King Abdullah University of Science and Technology

KAUST

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

- Sunday/Wednesday, 10:00 – 11:30, Bldg 9, Room 4229.

Course webpage:

https://vccvisualization.org/CS247_Scientific_Visualization/

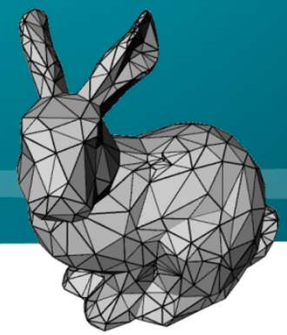
Contact

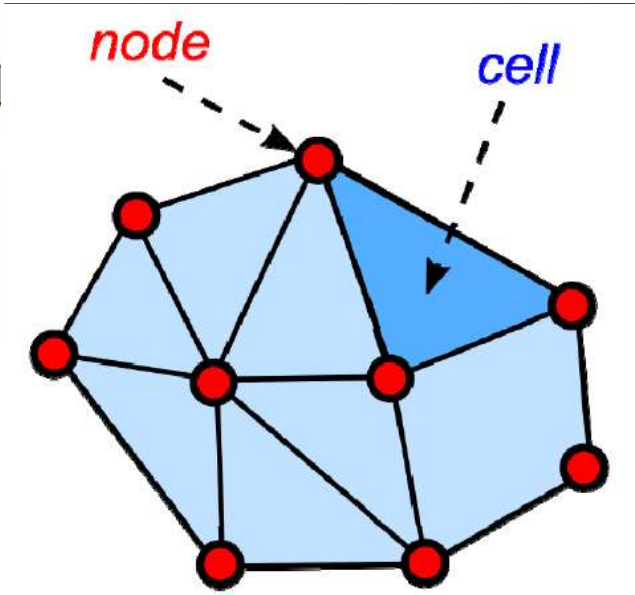
- Markus Hadwiger **markus.hadwiger@kaust.edu.sa**
- Programming assignments **kaust.cs247@gmail.com**
  - Alberto Jaspe alberto.jaspe@kaust.edu.sa
  - Amani Ageeli amani.ageeli@kaust.edu.sa

Prerequisites

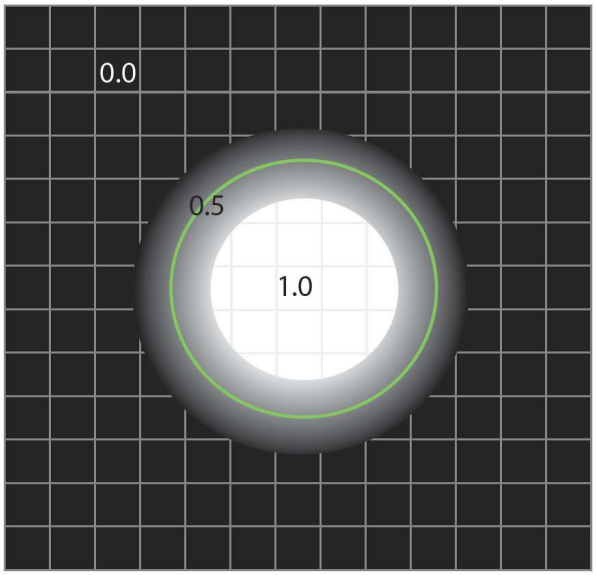
- **C/C++ programming**, computer graphics, linear algebra, multi-variable calculus
- OpenGL experience (a basic graphics course, ...) very helpful !

