Universitat Autònoma de Barcelona

2017/2018

Graphic and Multimedia Systems

Code: 43338
ECTS Credits: 6

Degree	Type	Year	Semester
4314660 Computer Engineering	OB	1	2

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Use of languages

Principal working language: english (eng)

Prerequisites

OIt is recommended that students have knowledge and skills in:

- Object-oriented programming languages (C++, Java, Python, etc.)
- Basic Data Structures.
- Basics of 2D and 3D Computer Graphics.

Objectives and Contextualisation

Computer Graphics' techniques, especially rendering and Computer Animation are used in many areas, primarily in entertainment (movies, television, video games, etc.) but also in others such as scientific visualization, medical imaging, mapping, industrial design (realization and both static and dynamic simulation products) to mention just a few.

The fact that we see those computer generated images often should not obscure the complex process involved in generating them. In most cases (as in the case of the entertainment industry) there is a graphic designer to create the character, screenwriters to write the script and also computer engineers to model the shape of the character and define the dynamic equations of motion, as well as to generate and visualize these movements.

The main objective of the course is to learn and master the necessary skills in order to apply the most advanced technologies in computer graphics and multimedia systems, so that the students, future professionals, will be able to decide the best techniques to be used or implemented in the creation, design and implementation of a graphical or multimedia application.

During the course we will describe the structure of multimedia systems that include storage, processing and interaction of different media (graphics, video, sound, images, etc.) in an interactive and user friendly system.

With regard to computer graphics, we will delve into animation themes (physical, collisions, animating behaviour, human movement , etc) and also advanced modeling (schemes of multi-resolution meshing and geometric mesh approach). In programming topics we will teach graphics library OpenGL 3.3 incorporating shaders using GLSL shading language.

To improve understanding of the interactive systems in graphics and multimedia, an **interface** class will be given (both **graphic** and **natural interfaces** will be mentioned); among others we will explain the most innovative devices suchas **Kinect** and **Leap motion**.

Finally we will discuss the basic concepts and applications of two cutting edge technologies such as Virtual and Augmented Reality.

On the practical side we expect the students to develop skills in using graphics library OpenGL 3.3 (Open Graphics Library) and in shaders in GLSL, using Qt, GLFW or WebGL frameworks to design, implement and validate advanced techniques discussed in the module.

Basic knowledge of Computer Graphics (2D and 3D) is recommended, as well as working knowledge on C programming and object oriented C++; in addition, a basic knowledge of OpenGL would be beneficial.

KNOWLEDGE: After completing the course the student should be able to:

- Know and understand the structure and technologies needed in a multimedia system and be able to discriminate which technology may be more useful in order to best achieve the expected end result
- Know, understand and implement or effectively use advanced techniques in animation, modeling, visualization and graphics animation.
- Know and understand the different kinds of user interfaces in order to be able to decide which one will be more efficient and ergonomic according to the required specifications of the application to be developed.
- Know and understand the main kinematic models (such as rigid solids and articulated objects), widely used in computer animation techniques
- Know and understand the main concepts and operating techniques of Virtual Reality and Augmented Reality, so they can effectively decide and implement the most appropriate algorithms to suit the purpose of the application of Virtual Reality or Augmented Reality that they would like to develop.
- Know and understand the graphics library OpenGL 3.1 (Open Graphics Library), used for graphical visualization in Windows, Linux and Mac OS platforms, as well as in workstations (Sun, Silicon Graphics) and GLSL shaders language, which willallow the students to implement shaders, graphic effects or optimization displays in scenes with lots of geometry.

SKILLS: The goal is for the students to acquire the following skills:

- Have a good level of knowledge and practical experience in OpenGL 3.1 and GLSL shaders in order to
    - be able to implement a graphical application, Virtual Reality and Augmented Reality,
    - be able to define complex mesh models and to use efficient visualization efficiently,
    - implement visual and animation effects in an efficient manner
    - Know how to design a Virtual Reality or Augmented Reality graphic application (such as a video game) based on a set of requested requirements, making decisions about the type of user interface, architecture and hardware required to develop the application

Skills

- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Conceptualise, design, develop and evaluate person-computer interaction in computer products, systems, applications and services.
- Continue the learning process, to a large extent autonomously
- Create and exploit virtual environments and create, manage and distribute multimedia content.
- Display a spirit of enterprise and innovation and a wide-ranging vision in the search for new areas to explore in a specific field of the computer engineering profession.
- Integrate and apply the knowledge acquired and solve problems in new or little-known situations within broader (or multidisciplinary) contexts.
- Launch, lead and manage manufacturing processes for computer hardware, safeguarding persons and goods and overseeing product quality and certification
- Propose, calculate and design products, processes and installations in all areas of computer engineering.
- Responsibly manage information and knowledge when leading multidisciplinary groups and/or projects.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Understand and apply ethical responsibility, legislation and codes of practice to professional activity in computer engineering.

