Course guide
270022 - G - Graphics

Last modified: 30/01/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 723 - CS - Department of Computer Science.

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: CARLOS ANTONIO ANDUJAR GRAN

Others:

Primer quadrimestre:
CARLOS ANTONIO ANDUJAR GRAN - 11, 12, 21, 22
ANTONIO CHICA CALAF - 12
MARTA FAIREN GONZALEZ - 12, 22
JOSE LUIS PONTÓN MARTINEZ - 11, 21

Segon quadrimestre:
CARLOS ANTONIO ANDUJAR GRAN - 11, 12, 13
OSCAR ARGUDO MEDRANO - 12
MARTA FAIREN GONZALEZ - 13
ALVARO VINACUA PLA - 11

REQUIREMENTS

- Prerequisite IDI
- Corequisite PROP

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CCO2.3. To develop and evaluate interactive systems and systems that show complex information, and its application to solve person-computer interaction problems.
CCO2.6. To design and implement graphic, virtual reality, augmented reality and video-games applications.
CT1.2A. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to solve the mathematical problems presented in engineering. Talent to apply the knowledge about: algebra, differential and integral calculus and numeric methods; statistics and optimization.
CT1.2C. To use properly theories, procedures and tools in the professional development of the informatics engineering in all its fields (specification, design, implementation, deployment and products evaluation) demonstrating the comprehension of the adopted compromises in the design decisions.
CT4.1. To identify the most adequate algorithmic solutions to solve medium difficulty problems.
CT5.2. To know, design and use efficiently the most adequate data types and data structures to solve a problem.
CT5.3. To design, write, test, refine, document and maintain code in an high level programming language to solve programming problems applying algorithmic schemas and using data structures.
CT5.5. To use the tools of a software development environment to create and develop applications.

Generical:
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

TEACHING METHODOLOGY

The teaching methodology is based on weekly theory classes (2h) and lab (2h). In the theory classes will introduce the concepts, equations, algorithms and techniques of the course contents, and exercises that help to assimilate the concepts and facilitate the development of practices that are performed in the lab sessions. The lab will consist of the teacher in introducing the scripts practices, structured sessions, and specific concepts required for their development. Students must complete the design and implementation of various applications related to the contents of the course. To facilitate their development, applications will be supplied skeletons will be partially programmed.

Two hours of theory classes are weekly.

The two hours of laboratory classes are also weekly.

The independent learning is considered essential because the students outside of class must deepen some of the content entered by the teacher, using the documentation provided and seeking new ones.

The course uses the C + + programming language, along with OpenGL and GLSL.

LEARNING OBJECTIVES OF THE SUBJECT

1.Understand in depth the various stages of the graphics pipeline
2.Being able to implement the algorithms associated with different stages of visualization
3.Understand the fundamentals, limitations of the model equations of local lighting
4.Assimilating the functionality, programming and execution model shaders in GLSL
5.Understanding and implementing technical skills have to interact with 3D scenes (selection, manipulation and navigation).
6.Know in depth the concepts, techniques and algorithms related texturació surfaces
7.Understand and be able to develop algorithms for the simulation of shadows
8.Understand and be able to develop algorithms for the simulation of mirror reflections
9.Understand and be able to develop algorithms for the simulation of transparent objects
10.Assimilate the main concepts, equations and algorithms for global illumination
11.Knowing the ray-tracing algorithm and its variants
12.Being able to implement features for efficient ray-geometry intersection
13.Identify the advantages and disadvantages of the different structures of spatial data
14.Being able to develop applications for interactive graphics rendering of 3D scenes
15.Understand the elements of realistic visualization and differences between models of local and global illumination
16.Know CG possibilities for the professional career, and develop quality skills.
17.Know the role of computer graphics in the development of software with clear social, economic or environmental contributions, in fields such as medicine, industrial design and cultural heritage.

STUDY LOAD

Type	Hours	Percentage
Guided activities	6,0	4.00
Hours small group	30,0	20.00
Self study	84,0	56.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

Introduction to Graphics

Description:
Paradigms display. Elements that define the rendering. Emission, reflection and transmission of light. Behavior and widespread speculation. Models of global and local illumination.

Computer graphics applications areas

Description:
Role of computer graphics in our world. Main applications with clear social, economic and environmental contributions. Applications in medicina, industry and cultural heritage.

Process visualization projective

Description:
Geometric transformations and coordinate systems. Shipping geometry. Vertex processing. Composition of primitive and cut. Rasterització and interpolation. Processing fragments. Operations fragment. Upgrading the frame buffer.

Development of shaders

Description:
Vertex shaders. Geometry Shaders. Fragment shaders. Language GLSL. API for developing shaders.

Interaction with 3D scenes

Description:
Selection of objects. Manipulation of objects. Handling the navigation camera and the scene.

2D Textures

Description:
Texture space. Reverse Mapping. Generation, transformation, and interpolation of texture coordinates. Projective texture mapping. Sampled textures. Mipmapping. Samplers in GLSL.

Simulation of shadows

Description:
Concepts. Umbra and penumbra. Properties. By projecting shadows on one or more plans. Shadow mapping.

