King Abdullah University of Science and Technology

KAUST

# AMCS / 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 + Thursday, 9:00 – 10:30, Building 9, Room 3222.

Course webpage:

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

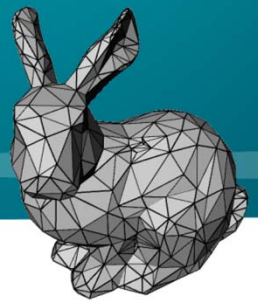
Contact

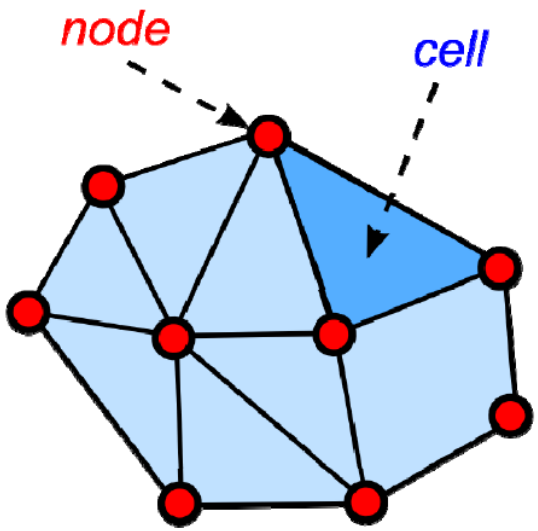

- Markus Hadwiger: **`markus.hadwiger@kaust.edu.sa`**
- Ali Awami: **`ali.awami@kaust.edu.sa`**


Prerequisites

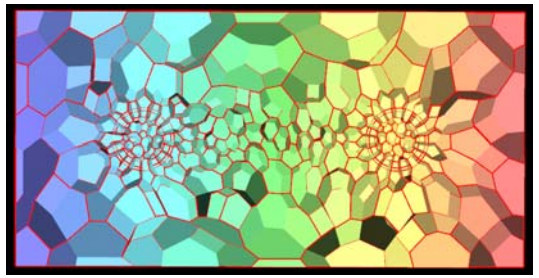
- **C/C++ programming**, computer graphics, linear algebra, basic calculus
- OpenGL experience very helpful !

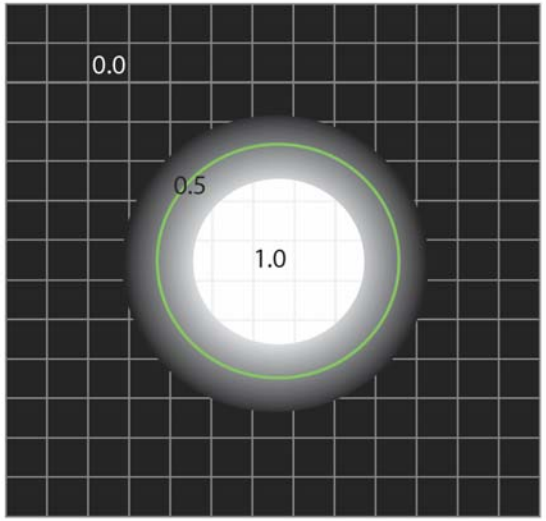
# Syllabus (1)

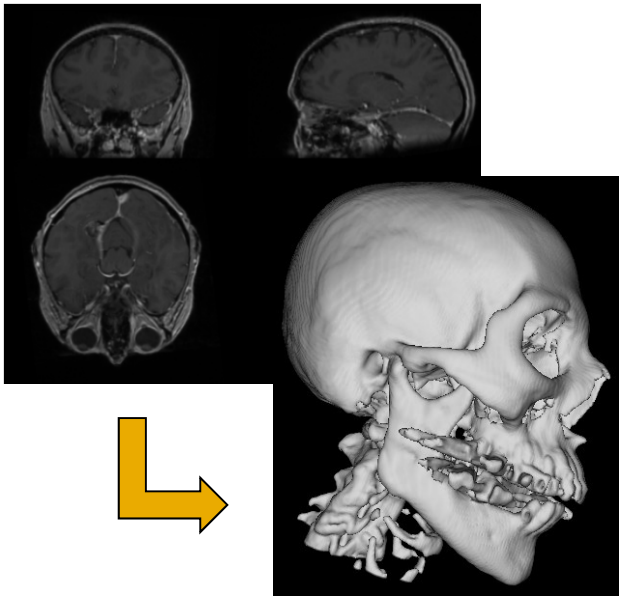


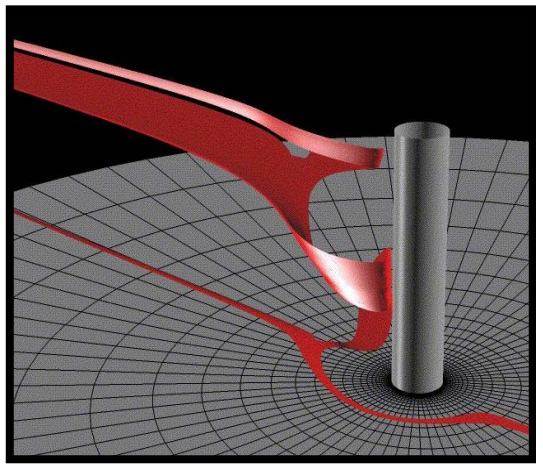



- Introduction
- Visualization basics, pipeline, and examples
- First scalar visualization example: iso-contouring
- GPU and computer graphics primer
- Data representation (grid types, data structures)



