.

Teaching methods

Interactive lessons (communicative method). Tasks to be carried out for self-study. Tutoring-workshop meetings held by a tutor.

Reference books

Piantoni, Bozzone Costa, Fumagalli, Volentieri! Corso di lingua e cultura italiana. Livello A1, Loescher, 2021, chapters. 1-5.

Learning Evaluation Methods

Final written and oral exam. The exam can be taken only by those who have attended 80% of the lessons.

Other information

Topics and syllabus of the course may slightly change based on the actual level of competence of the students.

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

12 Methods and Model for Digital Cities

Module 12A – Artificial Intelligence and Advanced Modelling for Sustainable Urban Planning

Module 12B – Economic Urban Assessment

CLASS NAME

ARTIFICIAL INTELLIGENCE AND ADVANCED MODELLING FOR SUSTAINABLE URBAN PLANNING

Prerequisites

Students coming from a bachelor's degree should have acquired the basis of urban planning both from the substantial and the processual point of view.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The teaching aims to give students knowledge and skills about urban modelling and AI theory and tools for spatial planning toward sustainability. The teaching is focused on the Italian and European legislative framework.
The application of models and AI tools are applied to two main fields: analysis and prediction.
From the analytical point of view the history of urban modelling furnishes successful examples for specific fields of application such as traffic management, urban mobility, city growth tendencies, population development spatially located.
From the forecasting point of view, the more the city is considered as a whole, the more its complexity lacks certainty. Considering sustainability SDG goals, the analysis and the forecasting will focus also on the relation between spatial use and environmental impact and on the relation between spatial use and social topics. Students are introduced in the urban modelling world and in the use of multiple models and methodologies aimed to describe as much as possible the complexity of the city.
Students will acquire the capacity to choose existing models or to define new ones according to the goals of city analysis or planning.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

- Students will acquire the capacity to choose existing models or to define new ones according to the goals of city analysis or planning;
- Students will be able to select the appropriate variables to build an urban model;
- Students will acquire knowledge and skills to interpret the urban systems and to formulate suitable models according to predefined planning goals.

Program and content

The teaching is divided in two main parts:

PART 1: Urban modelling history
The first part of the teaching will focus on the first phases of urban modelling from the seventies of the XX century to the nineties.
During this period many models were defined according to the availability of calculation power and data availability. Some of these models are cellular automata, agent based models, expert systems, fuzzy logic, swarm intelligence.
With the growth of the GIS instruments from the nineties on, the description of the territory acquired new possibilities related to the management of territory, the mapping of its spatial functions, and the multilayer weighted mapping.
A specific focus will be deepened about the relation between general models and specific ones.
The first part of the teaching ends with a critical overview of the potentialities of these models and the limits in forecasting. Part 1 will regards:

- Introduction
- Artificial Intelligence solutions for urban land dynamics
    - Artificial Life
        - Cellular automata
        - Agent based model
        - Swarm Intelligence
    - Intelligent Stochastic optimization process
        - Genetic algorithm
        - Simulated Annealing
        - Others
    - Evolution computing and Spatial DNA
        - Artificial Neural Network
        - Spatial DNA
        - Others
    - Knowledge based intelligent Systems
        - Fuzzy Logic
        - Expert system
        - Heuristics Search
        - Reasoning System
    - Discussion
- Main ideas for the review: the need for hybrid systems
    - Hybrid AI systems
    - Future modelling development
- Conclusion

PART 2: Artificial Intelligence perspectives

The second part of the teaching starts with the introduction of deep learning algorithms and other recent AI based tools.

The aim of Part 2 is to let students acquire a sufficient knowledge about the expertise required to manage and design the AI potentialities.

The goal is to compare the deep learning logic with the previous panel of models with specific reference to the forecasting stage.

Another aspect refers to the Big Data management and to the opportunities that emerge in terms of general and specific knowledge of urban phenomena.

