CS 247 – Scientific Visualization
Lecture 1: Introduction

Markus Hadwiger, KAUST

Lecture Overview

Goals

- Basics: Learn the most important techniques in scientific visualization
- Practice: Implement scalar and vector/flow field visualization techniques in OpenGL

Time and location

- Monday/Wednesday, 16:45 – 18:15, online (Zoom link + pwd on Blackboard; or send email).

Course webpage:

`http://faculty.kaust.edu.sa/sites/markushadwiger/Pages/CS247.aspx`

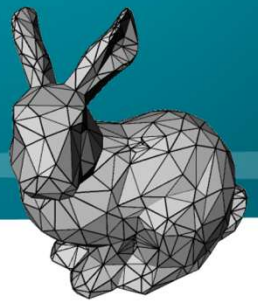
Contact

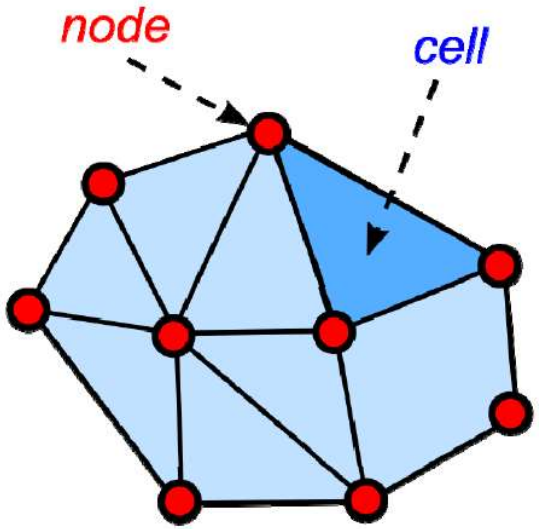
- Markus Hadwiger: **`markus.hadwiger@kaust.edu.sa`**
- Matej Mlejnek: **`matej.mlejnek@kaust.edu.sa`**
- Amani Ageeli: **`amani.ageeli@kaust.edu.sa`**

Prerequisites

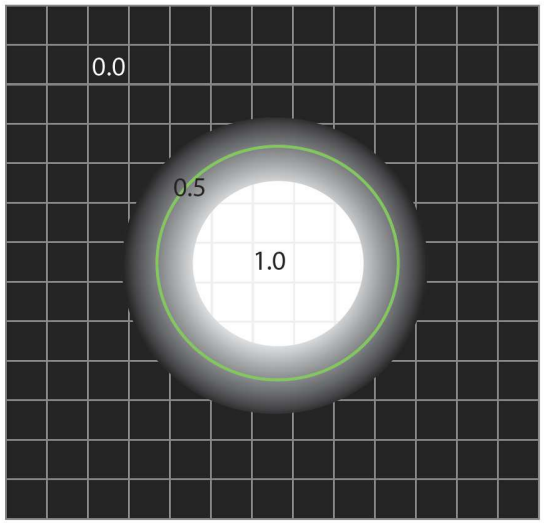
- **C/C++ programming**, computer graphics, linear algebra, multi-variable calculus
- OpenGL experience (a basic graphics course, ...) very helpful !

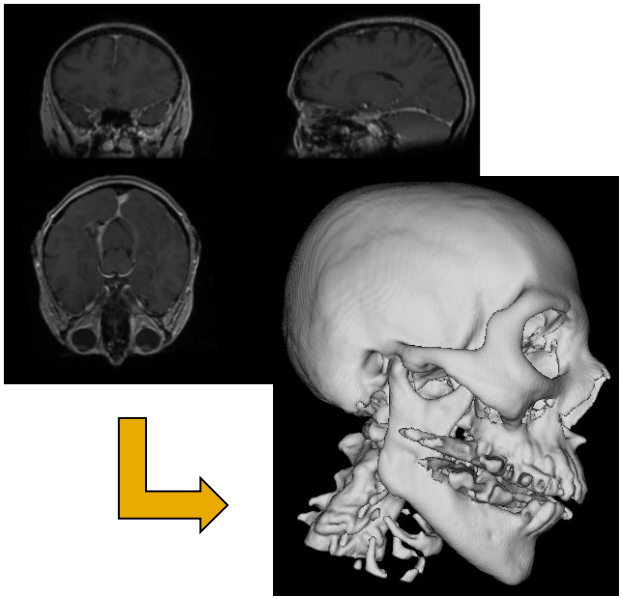
Syllabus (1)

