# Course Specifications

From the academic year 2021-2022 up to and including the academic year

## Computer Graphics (E016712)

Due to Covid 19, the education and assessment methods may vary from the information displayed in the schedules and course details. Any changes will be communicated on Ufora.

**Course size** *(nominal values; actual values may depend on programme)*

**Credits** 6.0      **Study time** 180 h      **Contact hrs** 60.0h

**Course offerings and teaching methods in academic year 2021-2022**

| A (semester 2) | English | Gent | group work | 15.0h |
| | | | lecture | 15.0h |
| B (semester 2) | English | Gent | group work | 5.0h |
| | | | lecture | 10.0h |

**Lecturers in academic year 2021-2022**

| Pizurica, Aleksandra | TW07 | lecturer-in-charge |
| Babin, Danilo | TW07 | co-lecturer |

**Offered in the following programmes in 2021-2022**

| | crdts | offering |
| --- | --- | --- |
| Master of Science in Electronics and ICT Engineering Technology(main subject ICT) | 3 | B |
| Master of Science in Computer Science Engineering | 6 | B |
| Master of Science in Computer Science Engineering | 6 | A |
| Master of Science in Information Engineering Technology | 6 | A, B |
| Exchange Programme in Computer Science (master's level) | 6 | A |

**Teaching languages**

English

**Keywords**

Computer graphics, image synthesis, point cloud, meshing, illumination and shading, texturing, animation, deep geometric learning

**Position of the course**

Computer graphics deals with generating and manipulating images and virtual scenes with the aid of computers. Today it constitutes a core technology embedded in cell phone and computer displays, digital photography, film, video games, virtual and augmented reality, and many specialized applications. This course teaches the fundamentals of Computer Graphics, starting from image formation and rendering on a computer screen. The student is taught basic methodology to construct and manipulate complex graphical objects and virtual scenes using meshing, transformations, lighting, shading and texturing objects in 3D. We also address creating meshes from point clouds (acquired by devices such as LiDAR), as well as techniques for deformation of curves and surfaces and animation of objects. Attention will be devoted also to state-of-the-art computer graphics approaches, which are often based on deep learning and an emerging area of geometric deep learning.

**Contents**

Applicable for the course of **6 ECTS (course offering A)**:
- Digital representation of images: Raster images, Vector images
- 2D and 3D transformations; Quaternions and rotation
- Viewing in 3D: Projections; Synthetic camera model; Conceptual and practical viewing models
- Meshes: Mesh generation and subdivision strategies
- Point clouds and Scene graphs: Point cloud meshing; Space partitioning (Octree, k-d tree)

- Illumination and Shading: Phong model, Gouraud and Phong shading, Elements of Ray tracing and Radiosity
- Texture synthesis and texture mapping
- Rasterization and Clipping: Scan conversion; Polygon filling; Line and polygon clipping
- Curves and Surfaces: Bezier curves, Splines, NURBS, Rendering curves and surfaces
- Animation: kinematics, dynamics, motion capture, boids, particle systems
- Deep learning in computer graphics: Scene generation and animation using deep learning; Deep geometric learning
- Advanced topics and applications (medical image visualization; advanced techniques for scene rendering or animation)

Applicable for the course of **3 ECTS (course offering B)**:
- Digital representation of images: Raster images, Vector images
- 2D and 3D transformations; Quaternions and rotation
- Viewing in 3D: Projections; Synthetic camera model; Conceptual and practical viewing models
- Meshes: Mesh generation and subdivision strategies
- Point clouds and Scene graphs: Point cloud meshing; Space partitioning (Octree, k-d tree)
- Illumination and Shading: Phong model, Gouraud and Phong shading, Elements of advanced rendering (Ray tracing, Radiosity)
- Texture synthesis and texture mapping

## Initial competences

Elementary knowledge of two-dimensional and three-dimensional geometry and of two-dimensional trigonometry; practical knowledge of a programming language for the execution of the projects.

## Final competences

1 To be able to distinguish basic graphics formats (raster and vector graphics) and to know their specific properties.
2 To understand, and to know how to apply elementary transformations in two and three dimensions, for translation, rotation and distortion of objects.
3 To understand and to know how to apply the concept of viewing in 3D: synthetic camera model, parallel and perspective projections, visibility in a display window.
4 To be able to apply illumination and shading to the generated objects and scenes and to generate synthetic textures.
5 To be able to generate virtual graphical objects using graphics programming frameworks such as OpenGL, WebGL or VTK.
6 Applicable **only for the course of 6 ECTS (course offering A)**:
- To have acquired the knowledge about basic principles of rasterization.
- To understand and know how to apply the basic principles of deforming curves and surfaces in 3D.
- To understand the principles of animation.
- To have acquired the knowledge about applications of computer graphics in specific domains such as medical image visualisation.
- To have acquired the knowledge about applications of deep learning in computer graphics.

## Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

## Conditions for exam contract

This course unit cannot be taken via an exam contract

## Teaching methods

Group work, Lecture

## Learning materials and price

The course material, an extensive PowerPoint presentation and slide notes is made available, free of charge, on the electronic learning platform, as the course progresses throughout the semester.

## References

- Edward Angel and Dave Shreiner, Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL, Addison-Wesley, 2012.
- J. F. Hughes, A. van Dam, M. McGuire, D. F. Sklar, J. D. Foley, S. K. Feiner and K. Akeley, Computer graphics: principles and practice, Third Edition, Addison-Wesley Professional, 2013.
- W. Schroeder and K. Martin, B. Lorensen, The Visualization Toolkit An Object-Oriented Approach To 3D Graphics, Fourth Edition, Kitware, 2006.
- SIGGRAPH 2020 Tutorial - Edward Angel and Dave Shreiner: An Interactive Introduction to WebGL, SIGGRAPH Courses 2020.

## Course content-related study coaching

Interactive support and coaching through the electronic learning platform (a course forum, and a project forum; students may open up new threads themselves); appointments, upon request by e-mail, for personal issues.

## Assessment moments

end-of-term and continuous assessment

## Examination methods in case of periodic assessment during the first examination period

Written examination, Open book examination

## Examination methods in case of periodic assessment during the second examination period

Written examination, Open book examination

## Examination methods in case of permanent assessment

Report, Participation

## Possibilities of retake in case of permanent assessment

examination during the second examination period is not possible

## Extra information on the examination methods

During examination period (PE): written exam consisting of two parts (Theory: closed book; Application and problem solving: open book).
During semester (NPE): evaluation of the project (group work) and homework assignments (individual).
The project involves programming, writing a report, demonstrating the code and presenting the work done. Homework assignments consist of small programming exercises (e.g., to create and manipulate simple graphics objects).
Applicable **only for the course of 6 ECTS (course offering A)**: Homework assignments include reading a scientific paper related to advanced state-of-the-art methods and presenting its summary and critical analysis.

## Calculation of the examination mark

Weighting:
- Exam: 60%
- Project: 30%
- Homework: 10%

In order to be able to pass this course, the minimum score of 9/20 is required both for PE (exam) and NPE (project and homework assignments). If these conditions are not met and the total score is still 10/20 or above, the final grade will be brought to 9/20. If the exam score is below 10/20, the maximum obtainable final grade is 10/20 regardless of the total score.
Failing to participate in one or more parts of the evaluation results in the non-passing final grade.