Data analytics applied to city management will regard:

- Predictive Analytics (build statistical models that can classify/predict the near future)
    - Traffic-demand forecasting
    - Fault avoidance
    - Planned service provisioning
- Real-Time Analytics (analyse data as it is created to provide instantaneous, actionable business intelligence to affect immediate change)
    - Dynamic policy, self-optimising networks
    - Traffic shaping,
    - Topology change,
    - Live customer care
- Near Real-Time Analytics (analyse indexed data to provide visibility regarding current environment, provide usage reports)
    - Network optimization,
    - New monetization use-cases,
    - Targeted services (location-based)
- Historical Analytics (build data warehouses, run batch queries to predict future events, generate trend reports)

- Campaign & service plan creation,
- Network planning,
- Subscriber profiling,
- Customer car

Teaching methods

The 6 CFU course is structured on lecture, exercise and laboratory. Ex-cathedra lessons, in-depth seminars, readings of books, exercises, practical activities.

Reference books

- I. As, P. Basu, *Artificial Intelligence in Urban Planning and Design Technologies, Implementation, and Impacts*, Elsevier 2022.

Other didactic materials of the course will be provided (slides, articles, essays) before the lessons. Each topic will have its own specific bibliography.

Learning Evaluation Methods

Students will be evaluated in the following way:

- 50% of the mark: evaluation of a specific research that will be conferred to the individuals;
- 50% of the mark: colloquium about the lessons.

Other information

-

CLASS NAME

ECONOMIC URBAN ASSESSMENT

Prerequisites

Skills and knowledge derived from the bachelor's in architecture such as: adequate knowledge of the aspects concerning technical and economic feasibility, cost calculation and the production and realisation process of architectural and building artefacts, as well as their safety aspects.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The aim of the teaching is to provide the basic knowledge of urban economy and the specific applications in urban planning and architecture fields; moreover students will be able to estimate real estate assets and to define the estimation of an urban regeneration plan.The course proposes the application of the criteria of estimation and valuation analysis applied to the urban and territorial sphere through the development of digital models simulating the main marketing trends. The main valuation analysis platforms at European level will be considered and the changes in the values of different urban areas will be analysed. Particular attention will be paid to the value of digital territories through market analyses that will enable the student to define the contribution of the digital product on the estimation process.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

- Knowledge of the main market analysis platforms.
- Estimative logic.
- Estimative metric calculation using software and digital platforms.
- Estimation criteria for urban and rural valuation.
- Economic aspects of valuation.
- Digital products for economical evaluation.

Program and content

The teaching is composed by three different modules:

- Urban economy
    - Definition of urban economy
    - History of urban economy
    - Main representative scholars and scientists in urban economy
- Estimation methodologies
    - Estimation at the building scale
    - Estimation at the urban scale
    - Main items of expenditure
- Urban regeneration evaluation
    - Basics of urban regeneration
    - Goals and objectives of urban regeneration
    - SWOT analysis for urban regeneration
    - Main items of expenditure for a selected real case study
    - Digital replica analysis

Teaching methods

The 6 CFU course is structured on lecture and exercise. Ex cathedra lessons, in-depth seminars, readings of books, exercises, practical activities. The exercises will be aimed at the production of a model for the development of simulations on economic evaluations at the urban scale. The students, through a series of exercises, will be guided in the use of different software for the development of models and analysis of their functioning. The product of the exercises will then be compared with an analysis of the real fabric of the city.

Reference books

- I. Bateman et al., *Applying Geographical Information Systems (GIS) to Environmental and Resource Economics.* Environ Resource Econ, 2002.
- E. Pagourtzi, V. Assimakopoulos, T. Hatzichristos, N. French, *Real estate appraisal: A review of valuation methods,* J. Prop. Invest. Financ. 21, 2003.
- F. Tajani, P. Morano, M. Locurcio, N. D'Addabbo, *Property valuations in times of crisis. Artificial neural networks and evolutionary algorithms in comparison.* In Proceedings of the 15th International Conference on Computational Science and its Applications, 2015.
- N. Arcuri, M. De Ruggiero, F. Salvo, R. Zinno, *Automated Valuation Methods through the Cost Approach in a BIM and GIS Integration Framework for Smart City Appraisals*. *Sustainability*, 2020.

Other didactic materials of the course will be provided (slides, articles, essays) before the lessons. Each topic will have its own specific bibliography.

