Course guide
270622 - FRR - Fast Realistic Rendering

Last modified: 02/02/2024

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

Degree: MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).

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

LECTURER

Coordinating lecturer: PERE PAU VÁZQUEZ ALCOCER

Others: Segon quadrimestre:
IMANOL MUÑOZ PANDIELLA - 10
PERE PAU VÁZQUEZ ALCOCER - 10

PRIOR SKILLS

Students are expected to be familiar with OpenGL and have taken some graphics subjects before taking this subject. In particular, students need to know at a minimum how to implement programs in OpenGL with vertex shaders, fragment shaders, and eventually geometry shaders. They are expected to be able to send geometry through the pipeline and be able to use other features such as texturing.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE1.1. Capability to understand and know how to apply current and future technologies for the design and evaluation of interactive graphic applications in three dimensions, either when priorizing image quality or when priorizing interactivity and speed, and to understand the associated commitments and the reasons that cause them.
CEE1.2. Capability to understand and know how to apply current and future technologies for the evaluation, implementation and operation of virtual and / or increased reality environments, and 3D user interfaces based on devices for natural interaction.
CEE1.3. Ability to integrate the technologies mentioned in CEE1.2 and CEE1.1 skills with other digital processing information technologies to build new applications as well as make significant contributions in multidisciplinary teams using computer graphics.
CEE3.1. Capability to identify computational barriers and to analyze the complexity of computational problems in different areas of science and technology as well as to represent high complexity problems in mathematical structures which can be treated effectively with algorithmic schemes.

Generical:
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.

Transversal:
CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.
CTR5. APPROPIATE ATTITUDE TOWARDS WORK: Capability to be motivated by professional achievement and to face new challenges, to have a broad vision of the possibilities of a career in the field of informatics engineering. Capability to be motivated by quality and continuous improvement, and to act strictly on professional development. Capability to adapt to technological or organizational changes. Capacity for working in absence of information and/or with time and/or resources constraints.

Basic:
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CB7. Ability to integrate knowledges and handle the complexity of making judgments based on information which, being incomplete or limited, includes considerations on social and ethical responsibilities linked to the application of their knowledge and judgments.

TEACHING METHODOLOGY

For the realization of the course in the teacher provide theoretical lectures and materials as articles or manuals that students have read and presented in some cases.
During the lectures will introduce the most relevant concepts and give guidelines for the preparation of submissions of articles.
During the laboratory classes will be three events: developing small exercises GLSL to implement a small project to be presented at the end of the course and make presentations of papers in the literature.

LEARNING OBJECTIVES OF THE SUBJECT

1.Get current graphics hardware and the development of GPU programming paradigms.
2.Understand the problems and limitations of developing graphical applications in real time.
3.Learn how to develop computer graphics applications for GPUs.
4.Learning the state of the art in algorithms to generate advanced shadows.
5.Learn techniques for accelerating scene rendering by geometry processing.
6.Learning image-based rendering algorithms.

STUDY LOAD

Type	Hours	Percentage
Self study	96,0	64.00
Hours small group	24,0	16.00
Guided activities	6,0	4.00
Hours large group	24,0	16.00

Total learning time: 150 h

CONTENTS

Introduction to graphics hardware.

Description:
The aim of this section is to present the graphics software and its evolution over the years. We present the fixed pipeline of OpenGL programmable pipeline and analyzing the flow of information and data sources available. We also introduce generic algorithms accelerated by GPU computing.

Introduction to GPU programming languages.

Description:
In this section we discuss Cg and GLSL, as well as introduced CUDA and OpenCL. GLSL and deepen all the different elements of the programming: types, data structures, control structures, subprograms and library definition.

GPU-aided geometry processing.

Description:
The accurate real-time rendering acceleration painting process from the point of view of geometry and illumination. As the scenes of today are very complex algorithms needed to process them efficiently. In this section we discuss the geometry processing using different aspects of GPUs, such as the calculation of visibility, restructuring primitives and grouping of primitives.

Shadow generation.

Description:
An important element in the perception of the realism of a scene is to display shadows. Over time, the algorithms have been refined display of shadows, moving shadows "hard" to shadows, to the generation of so-called ambient lighting. In this section we review the evolution and discuss the various methods of generating shadows using GPU.

Accelerated rendering using images.

Description:
With the appearance of textures to the GPU, there have been many improvements in painting realistic attempting to use this element to improve the result. Initially, only to replace color, later, to simulate details of the geometry, and then for storing precomputed geometry and lighting. In this section we will review how to use textures to simulate various effects ranging from bump-mapping to storing the complete geometry of an object or a lot of texture memory using impostors.

ACTIVITIES

Lectures

Description:
Material will be presented in lectures along the term. You are expected to conduct complementary readings that will be assigned on occasion, to be presented at a later date.

Specific objectives:
1, 2, 3

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Full-or-part-time: 73h 36m
Theory classes: 30h
Self study: 43h 36m

Implementation of the practical assignments.

Description:
Some assignments will be proposed and the students must develop them, partially during the lab sessions.

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1, 2, 3

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Full-or-part-time: 48h
Laboratory classes: 12h
Self study: 36h

Articles presentation

Description:
Papers will be assigned to the students and they will be presented and discussed by the students.

Specific objectives:
2, 3, 5

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CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.

Full-or-part-time: 26h
Practical classes: 6h
Self study: 20h

Final exam

Description:
At the end of the term you will have a final exam, which may be a take-home.

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

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Full-or-part-time: 2h 24m
Guided activities: 2h 24m

GRADING SYSTEM

The evaluation method will have three parts: the presentation of papers and attendance, development of the project and a final exam.
The presentation of papers and attendance will note (PRES) that depend on class attendance and participation, the rigor and quality of the presentation of the article that touches the student as well as the ability to answer questions from students and / or teacher about the article. Value will be questions that students make in the presentations of other students.
The weight of this part (PRES) will be 30% of the final grade.
The other part of the assessment (40%) will be the programming project (PROJ).
The final exam (EF), which can be done at home, will have a weight of 30%.
The final grade is then:
NF = PRES * 0.3 + PROJ * 0.4 + EF * 0.3

BIBLIOGRAPHY

Basic:
- Kessenich, J.; Sellers, G.; Shreiner, D. OpenGL programming guide: the official guide to learning OpenGL, version 4.5 with SPIR-V. 9th ed.. Upper Saddle River, NJ: Addison-Wesley, 2017. ISBN 9780134495491.
- Akenine-Möller, T. [et al.]. Real-time rendering. 4th ed. Boca Raton: CRC Press, 2018. ISBN 9781138627000.

Complementary:
- Wright, R.S. [et al.]. OpenGL superbible: comprehensive tutorial and reference. 5th ed. Upper Saddle River: Addison-Wesley, 2011. ISBN 9780321712615.

RESOURCES

Hyperlink:
- http://en.wikipedia.org/wiki/GLSL- http://en.wikipedia.org/wiki/OpenGL- http://www.opengl.org