



ACADEMIC YEAR: 2019/20

COURSE: Fundamentals of Computer Graphics

TYPE OF EDUCATIONAL ACTIVITY: Base

TEACHER: Erra Ugo

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website:

phone: +39 0971 205869

mobile (optional):

Language: Italian

ECTS: 6

n. of hours: 48

Campus: Potenza
Dept./School: School of
Engineering
Program: Computer
Engineering
and Information Technologies

Semester: I

EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES

The main objective of the course is to provide a theoretical and applicative introduction to 3D graphics with particular reference to approaches based on photorealistic off-line renderings.

- **Knowledge and understanding:** the student must demonstrate knowledge and understanding of the mathematical models and algorithms that use Ray Tracing in the generation of photorealistic images; camera model, transformation matrices, lighting and shading models, texture mapping; global illumination; implementation through the C/C++ language of all the theory illustrated in the lesson.
 - **Ability to apply knowledge and understanding:** the student must demonstrate that he or she is able to modify and develop algorithms autonomously from the theory illustrated in the lesson; develop procedures capable of generating images from the description of the scene; add and modify the approaches seen in the lesson to expand the possibilities of a photorealistic rendering system.
 - **Autonomy of judgment:** the student must be able to independently evaluate the fundamental properties and performance of a photorealistic rendering algorithm.
 - **Communication skills:** the student must have the ability to present clearly, using, if necessary, a language that can be understood even by non-experts, the functions of a photorealistic rendering system starting from its own as well as the aspects of efficiency and effectiveness.
 - **Learning ability:** the student must be able to consult texts autonomously and scientific articles of graphics rendering to extend the basic knowledge acquired during the course, also concerning other application domains such as real-time computer graphics for those who are interested in the Advanced Three-dimensional Graphics course.
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PRE-REQUIREMENTS

It is advisable to have acquired and assimilated the knowledge and methodologies provided by the teachings of mathematics and fundamental physics, as well as the courses of "Procedural Programming," "Algorithms and Data Structures" and "Object-Oriented Programming." More in details:

- knowledge of vector and matrix algebra is recommended;
 - knowledge of procedural programming (dynamic data structure, pointers, event-driven programming);
 - good knowledge of C language and basic knowledge of the C++;
 - skill in developing computing algorithms using procedural programming.
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SYLLABUS

Miscellaneous Math (2 hrs lessons): Trigonometry, Vectors, Linear Interpolation, Triangles;

Raster Images (2 hrs lessons): Raster Devices, Images, Pixels and Geometry, RGB Color, Alpha Compositing;

Ray Tracing (4 hrs lessons): The Basic Ray-Tracing Algorithm, Perspective, Computing Viewing Rays, Ray-Object



Intersection, Shading, A Ray-Tracing Program, Shadows;

Transformation Matrices (4 hrs lessons): 2D Linear Transformations, 3D Linear Transformations, Translation and Affine Transformations, Inverses of Transformation Matrices, Coordinate Transformations;

Viewing Camera (8 hrs lessons): Viewing Transformations, Projective Transformations, Perspective Projection, Some Properties of the Perspective Transform, Field-of-View;

Surface Shading (8 hrs lessons): Diffuse Shading, Phong Shading, Artistic Shading;

Texture Mapping (4 hrs lessons): Looking Up Texture Values, Texture Coordinate Functions, Applications of Texture Mapping;

Advanced Ray Tracing (8 hrs lessons): Transparency and Refraction, Instancing, Distribution Ray Tracing;

Global Illumination (8 hrs lessons): Particle Tracing for Lambertian Scenes, Path Tracing, Accurate Direct Lighting.

TEACHING METHODS

The main teaching opportunity will be the lesson in class; during the lesson will be presented the main contents of the syllabus. During the lesson, the theoretical aspects, practical applications, and exercises in C/C++ language will be given to encourage the student to put into practice immediately the concepts introduced. On the website, summary questions will also be provided to facilitate the self-assessment of learning on the themes of the lessons. They are usually questions with various difficulties, ranging from simple definitions to requests for comparison of solutions/techniques, up to issues that try to push you to find the reasons for some choices. Participation is strongly recommended.

EVALUATION METHODS

The verification test will be carried out in three phases:

1. During the course, there will be assigned two homework. Each homework consists of about five exercises in which the student will have to implement all or part of some theoretical aspects illustrated in the lesson. The sum of the two homework will give a **maximum score of 10 points**.
2. Towards the end of the course, students are invited to compose groups (maximum three people) for the development of a project whose topic can be proposed together with the teacher. It is required to submit the project with a short technical report and a website. The project can be evaluated in advance by the teacher, who can ask for changes and additional features implementation. The final evaluation of the project will give a **maximum score of 15 points**.
3. The oral test consists of a discussion of the project and of the homework to assess the degree of maturity and autonomy in dealing with application problems in the field of computer graphics, as well as the ability to present clearly and concisely the work done. The oral test will give a **maximum score of 5 points**.

The final grade will be given by the sum of the homework, the project, and an oral discussion, but also based on correctness, depth of knowledge acquired, and the level of participation of the student.

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Fundamentals of Computer Graphics, Fourth Edition, Steve Marschner, Peter Shirley. December 18, 2015 by A.K. Peters/CRC Press, ISBN 9781482229394.

- Course website with C/C++ code of the algorithms illustrated in the lesson, software development tools and tutorials .
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INTERACTION WITH STUDENTS

At the beginning of the course, the teacher describes the course's objectives, syllabus, and validation tests, indicating where to find the teaching material. The reception time is set for Tuesday and Wednesday from 10:30 a.m. to 12:30 p.m. in the teacher's studio or the computer graphics laboratory. In addition to the weekly reception time, the teacher is available at all times for contact with students, through their e-mail or at the end of the lesson.

EXAMINATION SESSIONS (FORECAST)¹

4/2/2020, 18/2/2020, 6/5/2020, 1/7/2020, 15/7/2020, 23/9/2020, 16/12/2020

¹ Subject to possible changes: check the web site of the Teacher or the Department/School for updates



Università degli Studi della Basilicata
Scuola di Ingegneria

SEMINARS BY EXTERNAL EXPERTS YES NO

FURTHER INFORMATION

