270022 - G - Graphics

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 723 - CS - Department of Computer Science
Academic year: 2018
Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: - Carlos Andujar Gran (andujar@cs.upc.edu)
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         - Robert Joan Arinyo (robert@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>Total learning time: 150h</th>
<th>Theory classes: 30h</th>
<th>20.00%</th>
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</thead>
<tbody>
<tr>
<td>Practical classes:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>30h</td>
<td>20.00%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>6h</td>
<td>4.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>84h</td>
<td>56.00%</td>
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</table>
## Content

### Introduction to Graphics

**Degree competences to which the content contributes:**

**Description:**

### Computer graphics applications areas

**Degree competences to which the content contributes:**

**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

**Degree competences to which the content contributes:**

**Description:**

### Development of shaders

**Degree competences to which the content contributes:**

**Description:**

### Interaction with 3D scenes

**Degree competences to which the content contributes:**

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

### 2D Textures

**Degree competences to which the content contributes:**
Description:

Simulation of shadows

Degree competences to which the content contributes:
Description:
Concepts. Umbra and penumbra. Properties. By projecting shadows on one or more plans. Shadow mapping.

Simulation of specular reflections

Degree competences to which the content contributes:
Description:
Concepts. Direct Reflection (with virtual objects). Simulation with dynamic textures. Environment mapping

Simulation of transparent objects

Degree competences to which the content contributes:
Description:

Global Illumination

Degree competences to which the content contributes:
Description:

Ray-tracing

Degree competences to which the content contributes:
Description:
Ray-tracing classic. Ambient occlusion

Ray-Intersection Geometry
Degree competences to which the content contributes:

Description:
### Planning of activities

| Introduction to Graphics | Hours: 4h  
Theory classes: 2h  
Practical classes: 0h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 2h |
<table>
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<tbody>
<tr>
<td>Specific objectives:</td>
<td>15, 17</td>
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</table>

| Applications of computer graphics | Hours: 2h  
Theory classes: 0h  
Practical classes: 0h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 2h |
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<tbody>
<tr>
<td>Specific objectives:</td>
<td>16, 17</td>
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</tbody>
</table>

| Process visualization projective | Hours: 10h  
Theory classes: 2h  
Practical classes: 0h  
Laboratory classes: 2h  
Guided activities: 0h  
Self study: 6h |
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<tbody>
<tr>
<td>Specific objectives:</td>
<td>1, 2, 14</td>
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</table>

| Development of shaders        | Hours: 18h  
Theory classes: 2h  
Practical classes: 0h  
Laboratory classes: 6h  
Guided activities: 0h  
Self study: 10h |
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<tr>
<td>Specific objectives:</td>
<td>1, 4, 14</td>
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</table>
Interaction with 3D scenes

| Hours: 18h |
|---|---|
| Theory classes: 2h |
| Practical classes: 0h |
| Laboratory classes: 6h |
| Guided activities: 0h |
| Self study: 10h |

Specific objectives:

5, 14

2D Textures

| Hours: 14h |
|---|---|
| Theory classes: 4h |
| Practical classes: 0h |
| Laboratory classes: 2h |
| Guided activities: 0h |
| Self study: 8h |

Specific objectives:

6

Partial Review

| Hours: 2h |
|---|---|
| Guided activities: 2h |
| Self study: 0h |

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

Specific objectives:

1, 2, 3, 4, 5, 6, 15, 17

A laboratory test

| Hours: 2h |
|---|---|
| Guided activities: 2h |
| Self study: 0h |

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

Specific objectives:

1, 2, 3, 4, 5, 6, 15, 17
<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>Hours: 12h</th>
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<tr>
<td></td>
<td>Theory classes: 2h</td>
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<td></td>
<td>Guided activities: 0h</td>
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<td>Self study: 8h</td>
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<td>7, 14</td>
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**Simulation of shadows**

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>Hours: 12h</th>
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<tr>
<td></td>
<td>Theory classes: 2h</td>
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<td>Guided activities: 0h</td>
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<td>Self study: 8h</td>
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<td>8, 14</td>
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**Simulation of specular reflections**

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>Hours: 4h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
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<tr>
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<td>Practical classes: 0h</td>
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<td>Laboratory classes: 0h</td>
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<td>Guided activities: 0h</td>
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<tr>
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<td>Self study: 2h</td>
</tr>
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<td>9, 14</td>
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**Simulation of transparent objects**

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th>Hours: 6h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
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<tr>
<td></td>
<td>Practical classes: 0h</td>
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<td></td>
<td>Guided activities: 0h</td>
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<tr>
<td></td>
<td>Self study: 4h</td>
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<td>10</td>
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## Ray-tracing

**Hours:** 20h  
- Theory classes: 4h  
- Practical classes: 0h  
- Laboratory classes: 6h  
- Guided activities: 0h  
- Self study: 10h

**Specific objectives:**  
10, 11, 14

## Intersection-beam geometry

**Hours:** 14h  
- Theory classes: 4h  
- Practical classes: 0h  
- Laboratory classes: 0h  
- Guided activities: 0h  
- Self study: 10h

**Specific objectives:**  
13, 14

## Test Laboratory 2

**Hours:** 2h  
- Guided activities: 2h  
- Self study: 0h

**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

## Final Exam

**Hours:** 3h  
- Guided activities: 3h  
- Self study: 0h

**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

## Working graphics applications in today's society

**Hours:** 4h  
- Guided activities: 0h  
- Self study: 4h
**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

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**Seminar on computer gràfics**

**Hours:** 3h
- Theory classes: 0h
- Practical classes: 0h
- Laboratory classes: 0h
- Guided activities: 3h
- Self study: 0h

**Specific objectives:**
16, 17

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**Qualification system**

F = final exam  
C1 = lab control 1  
C2 = lab control 2

Mark = 0.5F + 0.25C1 + 0.25C2
Bibliography

Basic:


Complementary:


Others resources:

Hyperlink

http://qt.nokia.com/

http://www.opengl.org/documentation/specs/