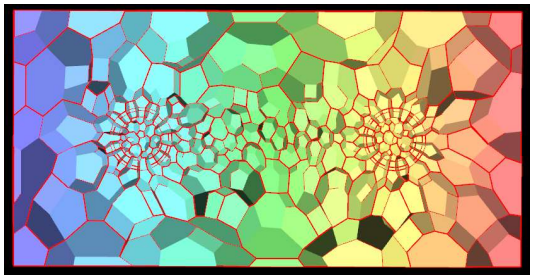


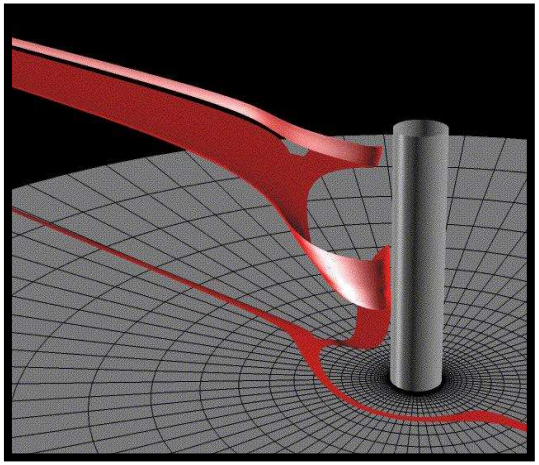


- Introduction
- Visualization basics, pipeline, and examples
- First scalar visualization example: iso-contouring
- GPU and computer graphics primer
- Data representation (grid types, data structures)





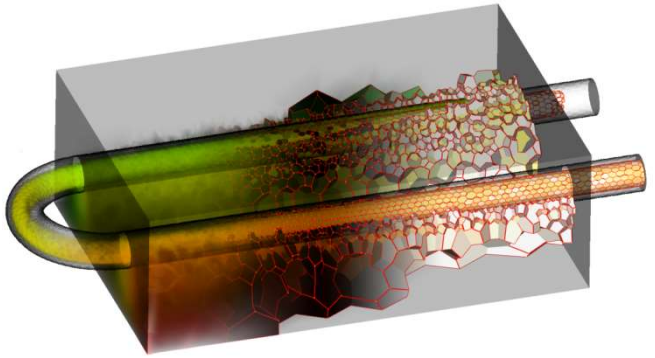




Syllabus (2)

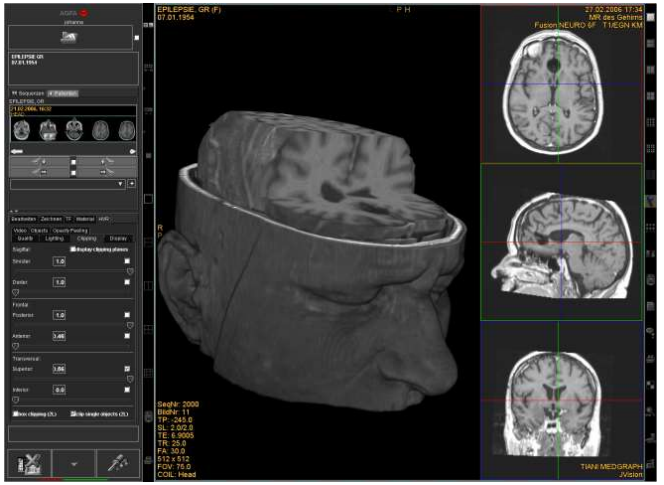
Scalar field visualization

- Iso-surface rendering
- Volume rendering
- Transfer functions
- Volume lighting
- Unstructured grid visualization

