Computer Graphics III
Winter Term 2019
Organization

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Contents and form

- **Advanced 3D computer graphics**
  - Main topic:
    - **Physically-based realistic rendering**
    - **(a.k.a. Monte Carlo light transport simulation)**
  - Loosely follows-up on *Computer Graphics II* (NPGR004)
  - Assumes working knowledge of basic computer graphics, rendering, and specifically ray tracing. Background in linear algebra, integral calculus, and probability theory is also necessary.
- **2/2 C + Ex**
  - Lecture once a week
  - Labs follow lecture in SW1

Lecture overview 1/2

- **Physical and mathematical fundamentals of image synthesis**
  - Light, radiometry, light reflection, rendering equation.
- **Monte Carlo integration**
  - Statistical estimators and their properties, variance reduction techniques, combined estimators.
- **Solution of the rendering equation via MC**
  - Path tracing

Lecture overview 2/2

- **Volumetric rendering methods**
  - Interaction of light with participating media, volume rendering equation, ray marching, volumetric path tracing, …
- **Advanced image synthesis methods**
  - Bidirectional path tracing, photon mapping, irradiance caching, virtual point lights, Metropolis light transport, …

Labs

- **Pen-and-paper exercises on the material from lectures** (solution of problems)

- **Two possible tracks: Programming assignments or a larger individual project**
  - You choose which of the two tracks suits you better
  - The individual project is only recommended if you have some previous knowledge of physically-based rendering, or if you are fine with studying on your own

- **Student's presentation of scientific papers**

Evaluation – Points

- **Creative assignment (Assignment 0)**
  - **10 pts** for delivering the assignment (+up to 5 extra point for good assessment by your class-mates)
- **Programming assignments (Assignment 1 to 5)**
  - **Max 45 pts** altogether for the programing assignments
  - Extra points can be gained for extended assignments
- **Penalty of 50% pts for each week of delay** in delivering any assignment
- ~~**Paper presentation**~~ **(cancelled in 2019/2010)**
  - ~~Max 10 pts~~
- **Final oral exam**
  - 0 – 45 pts

Evaluation

- 1 (výborně) 86 – 100 pts
- 2 (velmi dobře): 71 – 85 pts
- 3 (dobře): 51 – 70 pts
- 4 (Fail, nevyhověl/a): 0 – 50 pts

- In order to pass, students must obtain **at least 50% of points for each item** on the previous slide (including the final oral exam). Nothing is allowed to be skipped.

Final examination

- Oral
- **Three questions** in total
  - **Two questions** on the material covered in the lectures
    - Randomly selected from a list posted on the class web page:
  - **One question** = discussion of a scientific paper
    a) Students choose three papers during semester
       - The paper topic should be related to realistic rendering
       - Great source: http://kesen.realtimerendering.com/
    b) I approve the students' paper choice
    c) At the exam, I pick one of the three and the student explains what the paper is about

Literature

- M. Pharr, W. Jakob, G. Humphreys: *Physically-based Rendering: From Theory to Implementation*, 3rd ed. Morgan Kaufmann, 2016. [https://www.pbrt.org/]
  - Everything you ever wanted to know about implementing a physically-based renderer. The book can be browsed online.

- E. Veach: *Robust Monte Carlo Methods for Light Transport simulation*, Ph.D. Thesis, Stanford University, 1998.
  [Thesis: http://graphics.stanford.edu/papers/veach_thesis/]
  [Tech Award: https://www.youtube.com/watch?v=e3ss_Ozb9Yg]
  - Everything you ever wanted to know about the theory of light transport

- M. Cohen, J. Wallace: *Radiosity and Realistic Image Synthesis*, Academic Press, 1993. (Chapter 1-2)
  - Chapters 1 and 2 give a good intro to radiometry and photometry.

- P. Dutré, Global Illumination Compendium, [http://people.cs.kuleuven.be/~philip.dutre/GI/]
  - Compendium of useful formulas for implementing a physically-based renderer.

Further graphics classes (winter)

- **Computer graphics seminar**
  - 0/2, NPGR005 (J. Křivánek)
- **Geometric modelling**
  - 2/2, NPGR021 (Z. Šír)
- **Digital image processing**
  - 3/0, NPGR002 (J. Flusser, ÚTIA AV ČR)
- **Autonomous robotics**
  - 2/2, NPGR001 (Václav Hlaváč, CIIRC)
- **Machine learning in computer vision**
  - 2/2, NPGR035 (Elena Šikudová)
- **Animation and graphics production**
  - 1/1, NPGR039 (Ondřej Javora, FF UK)
- **Interactive 3D graphics on the web**
  - 2/2, NPGR012 (Jiří Žára, FEL ČVUT)

ASSIGNMENT 0

Assignment 0

- Max 2 students may work together
- **10 pts** for delivering the work
- 50% down for each week of delay
- **Extra points**:
  - 5 pts for the best rendering
  - 4 for the 2nd best
  - 3 for the 3rd best
  - 2 for the 4th best
  - 1 for the 5th best
- Due date: **Wed Oct 16th (during the labs)**

Assignment 0

- Install 3ds Max, edu version
  - https://www.autodesk.com/education/free-software/3ds-max
  - Lear basics of 3ds max from the edu videos shipped & other online resources
- Install demo version of Corona renderer
  - https://corona-renderer.com/download
  - Lean the basics of rendering with Corona
    - https://corona-renderer.com/resources/tutorials
- (you may also use Cinema4D & Corona for C4D)

Assignment 0

- **Create & render your own scene**
  - Inspiration: https://corona-renderer.com/gallery
  - Ok to download resources from 3rd parties
    - https://evermotion.org/
    - https://www.turbosquid.com/
  - Ok to use Corona material library
    - Shipped with Corona 1.7+
    - Or download materials from: https://corona-renderer.com/resources/materials

Assignment 0 – Requirements

- Technical **REQUIREMENTS**
  - Use at least 10 very different **materials**
    - https://www.youtube.com/watch?v=6l98ul6XwDg
  - **Lights:** Use all of the following: HDRI lighting, Corona sun, and a regular area light
    - https://www.youtube.com/watch?v=y8L4Lfem1uA
  - **Render elements**: break your rendering down to direct / indirect / diffuse / reflections elements (passes) so you see what contributions make up the final image
    - https://www.youtube.com/watch?v=loSHF5kfeTc
  - …

Assignment 0 –Requirements

- Technical **REQUIREMENTS**
  - …
  - Show the use of **denoising**
    - https://www.youtube.com/watch?v=v4fZojsjGpQ
    - Apply denoising on a noisy-enough scene to be able to clearly illustrate its effect.
  - Figure out for yourself **what makes rendering slow** (what kind of material / light combinations, lights close to geometry etc.)
  - Assemble results into a HTML page, for example using https://jeri.io/ (or other resources, since jeri needs a web server to run)

Assignment 0 – Presentation

- Each student (or group of 2 students) has **up to 7 minutes to showcase their work in front of the class**.
- Each of the technical requirements listed on the previous slides have to be clearly shown.
  - Failing to illustrate technical requirements leads to loss of points.
- Explain the story behind your artwork – why did you decide to do specifically that scene, how did you approach the work, what was difficult and what was each, what did you enjoy and what was pain etc.
- You classmates will rate each work and presentation.