Course guide

270022 - G - Graphics

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 Andujar Gran (andujar@cs.upc.edu)

Others:
- Alejandro Ríos Jerez (arios@cs.upc.edu)
- Alvaro Vinacua Pla (alvar@cs.upc.edu)
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- Marta Fairen Gonzalez (mfairen@cs.upc.edu)
- Oscar Argudo Medrano (oargudo@cs.upc.edu)

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. APPROPRIATE 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.00</td>
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<tr>
<td>Hours small group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
<tr>
<td>Self study</td>
<td>84,0</td>
<td>56.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>20.00</td>
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Total learning time: 150 h

CONTENTS

Introduction to Graphics

Description:
<table>
<thead>
<tr>
<th>Computer graphics applications areas</th>
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<tbody>
<tr>
<td><strong>Description:</strong> Role of computer graphics in our world. Main applications with clear social, economic and environmental contributions. Applications in medicina, industry and cultural heritage.</td>
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<tr>
<th>Process visualization projective</th>
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<tr>
<th>Development of shaders</th>
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<tr>
<td><strong>Description:</strong> Vertex shaders. Geometry Shaders. Fragment shaders. Language GLSL. API for developing shaders.</td>
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<tr>
<th>Interaction with 3D scenes</th>
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<tr>
<td><strong>Description:</strong> Selection of objects. Manipulation of objects. Handling the navigation camera and the scene.</td>
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<th>2D Textures</th>
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<tr>
<th>Simulation of shadows</th>
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<tr>
<td><strong>Description:</strong> Concepts. Umbra and penumbra. Properties. By projecting shadows on one or more plans. Shadow mapping.</td>
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<tr>
<th>Simulation of specular reflections</th>
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<tbody>
<tr>
<td><strong>Description:</strong> Concepts. Direct Reflection (with virtual objects). Simulation with dynamic textures. Environment mapping</td>
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<tr>
<th>Simulation of transparent objects</th>
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Global Illumination

Description:

Ray-tracing

Description:
Ray-tracing classic. Ambient occlusion

Ray-Intersection Geometry

Description:

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:
G8. APPROPRIATE 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.
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
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:
G8. APPROPRIATE 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.
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
Self study: 4h

Seminar on computer gràfics

Specific objectives:
16, 17

Related competencies:
G8. APPROPRIATE 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.
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
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:
Complementary:

RESOURCES

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