SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

VIRTUAL REALITY

AUTUMN SEMESTER

Établissement public sous tutelle du
ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE **CENTRALE**

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C++ Programming

Virtual Reality, Engineering programme specialisation
Autumn Semester

Professor: Guillaume MOREAU

Objectives

C++ is the mandatory programming language for Virtual Reality because of interactivity requirements. The goal of this course is to have the students create computer programs taking advantage of object-oriented concepts. For this, they will have to master object concepts (encapsulation, inheritance and polymorphism) as well as useful C++ extensions such as exceptions and containers.

In order to acquire operational knowledge of C++ programming, most of the course will be take the format of practical lab work. This course is a pre-requisite to many other courses of the Virtual Reality specialisation.

Course contents

- Reminder of C programming and algorithms
- Introduction to object concepts
- Objects in C++
- Exceptions
- The Standard Library: containers, functors, algorithms, streams
- Advanced C++ : casts and introspection

Course material

- B. Stroustrup (2013). The C++ programming Language, 4th edition. Addison Wesley
- OpenClassrooms : http://fr.openclassrooms.com/informatique/cours/programmez-avec-le-langage-c
- cplusplus.com http://www.cplusplus.com/doc/tutorial/

Keywords

Links with other programmes

First Year Course in Algorithms and Programming

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	12 hrs	20 hrs	0 hrs	0 hrs

REAL-TIME 3D COMPUTER GRAPHICS

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guillaume MOREAU

Objectives

The objectives are to 1/ understand the principles underlying the generation and rendering of real-time computer graphics, 2/ apply those techniques and algorithms in real-life examples by using the most common APIs both in academia and in industry.

This course presents the fundamentals of real-time computer graphics: 3D rendering, virtual cameras, representation of 3D objects by a set of polygons with colors, textures, etc. The ability to display computer generated images in real-time is a pre-requisite for many other computer graphic related application domains such as Virtual Reality, Augmented Reality, Scientific Visualisation or Video Games.

During the practical sessions, students will use the most common programming interfaces for real-time computer graphics such as OpenGL and OpenSceneGraph. Modern real-time rendering techniques such as shaders are also tackled using the Cg programming language in Unity3D.

Course contents

1) Presenting the principal algorithms used for displaying computer generated images

2) OpenGL:

- Introducing OpenGL: the most common low level graphical programming interface that allows real-time rendering of 3D objects. Presentation of the graphical pipeline.
- Geometrical Transformations: how can we go from a 3D object to a 2D image on a screen (model view and projection transformations, etc.).
- Z-buffer algorithm, backface culling, texture mapping, etc.
- Implementing and interacting with a simple 3D scene

3) Shaders
Shaders are programs to customise the graphical pipeline used to display in real-time 3D objects on a 2D screen.
Presentation of the modified graphical pipeline allowing shaders. Writing shaders in the Cg programming language.

4) Using a high level library: OpenSceneGraph
After using and understanding the low level OpenGL library, we present the concept of scene-graphs. A scene-graph allows for the representation of a full 3D scene by organizing the 3D objects composing the scene in a graph. We illustrate those concepts using a classical scene-graph library called OpenSceneGraph.

Course material

- The OpenGL Programming Guide. Dave Shreiner, Graham Sellers, John Kessenich, and Bill Licea-Kane.

- OpenSceneGraph Quick Start Guide. Paul Martz

Keywords

real-time 3D rendering, OpenGL, OpenSceneGraph, shaders

Links with other programmes

Pre-requisite for numerous other courses of the specialisation.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**12 hrs**	**10 hrs**	**8 hrs**	**0 hrs**

FUNDAMENTALS OF VIRTUAL REALITY

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Jean-Marie NORMAND

Objectives

After having defined the basic concepts of Virtual Reality, this course will address the elements which allow the immersion of users into a virtual world as well their interaction with it. Firstly, the technical elements (sensori-motor interfaces), and secondly, the human factors (human senses and motor responses). The main fields of application will be presented. Design and evaluation of virtual reality applications will be addressed through case studies.

Course contents

- Definitions
- The concept of presence
- Design and evaluation of virtual reality applications
- Human senses and motor responses
- Stereoscopic vision
- Interfacing devices for virtual reality

Course material

Le traité de la réalité virtuelle. Ph. Fuchs and G. Moreau (Eds), Les Presses de l'Ecole des mines, 2006. Freely available to students.

Keywords

Virtual reality, immersion, interaction, presence, human vision, interfacing devices

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	17 hrs	13 hrs	0 hrs	0 hrs

FROM PHYSICAL GEOMETRY TO 3D VIRTUAL MODELS

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Alain BERNARD

Objectives

Objectives: define needs and mathematical basis of parametric surfaces and use of methods for mesh generation.