- Use and develop methodologies, methods, techniques, specific programmes, norms and standards in graphic computing.

Learning outcomes

1. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
2. Continue the learning process, to a large extent autonomously
3. Display a spirit of enterprise and innovation and a wide-ranging vision in the search for new areas to explore in a specific field of the computer engineering profession.
4. Identify the basic problems to be solved in graphic computing, and the specific algorithms.
5. Identify the best methodologies that can be applied for the conceptualisation, design, development and evaluation of person-computer interaction.
6. Identify the best representations that can be defined for solving problems of multimedia content distribution.
7. Integrate and apply the knowledge acquired and solve problems in new or little-known situations within broader (or multidisciplinary) contexts.
8. Launch, lead and manage manufacturing processes for computer hardware, safeguarding persons and goods and overseeing product quality and certification
9. Propose, calculate and design products, processes and installations in all areas of computer engineering.
10. Responsibly manage information and knowledge when leading multidisciplinary groups and/or projects.
11. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
12. Understand and apply ethical responsibility, legislation and codes of practice to professional activity in computer engineering.
13. Use graphic computing techniques to plan, develop, evaluate and manage a solution to a particular problem based on graphic systems.
14. Use graphic-system techniques to plan, develop, evaluate and manage a solution to a particular problem based on virtual environments.

Content

PART 1. INTRODUCTION
1. Multimedia Systems (4 hours)

- What is Multimedia?
- History of Multimedia Systems
- Why Digital?
- Applications
- Trend in Multimedia technologies

PART 2. COMPUTER GRAPHICS
2. Introduction to Computer Graphics (4 hours)

- Introduction
- History
- Applications
- Computer Graphics technologies

3. Rendering (4 hours)

- Introduction
- 3D geometrical transforms
- Modelling
- Rendering

4. Computer Animation (4 hours)

- Conventional animation
- Computer Animation
- Computer Animation techniques
- Rigid-objects animation
- Articulated-object animation
- Dynamic simulation
- Particle animation

PART 3. TECHNOLOGIES
5. User Interfaces (4 hours)

- Basic concepts
- Graphical interfaces
- Natural interfaces

6. Gestural Interfaces (4 hours)

- Introduction
- Tap is a new click
- History
- Gestural Controllers
- Designing Interactive gestures

7. Gestural Devices (4 hours)

- Introduction
- Data Glove
- Image-Based-Multitouch Table
- Kinect
- Oblong g-speak

8. Virtual Reality (4 hours)

- Basic concepts
- Applications
- Virtual reality architecture

9. Augmented Reality (4 hours)

- Basic concepts
- Applications
- Augmented reality architecture
- Technologies

Methodology

This year the students have been offered a PBL (Project Based Learning) methodology in taking the subject. This methodology is explained.

PBL Methodology:

- **THEORY:** The PBL method aims to promote and motivate students self involvement in learning. The performance standards and evaluation system of the students who follow this path aredescribed in detail in the document PBL-Guide pdf, accessible by Cerbero (Graphical & Multimedia Systems subject). The teacher's theory lectures are aimed at students following this method.
- **PROBLEMS:**The problems section of the course can be done by students in either of the courses options- It is based on a series of lectures using slides to introduce concepts of OpenGL graphics library and by problems to be solved by the students in order to master the use of the library. This classes are highly recommended in this pathway (as similar problems will be part of the final test). Students will

have access to the OpenGL slides in an electronic format (PDF) in Cerbero or in handouts given before the lessons.

- **PRÁCTICAL COURSEWORK:** Classes are held in closed laboratory sessions in the computer classroom and are supervised by the teacher. The practices will be done in groups of 2 students and will be conducted on C++ and WebGL environments that includes OpenGL graphic library.

Students can find the rules for handing in work and assessment practices in the practices' files availablein Cerbero.

The practices aim to enable students to define graphical applications in C++ and graphic library multi-platform OpenGL 3.3 (https://www.opengl.org/sdk/docs/man3/) or Augmented realityapplications by using multi-platform Qt framework. The basic environment provided is based on collapsible menus, menu buttons and keyboard and mouse commands that are added as the practices unfold until an environment including all of them is achieved.

The practice's statements are available in the practice folder in PDF format in Cerbero (http:// cerbero.uab.cat).

The course consists of four practices distributed in 4 sessions in a closed regime:

1. Week 1: Creation of a visualization environment using Qt or GLFW for IDE development and OpenGL o render scenes
2. Week 2: Implementation of shaders in order to simulate illumination
3. Week 3: Augmented Reality
4. Week 4: Computer Animation

They will be conducted in groups of 2 and each student is required to complete 30 hours to prepare the practice and writethe final essay, 8 hours in the IT classroom supervised by the teacher and 6 hours of unsupervised student work in the computer room.