Learning Evaluation Methods

The final evaluation consists of an oral exam aimed at verifying learning and achievement of the training goals. The students will present the results of the exercise within the selected digital instruments and modelisation to simulate different SWOT economic analysis at the urban scale. The application of the models will be analysed and evaluated during the examination.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

13 Virtual Architecture Design and Interaction

CLASS NAME

VIRTUAL ARCHITECTURE DESIGN AND INTERACTION

Prerequisites

Students are expected to have already developed in their bachelor program:

- An understanding and knowledge of architectural theory for digital culture.
- Appropriate skills both in terms of understanding and designing architectural projects for digital culture.
- Basic understanding of scripting concepts and technique.

The course requires the student to have acquired the skills provided by the examinations 'History and design of digital culture', 'Production of digital models for architecture and gamification' in order to gain specific experience in 3D modelling.

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

In the first lessons, the course will provide support in defining the development path of the models that will be addressed by requiring students to have access to open source programmes or educational licences for specific modelling software (example: 3D modelling software (Sketchup Pro, 3ds Max, Rhino 3D, SolidWorks etc.); Unreal Engine 4 or 5: UE5 is a powerful and flexible development platform for creating multi-platform 2D and 3D interactive experiences and simulations). The course will also support the extension of models within immersive user platforms by supporting students through the use of devices for virtual navigation in digital scenarios (e.g: HCT Viver; Oculus Rift or other similar options in terms of capabilities, resolution, and overall user experience).
The single-subject course will cover the composition of digital architectures and virtual spaces in which digitally usable content will be set through immersive reality systems.
The composition of digital space and the definition of digital worlds and architectures allows the student to consolidate the cultural competences acquired during the degree course in order to express the design of his/her own virtual space.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

- Ability to use innovative digital tools for architecture design.
- Knowledge of theoretical approaches for virtual architectural design.
- Experience creating complex virtual environments.
- Ability to build and export virtual architectural environments to Oculus Rift Virtual Reality headset, for immersive interactions.
- Ability to integrate new skills into existing architectural design workflows.

Program and content

The module is organised in two complementary Parts as follows:

Part 1 (3CFU): Analysis and methods for virtual architectural design
The module aims at developing students' skills at postgraduate level. Hence, preliminary sessions will be dedicated to:

- Context analysis for virtual architectural design.
- Methods for virtual architectural design.

- Design references for virtual architectural design.
- Space design for virtual architecture and interaction.
- Space design of virtual installation and exhibition for museum and events (i.e. Biennali, etc.).

Part 2 (3CFU):
Virtual architecture involves the design and creation of virtual places in terms of its functional organization and electronic representation. etc. An emerging concept for designed virtual places is to provide an electronic location for people to socialize, work, play, and learn. Using the metaphor of buildings and rooms the course is oriented to the design of virtual places. Since the users of virtual architecture do not have the limits of our physics and material properties, students of this course will investigate what types of architecture/virtual place will emerge from non-physical constraints and what would be the new modes of interaction with a virtual place. Using the potentialities enabled by Virtual Reality, this course wishes to explore speculative architectures, adapted to alternative physics, materials and interactions. The main objective is that starting from the articulation and design of basic function students will expand the scale and detail of their virtual architectural environment.

The Part 2 structure is composed in five stages

- Stage 1:
  Students will define and script a single function (live, work, play, and learn) with their specific interaction and will describe them through an abstract object.
- Stage 2:
  Students will develop an architectural place responding to the logic or interaction they've created in stage 1.
- Stage 3:
  Students will create an interactive architectural environment starting from the interaction and architectural object they've created in previous stages.
- Stage 4:
  Students will develop a tour/exploration method for interacting with the architectural environment created in previous stages.
- Stage 5:
  Students will show up their projects for a final virtual exhibition.

The design-studio based activities, including tutorials, will allow students to develop their own assignment. Main focus on architecture virtual design will be on functional organization of virtual places such as theatres, museums, schools, libraries, offices, multi-purpose sports hall etc. etc.

Teaching methods

The 6 CFU course is structured on lecture, exercise and laboratory. The module is organized through a variety of teaching activities which include ex-cathedra lectures as well as seminars, demonstrations and workshops, and practice-based activities in the design studio. During the semester there will be organised study tours and lectures involving external experts. Students will practise design activities under the supervision of the academic staff.

