Course guide
270150 - TGA - Graphic Cards and Accelerators

Last modified: 13/07/2023

Unit in charge: Barcelona School of Informatics
Teaching unit: 701 - DAC - Department of Computer Architecture.

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

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

LECTURER

Coordinating lecturer: AGUSTÍN FERNÁNDEZ JIMÉNEZ

Others: Primer quadrimestre:
AGUSTÍN FERNÁNDEZ JIMÉNEZ - 11, 12
DANIEL JIMENEZ GONZALEZ - 12

PRIOR SKILLS

Basic knowledge of computer architecture.
Basic knowledge about graphics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CCO2.6. To design and implement graphic, virtual reality, augmented reality and video-games applications.
CCO3.1. To implement critical code following criteria like execution time, efficiency and security.
CCO3.2. To program taking into account the hardware architecture, using assembly language as well as high-level programming languages.
CEC2.1. To analyse, evaluate, select and configure hardware platforms for the development and execution of computer applications and services.
CEC2.2. To program taking into account the hardware architecture, using assembly language as well as high-level programming languages.
CEC3.1. To analyse, evaluate and select the most adequate hardware and software platform to support embedded and real-time applications.
CT1.1B. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming. Knowledge about the structure, operation and interconnection of computer systems, and about the fundamentals of its programming.
CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.
CT6.3. To demonstrate knowledge about the characteristics, functionalities and structure of the Operating Systems allowing an adequate use, management and design, as well as the implementation of applications based on its services.
CT7.1. To demonstrate knowledge about metrics of quality and be able to use them.
CT7.2. To evaluate hardware/software systems in function of a determined criteria of quality.

Generical:
G4. EFFECTIVE ORAL AND WRITTEN communication: To communicate with other people knowledge, procedures, results and ideas orally and in a written way. To participate in discussions about topics related to the activity of a technical informatics engineer.
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

TEACHING METHODOLOGY

There are two types of classes: theory and laboratory classes.

During the first weeks there will be no laboratory classes.

The theory classes will be expository by the teacher, including theoretical concepts, practical examples and resolution of training exercises.

The laboratory classes will be of two types: the first classes will be directed, aimed at knowing the tools and programming languages used; The following classes will be oriented to the realization of a small project.

In addition, depending on the availability of each course, there will be conferences by experts.

LEARNING OBJECTIVES OF THE SUBJECT

1.Know in depth the operation of a graphics card
2.Know the limitations of a graphics card in the execution of general purpose applications.
3.Know the basic techniques to implement general purpose applications on a graphics card.
4.Know the possibilities offered by a graphics card to implement non-interactive graphics applications.
5.Given some performance requirements, evaluate which is the best hardware alternative to achieve them.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

Unit 1 1: Introduction

Description:
- History of Graphics Cards
- The graphic pipeline

UNIT 2: Components of a graphics card

Description:
- Shaders
- Rasteritzation
- Textures
- Antialiasing

UNIT 3: Commercial Examples

Description:
- Historical evolution of graphic hardware
- Classic Examples
- Current Examples

Unit 4: High Performance Computing

Description:
- CPUs vs GPUs
- Supercomputing and GPUs
- Paradigms of computing/parallelism
- Multi-GPU systems
- Accelerators

Unit 5: Software

Description:
- GPGPU
- CUDA
- OpenGL
- DirectX
- Shader Assembly and Shading Languages

Unit 6: Technological Aspects

Description:
- Cooling
- Overclocking
- Benchmarking
- Buses
- Connectors

ACTIVITIES

Final exam

Description:
It is a remote exam. Around week 13, the exam will be given during class time. Students have 2 weeks to take the exam. Each exam question has a limited space to answer. The answers must be concise, clear and correct.

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

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G4. EFFECTIVE ORAL AND WRITTEN communication: To communicate with other people knowledge, procedures, results and ideas orally and in a written way. To participate in discussions about topics related to the activity of a technical informatics engineer.
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Full-or-part-time: 30h
Self study: 30h

CUDA

Description:
The basic tools offered by CUDA for graphics card programming will be presented.

Specific objectives:
3

Related competencies :
G4. EFFECTIVE ORAL AND WRITTEN communication: To communicate with other people knowledge, procedures, results and ideas orally and in a written way. To participate in discussions about topics related to the activity of a technical informatics engineer.
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Full-or-part-time: 34h
Theory classes: 6h
Laboratory classes: 14h
Self study: 14h

Graphic pipeline

Description:
Exhaustive description of the graphic pipeline.

Specific objectives:
1, 2

Full-or-part-time: 9h
Theory classes: 2h
Laboratory classes: 2h
Self study: 5h

Commercial Examples

Description:
Some examples of commercial graphics cards will be presented, with the aim of understanding their current design.

Specific objectives:
1, 2, 5

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

GPGPU

Description:
Describe the classical GPGPU techniques and how their limitations have influenced the design of new architectures and programming languages.

Specific objectives:
2, 3

Related competencies :
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G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

OpenCL

Description:
Language description.

Specific objectives:
3

Related competencies :
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G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

Project

Description:
Implementation of a software project with GPUs.

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

Related competencies :
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G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 30h
Laboratory classes: 10h
Self study: 20h

Basic components of a graphics card

Description:
Some fundamental elements of a graphics card will be presented: texture unit, memory, z buffer, ...

Specific objectives:
1, 2, 3, 4

Related competencies :
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Full-or-part-time: 9h
Theory classes: 4h
Self study: 5h

CPUs vs GPUs

Description:
The essential differences between a CPU and a GPU will be introduced.

Specific objectives:
1, 5

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

Shading Languages

Description:
Description of the basic characteristics of the programming languages of the shaders, in high and low level.

Specific objectives:
1, 3, 4

Related competencies :
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G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

History

Description:
Historical overview of the evolution of graphics cards, from the first PC to today.

Specific objectives:
1

Full-or-part-time: 2h
Theory classes: 2h

Talks

Description:
During the course, and depending on availability, talks on related topics will be given.

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

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G4. EFFECTIVE ORAL AND WRITTEN communication: To communicate with other people knowledge, procedures, results and ideas orally and in a written way. To participate in discussions about topics related to the activity of a technical informatics engineer.
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

GRADING SYSTEM

50% Take-home exam
50% Laboratory

The take-home exam will be held at the end of the course. The statement will be delivered in class and will be returned resolved after about 10 days. It is an individual test that must be done by hand on the exam sheets distributed by the teacher.

The laboratory grade is obtained from the follow-up notes of the practice sessions prepared by each teacher and the evaluation of the project. To evaluate the project, students must submit a written report.

BIBLIOGRAPHY

Basic:

- Patterson, D.A.; Hennessy, J.L. Estructura y diseño de computadores: la interfaz software/hardware. 4a. ed. Reverté, 2011. ISBN 9788429126204.
- Hwu, Wen-mei W.; Kirk, D.B.; El Hajj, I. Programming massively parallel processors : a hands-on approach. Fourth edition. Cambridge, Mass.: Morgan Kaufmann, 2023. ISBN 9780323912310.
- Ujaldón Martínez, M. Procesadores gráficos para PC. Ciencia 3, 2005. ISBN 8495391090.
- Gaster B.R.; Howes, L.; Kaeli, D.R.; Mistry, P.; Schaa, D. Heterogeneous computing with OpenCL. Rev. ed. Elsevier/Morgan Kaufmann, 2013. ISBN 9780124058941.