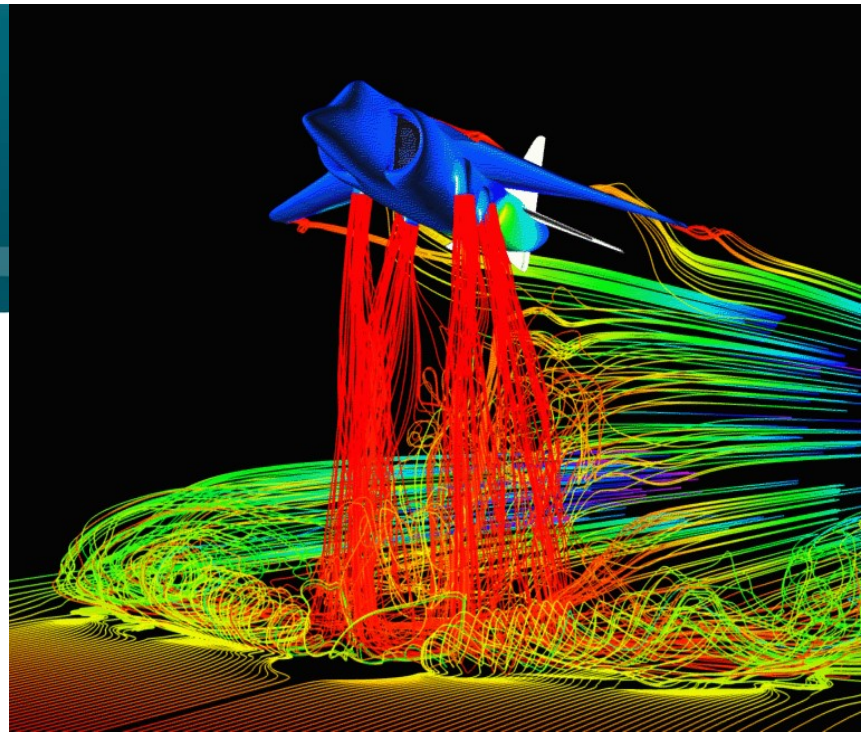


Applications

- Medical visualization
- Industrial CT (computed tomography)
- CFD (computational fluid dynamics) visualization of scalar quantities



Syllabus (3)



Vector field and flow visualization

- Direct vs. indirect techniques
- Particle tracing
- Integral curves and surfaces
- Dense flow visualization techniques

Applications

- CFD flow visualization
- Weather visualization

If time permits

- Basic tensor visualization
- Visualization systems

Lecture Structure and Grading

Lectures

Weekly reading assignments (required + sometimes additional optional ones)

- Part of quiz questions (see later)

Programming assignments

- 6+1 programming assignments; short written report + personal presentation for each

Quizzes

- 4 quizzes, 30 min each;
  announced a week in advance, roughly every 3-4 weeks
- From lectures, (required) reading assignments, programming assignments

Grading: 60% prog. assignments; 40% quizzes

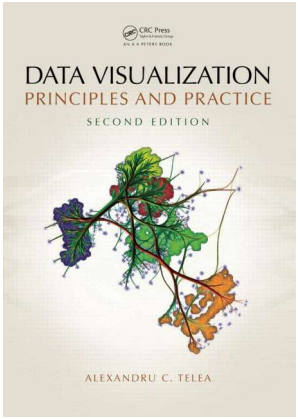
No mid-term/final exam!

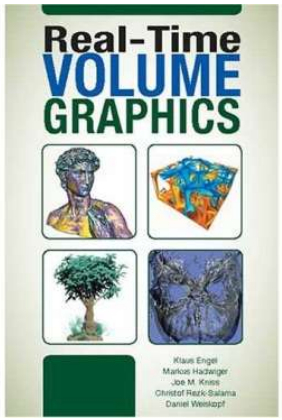
Resources

Course webpage:
`http://faculty.kaust.edu.sa/sites/markushadwiger/Pages/CS247.aspx`

Textbooks:

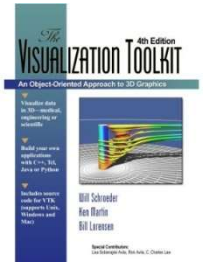
- Data Visualization: Principles and Practice
- Real-Time Volume Graphics