Reference books

- W.J. Mitchell, *City of Bits. Space, Place, and Infobahn*, Cambridge (Mass.) 1995.

Other specific bibliography will be selected from archives of several index of publication, organisations, and associations, which are active in education and research in the field of Computer-aided architectural design (CAAD) of which main references among many others are:

- Cumulative index of publications about computer aided architectural design. http://papers.cumincad.org
- Association for Computer Aided Design in Architecture. http://acadia.org
- Association for Computer Aided Architectural Design Research in Asia. https://www.caadria.org
- Association for Education and Research in Computer Aided Architectural Design in Europe http://ecaade.org

Learning Evaluation Methods

The module is based on the idea students will learn throughout the term and via various tools/methods, so the final examination represents only the final stage of such a process. In fact, students will have several opportunities to interact with staff during tutorials but will also be encouraged towards peer-to-peer learning (via group discussions, group presentations and crits). Students will be asked to respond to the proposed brief with their own ‘research project’ and present a final portfolio in both digital and printed versions. The oral discussion will be based on portfolio contents’ as well as on students’ critical understanding of theoretical approaches.
Students will present their projects for an invited panel at a final review and marking.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

14 SfM Survey for Cultural Heritage and Architecture

CLASS NAME

SFM SURVEY FOR CULTURAL HERITAGE AND ARCHITECTURE

Prerequisites

Students enrolled in this course must have basic notions in the field of Survey and Architectural Representation. In particular, the student must possess knowledge acquire during the bachelor program in:

- Projective geometry.
- Basic notions of photography.
- Cartesian and polar references, direct and indirect detection systems, main 2D and 3D representation methodologies.

Training objectives

The course teaches how to design and build a 3D Structure from Motion model of real architectural objects or spaces. The course addresses, through a series of theoretical lessons, the theme of basic photogrammetry and digital photo shooting for metric acquisition, and then delves into the theme of digital images post-production and their use in the context of documentation and reconstruction of 3D scenarios. Through the laboratory activities, the student will experiment with tools, software and methods to create a dataset of images suitable for structuring SfM models responding to reality. The student will have mastered the mesh management phases (optimization and import) to obtain useful outputs for rendering scenarios or computerising models.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

At the end of the course the student will know:

- Principles and Tools of SfM photogrammetry.
- The methods of optimising the 3D models according to the intended purposes.
- The main uses of SfM models in the field of Digital Cultural Heritage.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student must:

- Manage a photographic set in the case of acquisitions of small elements in the studio;
- Create image datasets functional to the production of effective 3D photogrammetric models;
- Scale and orient SfM models on the basis of other metric measurements (obtained by direct or indirect instruments).
- Integrate different SfM models, with each other or with other databases, within a reference system.
- Optimise and evaluate the quality of SfM models. Segment of the models.
- Import the models on management (GIS or BIM software) and / or on rendering software.

Program and content

The course deals with the principles of SfM photogrammetry for the development of models of different contexts and at different scales of detail, capable of generating realistic 3D scenarios for the digitalization and virtualization of the Cultural Heritage.

During the course, the techniques of photogrammetric shooting, the tools and the methods of managing the set and producing the image dataset will be analysed. The course will deal with the geometric-projective and stereophotogrammetric principles underlying the 3D reconstruction process of SfM software. Students will learn the shooting modes for images and video frames, the acquisition tools and the performance of the different instrument's cameras.

List of lesson contents:

- History of Photogrammetry.
- Geometric principles of stereophotogrammetry.
- Digital images, composition and differences based on the instrument used.
- Preparation of the photographic set.
- Lighting and exposure of the scene, Colour-Checker and white balance.
- Acquisition mode with parallel axes and converging axes.
- Use of SfM reconstruction software.
- Image alignment, Mesh and texture of SfM models.
- Optimization of models.
- Alignment of multiple models or model portions.
- Georeferencing with respect to a Cartesian reference.
- Semantisation of models.
- Export and import to other software.
- Elaboration of orthomosaics from SfM models.
- Rendering and virtual scene.

