Light matter interaction and materials appearance: from physics to virtual reality, 5 ECTS

UJM semester 2

Course instructors: Prof. Alain Trémeau **Language of instruction: English**

Overview

This course takes its outset in the visual appearance of real world materials. The goal in material design is to get as close as possible to replicating the visual appearance of real materials by computer graphical rendering based on mathematical/physical models.

The students will get an introduction into the physical models behind the photorealistic rendering of digitally modelled materials. In addition to surface rendering techniques, this course will introduce techniques for simulating the light scattering that takes place under the surface of most real world materials.

Material appearance is determined by the optical properties of materials. Computation of optical properties from the physical composition of a material will be also introduced in this course. We will survey optical models necessary needed to model materials such as skin (subsurface scattering), plants (including internal structure) and automotive paints (including color flop and sparkle).

Learning outcomes

On successful completion of this course, students should have the skills and knowledge to:

- Understand and master basic knowledge, theories and methods in light-matter interactions;
- Critically review and assess scientific literature in the field and apply theoretical knowledge to identify the novelty and practicality of proposed methods.
- Understand and master basic knowledge, theories and methods useful for simulation of various types of light sources and lighting viewing conditions.
- Analyze real-world light-material interaction and suggest ways of simulating it.
- Understand and master basic knowledge, theories and methods useful for simulation examples of wavelength dependent phenomena such as dispersion, interference and diffraction.
- Combine shading and tracing techniques with theory for light-material interaction.
- Compute the optical properties of a material from a physical description of the material composition.
- Understand and master basic knowledge, theories and methods used for simulation of various optical phenomenon, such as subsurface scattering.
- Understand and master basic knowledge, theories and methods useful for implementing rendering techniques for global illumination.
- Identify, formulate and solve practical problems in material appearance modeling;

Content

- Light-matter interactions: optical properties of materials. The Impact of Light. Sources, Shadows and Shading. BRDF, glossy materials, microfacet models. BSSRDF, subsurface scattering, single scattering, diffusion. Dispersion and spectral rendering. Problems related to material characterisation, metrology, digitalisation.

- Visual effects: global illumination, Fresnel effects (metallic reflection as well as reflection, refraction, and dispersion in transparent objects such as water and glass), absorption, translucency, interference, diffraction, light scattering in volumes.
- Visual Perception of the Physical Properties of materials.
- Materials characterization in various application domains. Material appearance modelling. Digital Material Appearance.
- Machine Learning -based methods for Materials Design. Data mining-aided materials discovery and optimization.
- Rendering of Physically-Based Materials.

Teaching methods

- Lectures and seminars: 18 hours
- Practical work: 12 hours
- Project work: 12 hours

Study materials

- Pharr, M., Jakob, W., and Humphreys, G. Physically Based Rendering: From Theory to Implementation, third edition. Morgan Kaufmann/Elsevier, 2017. http://www.pbrt.org
- http://webstaff.itn.liu.se/~jonun/web/teaching/2009-TNCG13/Siggraph09/courses/amam.pdf
- https://kurser.dtu.dk/course/02941, https://courses.compute.dtu.dk/02941/

Assumed Knowledge

- Knowledge of basic rendering and reflectance functions
- Knowledge of computer graphics fundamentals.

Evaluation criteria

- Written exam 40%
- Written assignments / Labs 30%
- Project work 20%
- Seminar presentations 10%