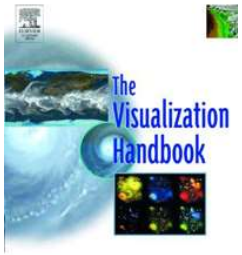


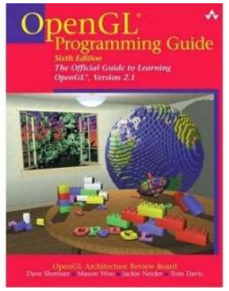


Additional books:

- The Visualization Toolkit:
  An Object-Oriented Approach
  to 3D Graphics (4th Edition)
- The Visualization Handbook
- OpenGL Programming Guide (9th edition, OpenGL 4.5)
  `www.opengl.org/documentation/red_book/`







For GPU, GPGPU, and graphics programming, also look here:

`http://faculty.kaust.edu.sa/sites/markushadwiger/Pages/CS380.aspx`

Programming Assignments (1)

6 assignments (+1 introductory)

- Based on C/C++ and OpenGL
- You get a basic framework from us (in bitbucket/git repository)

Organization

1. Use *bitbucket/git* to get material and submit solution (**`bitbucket.org/kaust_cs247/cs247_2021/wiki`**)
2. Get assignment info and framework by forking the git project
3. Submit solution and report via git by submission deadline
4. Personal (online) presentation after submission

Programming Assignments (2)

- Submit via *bitbucket+git* at the latest on day the assignment is due (code, libs, everything that is needed to run your program)

- Submission must include short report (2 pages, pdf), including short explanation of algorithms, your solution, problems, how to run it, screenshots

- Personal presentations:
  Present your program live and explain source code (10-15 min)
  - Sign up for presentation slot in advance (doodle)
  - Present via Zoom

Programming Assignments (3)

Grading

- Submission complete, code working for all the required features
- Documentation complete (report, but also source code comments!)
- Personal presentation
- Optional features, coding style, clean solution
- Every day of late submission reduces points by 10%
- No copies from the Internet (or anywhere else)!
  You have to do it yourself and understand what you program:
  your explanations during the presentations will be part of the grade!

Programming Assignments (4)

Teaching Assistants:

- Matej Mlejnek (**`matej.mlejnek@kaust.edu.sa`**)
  – main contact for assignments; assignment presentations

- Amani Ageeli (**`amani.ageeli@kaust.edu.sa`**)
  – help with programming questions

Help in programming assignments (in this order!):

1. **Think about it, read about it, google it!**
2. **Discuss on Piazza: http://piazza.com/kaust.edu.sa/spring2021/cs247**
3. Ask TAs (Matej, Amani)

Programming Assignments Schedule (tentative)

Assignment 0:	Lab sign-up: setup piazza + bitbucket account, fork repo	until	**Jan 31**
	Basic OpenGL example		
Assignment 1:	Volume slice viewer	until	**Feb 14**
Assignment 2:	Iso-contours (marching squares)	until	**Feb 28**
Assignment 3:	Iso-surface rendering (marching cubes)	until	**Mar 16**
Assignment 4:	Volume ray-casting, part 1	until	**Apr 1**
	Volume ray-casting, part 2	until	**Apr 8**
Assignment 5:	Flow vis, part 1 (hedgehog plots, streamlines, pathlines)	until	**Apr 22**
Assignment 6:	Flow vis, part 2 (LIC with color coding)	until	**May 6**

Reading Assignment #1 (until Feb 1)

Sign up for piazza!
http://piazza.com/kaust.edu.sa/spring2021/cs247

Read (required):

- Data Visualization book, Chapter 1
- Data Visualization book, Chapter 2 until 2.3 (inclusive)
- Download and look at:
  NIH/NSF Visualization Research Challenges report

  `http://gvi.seas.harvard.edu/sites/all/files/NIH-NSF-VRC-Report.pdf`

- Start familiarizing yourself with OpenGL if you do not know it !

Thank you.

Thanks for material

- Helwig Hauser
- Eduard Gröller
- Daniel Weiskopf
- Torsten Möller
- Ronny Peikert
- Philipp Muigg
- Christof Rezk-Salama