Description of laboratory activities

The course allows you to develop technical and operational skills hand in hand with artistic and creative expression through the constant practical application of theoretical concepts. Communication skills are completed through direct discussions with the teaching staff. During the laboratory hours, students will work in the classroom to deepen their practical knowledge related to the development of digital graphic products. During the laboratory activities, the development of some SfM models at different scales and levels of detail will be promoted.

Teaching methods

The 6 CFU course is structured on lecture, tutorial and laboratory.
The lectures include lessons related to the use of software and the main complexities of modelling and development of a SfM output workflow. The laboratory activities, on the other hand, concern the development of a practical test in which the acquired knowledge is practically developed and consolidated.

Reference books

- K. B. Atkinson (ed.), *Close Range Photogrammetry and Machine Vision*, Caithness 2001.
- F. Remondino, S. El-Hakim, *Image-based 3D modelling*: a review. The photogrammetric record. Blackwell Publishing Ltd. 2006.
- F. Nex, F. Remondino, *UAV for 3D mapping applications*: a review. in Appl Geomat 6, 2014.

Texts for further study

- L. De Luca, *La Fotomodellazione Architettonica*, Palermo 2011.
- M. Gaiani (a cura di), *I portici di Bologna. Architettura, modelli 3D e ricerche tecnologiche*, Bologna 2015. (Italian)

Learning Evaluation Methods

The verification of the acquired knowledge will take place through the evaluation of a 3D model integrated by several SfM models at different levels of detail. This digital product will contain the main steps covered during the lessons to facilitate the phased learning of each theoretical or practical topic dealt with. The lectures of the course are structured to guide the student during the practical activities. The laboratory hours are used as practical moments of verification and comparison on the

skills acquired. The course laboratory activities is designed as an open working moment in which students will interface with teaching staff through a learning-by-doing process.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

15 Digital Heritage Intervention

Module 15A – Business for Digital Cultural Heritage

Module 15B – Digital Heritage Management

CLASS NAME

BUSINESS FOR DIGITAL CULTURAL HERITAGE

Prerequisites

The course requires students to have a basic knowledge of mathematical tools, estimate and economic theories applied at cultural and architectural heritage

Training objectives

KNOWLEDGE AND UNDERSTANDING OUTCOMES

The goal of the course is to acquire the main elements of knowledge and evaluation of the complex cultural system, including current trends, and with reference to its interrelationships and modes of operation. The overall goal of the course is to examine in theoretical and applied terms the main profiles of the financial management of digital product considering the digital new regulations with regard also to the processes of finding financial resources.
The course will promote the acquisition of:
- specialized knowledge in the field of economical evaluation with reference to the digital cultural sectors;
- specialized knowledge in the field of methodologies of economic sciences, for the analysis of territorial systems and for the design of plans and programs, with reference to the sectors of digital product in the context of territorial cultural and economic development;
- knowledge and methodologies of analysis and design of activities and services in the field of protection, enhancement, promotion of cultural heritage and entertainment activities;
- ability to acquire, analyse, reprocess, and use qualitative and quantitative information and data useful for the analysis of the market and activities of enterprises operating in the field of cultural heritage and activities;
specialized skills in fund-raising activities of enterprises in the cultural heritage sector.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

Upon the end of the course, students will have acquired knowledge of some fundamental aspects of the economic and financial management of digital cultural heritage. At the same time, students will have acquired the ability to apply this knowledge to the observation of the patrimonial, economic and financial situation of cultural enterprises and to effectively interact with professionals in the field on economic and financial management issues.
In addition, by the end of the course, students will have acquired skills on the complex topic of financing and economic-financial sustainability of cultural entities, with a focus on Non-Profit entities. Among other things, legal, economic, tax and management aspects are covered, with a multidisciplinary approach, as well as strategic marketing, integrated communication, stakeholder relations, funding calls, cultural membership and fund raising.

Program and content

- Use of digital cultural resources: websites and databases;
- Relationship between digital and real architectural intervention;
- Digital restoration procedure, how change
- FNT and digital product in connection with digital economy;
- Digital procedures, how they contribute to changing economic values on the architectural, urban and landscape scale;
- Digital education as a catalyst for the transformation of the cultural field;
- Management of enterprises in the digital cultural field;

- Digital enterprise: structure, objectives, strategies, economic management, elements of Cultural Marketing;
- Fund Raising: cultural, fund-raising cycle, relationships with public and private funders.