Simulation of specular reflections

Description:
Concepts. Direct Reflection (with virtual objects). Simulation with dynamic textures. Environment mapping

Simulation of transparent objects

Description:
Introduction. Scattering. Refraction. Snell law. Critical angle. Fresnel equations. Alpha blending.

Global Illumination

Description:
Figures basic radiometry. BSDF. General rendering equation. Mechanisms of transport of light. Classification of global illumination algorithms.

Ray-tracing

Description:
Ray-tracing classic. Ambient occlusion

Ray-Intersection Geometry

Description:
Algorithms-ray intersection geometry. Spatial Data Structures. Subdivision of space. Branch of the scene.

ACTIVITIES

Introduction to Graphics

Specific objectives:
15, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.

Full-or-part-time: 4h
Theory classes: 2h
Self study: 2h

Applications of computer graphics

Specific objectives:
16, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 2h
Self study: 2h

Process visualization projective

Specific objectives:
1, 2, 14

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 4h
Self study: 6h

Development of shaders

Specific objectives:
1, 4, 14

Full-or-part-time: 30h
Theory classes: 2h
Laboratory classes: 8h
Self study: 20h

Interaction with 3D scenes

Specific objectives:
5, 14

Full-or-part-time: 18h
Theory classes: 2h
Laboratory classes: 6h
Self study: 10h

2D Textures

Specific objectives:
6

Full-or-part-time: 14h
Theory classes: 4h
Laboratory classes: 2h
Self study: 8h

Partial Review

Description:
Consideration of the first part of the course topics.

Specific objectives:
1, 2, 3, 4, 5, 6, 15, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.

Full-or-part-time: 2h
Guided activities: 2h

A laboratory test

Description:
Testing concepts, techniques, algorithms, languages ☐☐and APIs on the first lab.

Specific objectives:
1, 2, 3, 4, 5, 6, 15, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.

Full-or-part-time: 2h
Guided activities: 2h

Simulation of shadows

Specific objectives:
7, 14

Full-or-part-time: 14h
Theory classes: 4h
Laboratory classes: 2h
Self study: 8h

Simulation of specular reflections

Specific objectives:
8, 14

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 2h
Self study: 8h

Simulation of transparent objects

Specific objectives:
9, 14

Full-or-part-time: 4h
Theory classes: 2h
Self study: 2h

Global Illumination

Specific objectives:
10

Full-or-part-time: 6h
Theory classes: 2h
Self study: 4h

Ray-tracing

Specific objectives:
10, 11, 14

Full-or-part-time: 14h
Theory classes: 2h
Laboratory classes: 2h
Self study: 10h

Intersection-beam geometry

Specific objectives:
13, 14

Full-or-part-time: 5h
Theory classes: 1h
Self study: 4h

Test Laboratory 2

Description:
Testing concepts, techniques, algorithms, languages ☐☐and APIs on the second lab.

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.

Full-or-part-time: 2h
Guided activities: 2h

Final Exam

Description:
Final examination of the entire syllabus

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.

Full-or-part-time: 3h
Guided activities: 3h

Working graphics applications in today's society

Description:
Written work on the role of computer graphics in the software development impact social, economic and / or environmental, in areas such as medicine, design and cultural heritage.

Specific objectives:
16, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 4h
Self study: 4h

Seminar on computer gràfics

Specific objectives:
16, 17

Related competencies :
G2. SUSTAINABILITY AND SOCIAL COMPROMISE: to know and understand the complexity of the economic and social phenomena typical of the welfare society. To be capable of analyse and evaluate the social and environmental impact.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 2h
Self study: 2h

GRADING SYSTEM

F = final exam
AA = other online activities
C1 = lab control 1
C2 = lab control 2

Mark = max(0.5E, 0.4E + 0.1AA) + 0.25C1 + 0.25C2

BIBLIOGRAPHY

Basic:
- Andújar, C.; Brunet, P.; Fairen, M.; Monclús, E.; Navazo, I.; Vàzquez, P.P.; Vinacua, A. Informàtica gràfica: un enfocament multimèdia. CPET, 2008.
- Angel, E.; Shreiner, D. Interactive computer graphics : a top-down approach with WebGL. 7th ed., global ed. Harlow: Pearson, 2015. ISBN 9781292019345.
- Akenine-Moller, T. [et al.]. Real-time rendering. 4th ed. CRC Press, 2018. ISBN 9781138627000.
- Rost, R.J.; Licea-Kane, B. OpenGL shading language. 3rd ed. Addison-Wesley, 2010. ISBN 9780321637635.
- Watt, A.H. 3D computer graphics. 3rd ed. Addison-Wesley, 2000. ISBN 0201398559.

Complementary:
- Pharr, M.; Jakob, W.; Humphreys, G. Physically based rendering: from theory to implementation. 3rd ed. Morgan Kaufmann Publisher, 2016. ISBN 9780128007099.
- Kessenich, J.; Sellers, G.; Shreiner, D. OpenGL programming guide: the official guide to learning OpenGL, version 4.5 with SPIR-V. 9th ed. Addison-Wesley, 2017. ISBN 9780134495491.
- Langetepe, E.; Zachmann, G. Geometric data structures for computer graphics. AK Peters, 2006. ISBN 9781568812359.

RESOURCES

Hyperlink:
- http://qt.nokia.com/- http://www.opengl.org/documentation/specs/