Each practice group has to sign infor an 8 hour timetable to perform the supervised practices. In order to sign in, students must use the manager Cerbero (http://cerbero.uab.cat).

Attendance of practical sessions **IS MANDATORY**. Students must prepare the practical work as explained in the practical course's statement prior to the corresponding practice class. The work is considered done once the students have attended all the supervised practice sessions in their allocated time and after they have written the final practices' report.

Rules of delivery and assessment practices can be found in the rules and regulation documents available in Cerbero (http://cerbero.uab.cat). Work practices will be evaluated and there will also be an individual assessment after the delivery of each practice.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Lectures	24	0.96	4, 5, 11, 13
Practices resolution of practical work	12	0.48	1, 2, 13
Problem solving	3	0.12	1, 4, 11, 13
Type: Supervised			
Problem solving	15	0.6	5, 11
Type: Autonomous			

Self or group practical training resolution	34	1.36	1, 4, 11
Self or group problem resolution	22	0.88	4, 5, 11, 13
Self-study	34	1.36	1, 2, 11

Evaluation

PBL Methodology:

For the assessment of the PBL path we will use the following TOOLS and ACTIVITIES:

- A teacher's assessment of the group from the presentation of the project (quality of work, presentation, essay delivered). **Group mark (10)**. Including:
    - **STUDENT PORTFOLIO:** A document that includes the development of the student's work: project planning, meeting minutes, researched information, user's manual with a clear explanation of the application and tests performed.
    - **APPLICATION:** Source and executable (Debug and Release) version of the developed application (debugged and released).
    - **PRESENTATION:** A presentation of 10-14 slides on the developed project and obtained results.
- An individual assessment from the observations by the teachers in the supervised sessions, attitude, attendance at group sessions' evaluation. **Individual mark (10)**.
- Surveys from co-evaluation and self-evaluation among group members, 3 reviews will be conducted using Cerbero. **Partner's co-evaluation mark (1)**.
- The students will prepare presentations and the groups will rank their fellow students' work from 1 (the most liked) to 5 (the least liked). **Groups' co-evaluation mark (0.5)**.

MARKING:

The final course mark is calculated as weighted and comprehensively considering the above activities and the degree of involvement of each group member.

SUBJECT FINAL MARK (10) = 0'5 * Group Mark (10) + 0'5 * Individual Mark (10) + Co-assessment colleagues Mark (1) + Co-assessment Groups (0,5)

If not pass, the group can choose between improving the work for the second call following the suggestions of Professor or passed to the itinerary TPPT, must present practices.

EVALUATION CRITERIA:

- To be granted with a pass in the subject a minimum of 5 points must be obtained
- The first practice session (mandatory also for the PBL path) will be evaluated without a mark, as in "pass/ fail". **To pass the subject you must obtain a pass.**
    - **IMPORTANT FOR ALL STUDENTS:** You must register (if you have not already done so) on the Cerbero server and you must register in the kind of teaching SGM2014 within the subject of Graphical & Multimedia Systems (password SGM2015). Sign in in a practice group. To register with Cerbero, you must give some personal information such as name, surname, e-mail and also a passport-style picture of yourself in JPG format. You can find the instructions in the subjects' web page.

ASSESSMENT TIMETABLE:

- Monitoring and periodic assessment of the groups: throughout the course.
- Delivery of the portfolio, presentation and application, as well as work's exhibition by the students: the last week of theory class.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
PBL Project Presentation	0,7	4	0.16	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 13, 14
Practice wORK	0,3	2	0.08	2, 4, 7, 8, 11, 12, 13

Bibliography

SUBJECT SLIDES AND REFERENCES: http://cerbero.uab.cat, Graphical & Multimedia Systems subject.

BASIC BIBLIOGRAPHY:

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- F.D. Foley, A. van Dam, S.K. Feiner, J.F. Hughes, **Computer Graphics. Principles and Practice**, second edition in C, Addison-Wesley, 1995.
- P. Shirley, **Fundamentals of Computer Graphics,** 3rd Ed., AK Peters, 2002.
- D. Hearn, P. Baker, **Computer Graphics**, 2nd edition, C version Prentice Hall, 1997.
- D. Shreiner, G. Sellers, J. Kessenich, B. Licea-Kane, **OpenGL Programming Guide, 8th Edition** Addison-Wesley Developers Press, 2013.

COMPLEMENTARY BIBLIOGRAPHY:

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- M. Pharr, **GPU Gems 2**, Addison-Wesley, 2005.
- E. Lengyel, **Mathematic for 3D game programming & Computer Graphics**, Charles River Media, 2004.
- E. Lengyel, **The OpenGL extensions guide**, Charles River Media, 2003.
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