Teaching methods

The 6 CFU course is structured around 45 hours of lectures. The student will be accompanied in the acquisition of the necessary knowledge through a course of frontal lectures where both important examples and case studies and operational procedures for the definition of workflows will be described. The grade is made up of the result of the oral examination aimed at verifying the theoretical knowledge acquired during the course and the evaluation of a proposed management project.

Reference books

M. Magliacani. *Managing Cultural Heritage: Ecomuseum, Community Governance and Social Accountability*. 2015
R. Towse. *A Handbook of Cultural Economics*. 2011
P. Krugman, R. Weills. *Principles of Economics*. 2012
J. Heilbrun, C.M. Gray. *The Economics of Art and Culture*. 2004
I. Robertson. *Understanding of International Art Markets and Management.* 2005
R. Towse. *A Textbook of Cultural Economics*. 2010

Learning Evaluation Methods

The course contemplates in the exercises a series of small tests to verify the knowledge acquired. The final evaluation consists of an oral exam aimed at verifying learning and achievement of the training goals.

Other information

-

CLASS NAME

DIGITAL HERITAGE MANAGEMENT

Prerequisites

Students enrolled in this course must have a basic knowledge of the discipline of Restoration and Conservation of Historic Architectural Heritage, as well as of the Survey and Representation of Historic Architecture acquired during their bachelor program. In particular, the student must possess knowledge of: History of Restoration, Diagnostics, material analysis of architecture. It also required knowledge achieved from the course "BIM and Digital Management for Architectural Heritage" such as management of BIM processes, ability to develop and manage 3D models.

Training objectives

The course teaches how to develop a restoration project and how to articulate the production of the material necessary to manage a project by addressing different aspects ranging from national and international standards to an examination of the types of products that constitute a restoration project.
Through theoretical lectures, which address the evolution of digital practices for the conservation of historical architecture, the course deals with the different processes of digital documentation aimed at the restoration of historical architecture, focusing on the reconstruction of virtual scenarios in which the works are subjected to digital simulations useful for the configuration of intervention actions on the built environment.
Through laboratory activities, the student experiments with tools, software and methods to create databases and atlases on the degradations connected with building process management systems (e.g. H-BIM), thus enabling the student to master the management phases of a documentation and project development process that can be visualised through digital systems.

KNOWLEDGE AND UNDERSTANDING OUTCOMES

By the end of the course the student will have knowledge of:

- The evolution of digital restoration applied to different national and international contexts;
- The simulation practices of a complex project by setting up different types of data and checking the output of a digital simulation on a historical building;
- The main uses of digital models for the management, promotion and development of interventions for the conservation and maintenance of historical architecture.

ABILITY OUTCOMES: SUBJECT-BASED PRACTICAL/PROFESSIONAL SKILLS

At the end of the course the student should know how to:

- Manage a data set for the development of digital atlases on the state of buildings;
- Manage information systems for the development of a restoration project also in terms of analysis and development of specifications and estimated metric calculations;
- Carry out digital simulations on building transformation processes;
- Manage planned management tools on historical architecture in relation to a conservation project.

Program and content

The course is articulated in a series of modules that address topics related to architectural restoration to achieve the intended learning objectives.

List of lesson contents

- From restoration to digital restoration, evolution of experiences and points of view.
- The concept of Cultural Heritage in international legislation.
- Virtual Restoration and Digital Restoration, considerations and opportunities.
- Image Processing techniques applied to different case studies.
- The restoration intervention applied to different scales and digital correspondence.

- The preparation of a complex documentation system.
- Databases for documentation, intervention and heritage management.
- From the analysis of the built environment to the Databank.
- From the Database to the Model.
- From the Model to Simulation.
- From simulation to intervention.
- Simulation practices for consolidation.
- Simulation practices on the project, pictorial reintegration's and 3D reconstructions.