Geometric and physical models for virtual reality are required to create virtual worlds. It is essential to be able to represent 3D objects. This course presents different ways to represent 3D objects (meshes, tessellation, parametric surfaces, solid models, etc.) only digitally or from real objects (thanks to 3D scanners). Finally, in order to simulate physical phenomena in real time, we have to implement simplification model techniques to accelerate numerical calculations.

Course contents

Courses and digitalization, modelling and simulation applications:

- Curves and surfaces, point cloud
- 3D scanning and reverse-engineering
- mesh simulation

Course material

Keywords

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	14 hrs	16 hrs	0 hrs	0 hrs

First semester project

Virtual Reality, Engineering programme specialisation
Autumn Semester

Professor: Guillaume MOREAU

Objectives

The goal of this very first project is to work on a practical and integrated basis the notions that have been covered during the first semester. Students may propose project topics, with the requirement that they find a faculty member to validate and supervise their project. Projects are undertaken in groups of two.

Course contents

Course material

Keywords

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	1	0 hrs	0 hrs	0 hrs	32 hrs

COMPUTER VISION AND AUGMENTED REALITY

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Jean-Marie NORMAND

Objectives

This course aims at illustrating the mathematical tools that allow computers to extract useful information from images: image segmentation, object detection, pose computation, etc. In order to acquire practical knowledge of computer vision and augmented reality, the course will include an initiation to OpenCV library with many lab sessions ranging from basic image processing to pose computation for Augmented Reality and 3D reconstruction.

Course contents

- Sensors, image construction
- Image processing
- Feature point detection, tracking
- Initiation to the OpenCV library
- Camera calibration
- Pose computation for augmented reality
- Tracking in image sequences
- 3D Reconstruction

Course material

Computer Vision: Algorithms and Applications. Richard Szeliski 2010 (http://szeliski.org/Book/)

Learning OpenCV. Gary Bradski & Adrian Kaehler. 2008

Keywords

computer vision, augmented reality, camera calibration, pose computation

Links with other programmes

The C++ Programming course is mandatory for OpenCV manipulation.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	10 hrs	0 hrs	22 hrs	0 hrs

INDUSTRIAL SOFTWARE DEVELOPMENT

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guillaume MOREAU

Objectives

This course is run jointly (except for lab work) for the Computer Science and Virtual Reality specialisations. It aims to provide methods and tools for the development of industrial quality software. This includes unit and integration tests, version management, code metrics, continuous integration services and design patterns. It will also be an opportunity to extend the students technical knowledge.

To account for the different skills sets between the Computer Science and Virtual Reality specialisations, lab work will use java language for the former and C++ for the latter (with an adapted tool set). All notions covered in lectures will be applied practically in lab sessions.

Course contents

- Group work in computer science
- Version management
- Software tests
- Unit testing
- Advanced build tools and continuous integration
- Code metrics

Course material

Keywords

Links with other programmes

Pre-requisites: C++ Programming for the Virtual Reality specialisation or Object Oriented Programming for the Computer Science specialisation.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	10 hrs	22 hrs	0 hrs	0 hrs

3D INTERACTION

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Jean-Marie NORMAND

Objectives

Interaction between the user and the virtual world is inherent to Virtual Realty. Nevertheless, interacting with a 3D world raises important challenges that will be addressed in this module: navigating inside the virtual world, whatever its size, selection and manipulation of objects in a virtual and maybe complex environment that may contain numerous virtual objects.

Course contents

- Introduction
  - Needs and motivation
  - Virtual environments
  - History of 3D interaction
  - Input devices
  - Output devices
- Interaction techniques
  - for selection
  - for manipulation
  - for navigation
- Interaction in augmented reality
- System control
- GUI, vocal control, gestural control, BCI, VirtualTools etc
- Performance evaluation

Course material

Keywords

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	16 hrs	16 hrs	0 hrs	0 hrs

HANDS ON VR: SIMULATION AND INTERACTION IN VIRTUAL REALITY

VIRTUAL REALITY, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Jean-Marie NORMAND

Objectives

To create interaction between the virtual world and reality: how to transfer a real object into the virtual world and how to simulate / interact with simple tools. Thanks to haptic devices and real-virtual links, it is possible to manipulate physical objects through real time simulation of the virtual world.

This course will look at the use of tools to build virtual worlds (such as Unity3D, Blender, etc.) as well as software covered in the other courses of this specialisation (3D scanner for 3D modeling, 3D interaction, etc.).

Course contents

The entire course is conducted through practical sessions. Students will gain hands-on experience of Virtual Reality through involvement in short projects alongside industry experts or researchers.

The project topics are:

- Tracking and kinematics of the human body
- Modeling 3D scene in Blender
- Assembly / maintenance / ergonomics - haptic
- Sounding technical objects
- Advanced 3D photogrammetry
- Interactive virtual factory

Course material

Keywords

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	0 hrs	32 hrs	0 hrs	0 hrs