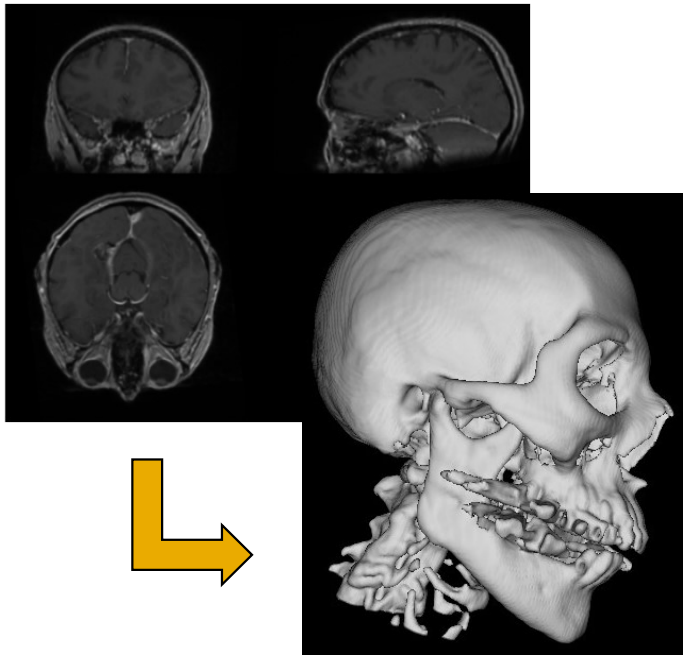
Syllabus (1)

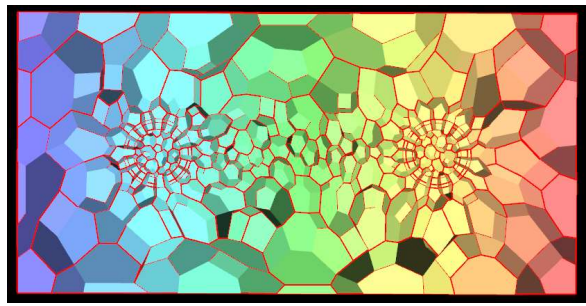


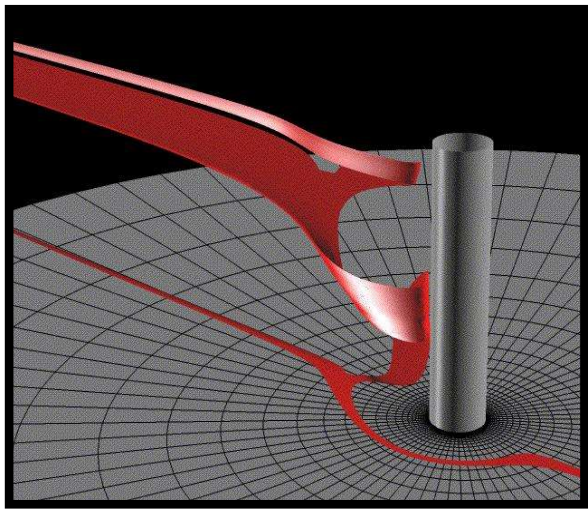


- Introduction
- Visualization basics, pipeline, and examples
- First scalar visualization example: iso-contouring
- GPU and computer graphics primer
- Data representation (grid types, data structures)





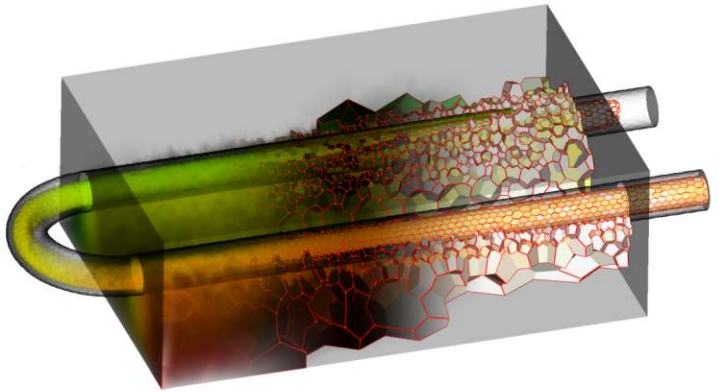




Syllabus (2)