Description of laboratory activities

The course enables the development of critical awareness, technical and operational skills through the practical application of theoretical concepts applied to a case study. Students will work on a real subject developing the exercises of analysis, data conversion and development of models and virtual restoration practices. During the laboratory hours students will work in the classroom to deepen their practical knowledge of the development of graphic products and models, carrying out their own restoration project that will be presented during the examination.

Teaching methods

The 6 CFU course is structured on lectures, tutorials and laboratory. The student will be accompanied in the acquisition of the necessary knowledge through a course of frontal lectures where both important examples and case studies and operational procedures for the definition of workflows will be described. The laboratory activities focus on a specific case study that will be the subject of exercises and analysis by the student for which an information model will be developed that will collect the specificities of the readings on alterations and diagnostics. The model becomes the simulation tool for a conservation project. During the examination, the student will present his or her own restoration project supported by the digital product through which he or she proposes a simulation. The grade is made up of the result of the oral examination aimed at verifying the theoretical knowledge acquired during the course and the evaluation of the proposed conservation project.

Reference books

- C. Brandi, *Theory of restoration*, Firenze 2005.

Texts for further study

- Conti, *Storia del restauro e della conservazione delle opere d'arte*, Milano 1988.
- V. Cappellini, *La realtà virtuale per i beni culturali*, Bologna 2000.
- S. Dellepiane, *Elaborazione di immagini digitali*, ECIG, 2004.
- D. Bennardi, R. Furferi, *Il restauro virtuale tra ideologia e metodologia*, Firenze 2007.
- M. Limoncelli, *Il restauro virtuale in archeologia*, Roma 2012.

Learning Evaluation Methods

Verification of acquired knowledge will take place through the delivery and evaluation of a digital restoration project. The student will present the criteria motivating the project choices and will describe the models and management systems produced within the course. An oral test will verify knowledge of the topics covered during the lectures. The course workshop is designed as an open working moment in which students will interface with teaching staff through a learning by doing process.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

16 Artificial intelligence

CLASS NAME

ARTIFICIAL INTELLIGENCE

Prerequisites

Basic mathematical skills, practical knowledge of at least one programming language.

Training objectives

The course follows a conceptual pathway along the fundamental principles of the discipline. It is divided into two parts: the first part is an introduction to classical formal logic, both propositional and first order, with a special focus to the aspects of automatic calculus, while the second part is an introduction to the basic principles of machine learning from a probabilistic perspective.

Program and content

1) Classical logic and automated symbolic reasoning

Boolean algebras
Logical language and semantical structures: logical consequence
Deductive systems for propositional logic
Decision problems and decidability
Predicates and relations: first order logic
Semi-decidability of first order logic
First-order resolution with unification

2) Machine Learning

Logic and probability: representation or statistics?
The language of probability: representation
Bayesian inference
Graphical models and automation
Probabilistic learning
Clustering: K-means, EM algorithm, missing data.
Causal models, probabilistic and structural.
Reinforcement Learning.

Teaching methods

The course is structured into theory lectures.

Reference books

See the home page of the course (http://vision.unipv.it/AI) for lecture slides, suggested readings and software for the exercises.

Learning Evaluation Methods

The final exam is an interview about the theory, together with the discussion of practical activities shown during lessons.

Other information

-

VIRTUAL REALITY ENGINEERING AND GAME DESIGN

FOR ARCHITECTURE AND CULTURAL HERITAGE

Syllabus

17 Computer vision

CLASS NAME

COMPUTER VISION

Prerequisites

Basic knowledge of computer science.

Training objectives

The student will be able to consider problems related to artificial vision. In particular problem related feature analysis and pattern recognition.

Program and content

Basic definitions. Low-level image analysis methods, including image formation, edge detection, feature detection, and image segmentation.
3D Vision and motion analysis
Object recognition
Recognition Processes. Direct Comparison. Alignment methods. Invariant properties methods. Parts decompositions method. Hough transform.
Mathematical morphology.

Teaching methods

Lectures conducted using presentations projected on screen (available to students) and insights using the chalkboard.

Reference books

Slides of the lessons.

3C Vision: Cues, Context and Channels, Virginio Cantoni, Stefano Levialdi, Bertrand Zavidovique, Elsevier2011

Learning Evaluation Methods

An oral examination and the discussion of a project related to a topic of the course

Other information

-