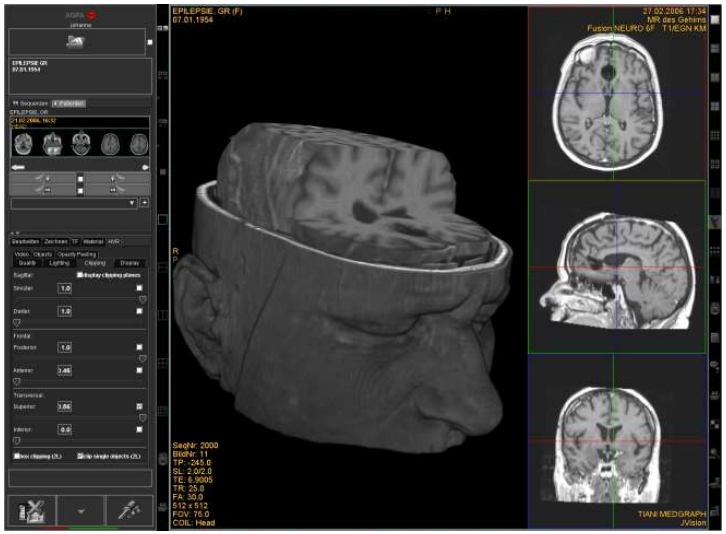
Scalar field visualization

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

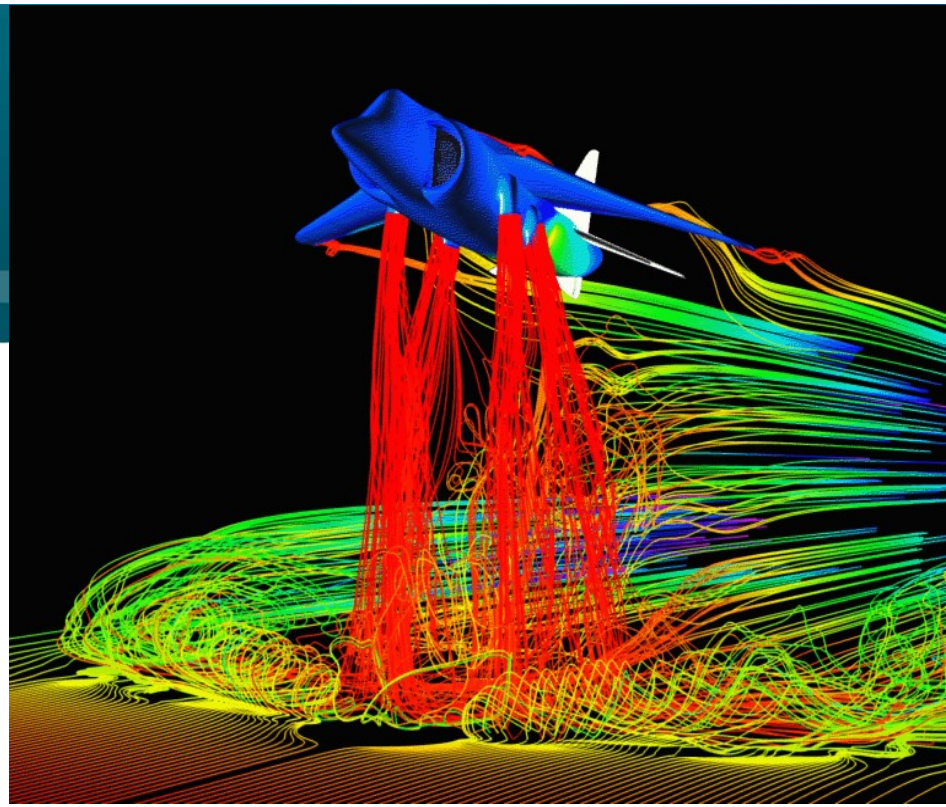


Applications

- 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 (or maybe only 3, we'll see) 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!

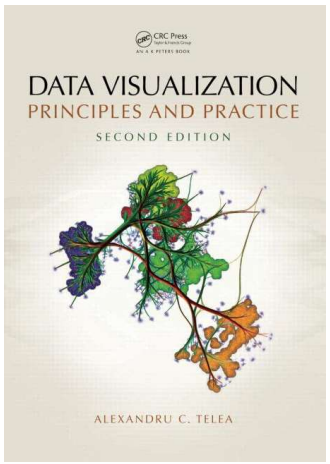
Resources

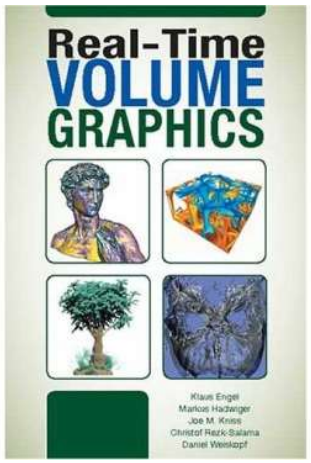
Course webpage:

`https://vccvisualization.org/CS247_Scientific_Visualization/`

Textbooks:

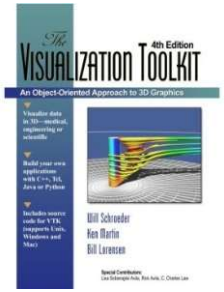
- Data Visualization: Principles and Practice
- Real-Time Volume Graphics



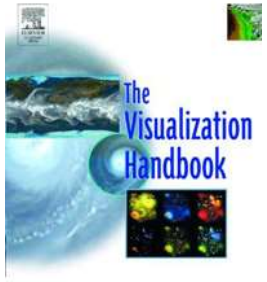


Additional books:

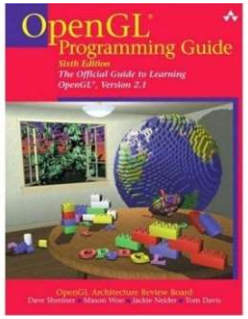
- The Visualization Toolkit:
  An Object-Oriented Approach
  to 3D Graphics (4th Edition)



- 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:

`https://vccvisualization.org/CS380_GPU_and_GPGPU_Programming/`

Programming Assignments (1)

6 assignments (+1 introductory)

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

Organization

1. Use *git* + *github classroom* to get material and submit solution

   Sign up: `https://classroom.github.com/classrooms/98274160-cs247-kaust-2025`
   Tutorial: `https://www.youtube.com/watch?v=ObaFRGp_Eko`

2. Assignment info and framework in git repository
3. Submit solution and report via git by submission deadline
4. Personal (online) presentation after submission

Programming Assignments (2)

- Submit via *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 to Alberto

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)

General contact: **kaust.cs247@gmail.com**

Teaching Assistants:

- Alberto Jaspe (alberto.jaspe@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 discord** (if you are registered, you will get an invite; if not, email Alberto)
3. Ask TAs: **kaust.cs247@gmail.com** (Alberto, Amani)

Programming Assignments Schedule (tentative)

Assignment 0:	Lab sign-up: join discord, setup github account + get repo	until	**Feb 2**
	Basic OpenGL example [we will offer a tutorial!]		
Assignment 1:	Volume slice viewer	until	**Feb 16**
Assignment 2:	Iso-contours (marching squares)	until	**Mar 2**
Assignment 3:	Iso-surface rendering (marching cubes)	until	**Mar 23**
Assignment 4:	Volume ray-casting, part 1	until	**Apr 13**
	Volume ray-casting, part 2	until	**Apr 20**
Assignment 5:	Flow vis, part 1 (hedgehog plots, streamlines, pathlines)	until	**May 4**
Assignment 6:	Flow vis, part 2 (LIC with color coding)	until	**May 14**

Reading Assignment #1 (until Feb 2)

Join discord; setup github classroom (Alberto gives you access)

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://tab.computer.org/vgtc/vrc/`
  `NIH-NSF-VRC-Report-Final.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