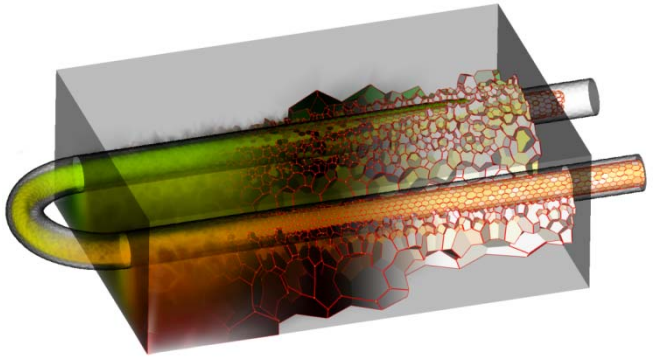




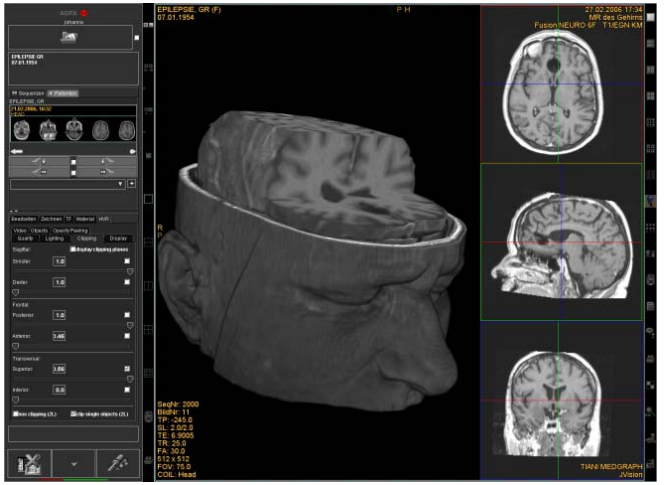
# Syllabus (2)


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

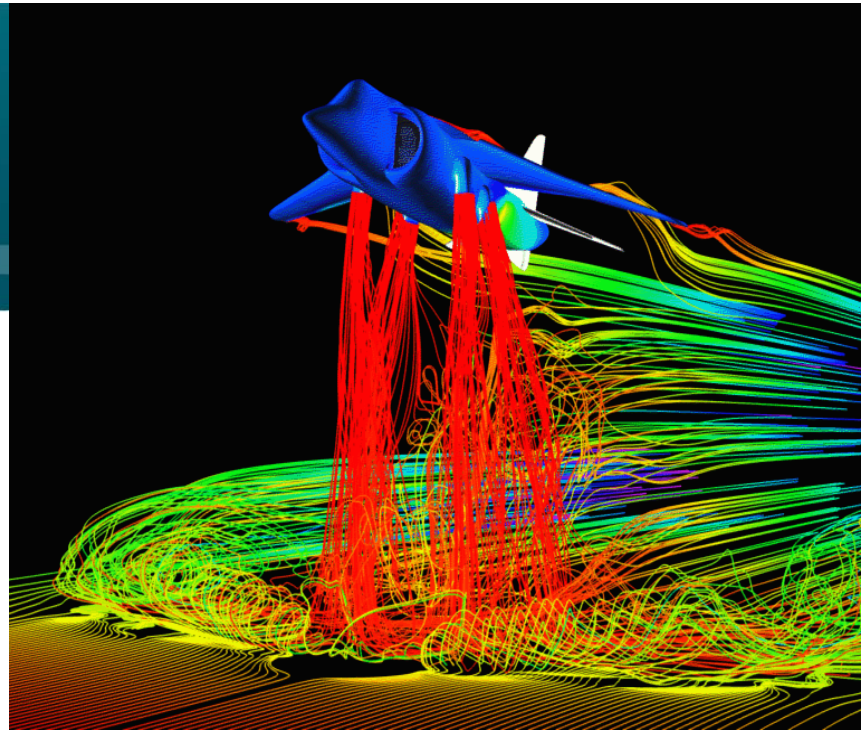


Applications

- 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

- Basic tensor visualization
- Visualization systems

# Lecture Structure and Grading

Lectures

Weekly reading assignments (required + optional)

- Part of quiz questions (see below)

Programming assignments

- 5 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% programming assignments; 40% quizzes

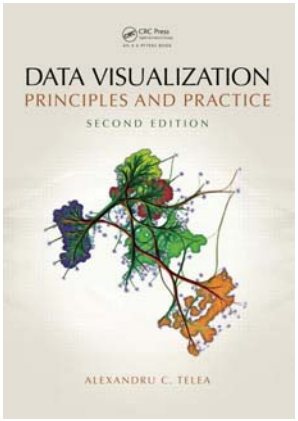
No mid-term/final exam!

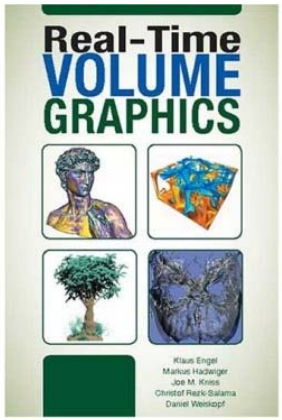
# Resources

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

Textbooks:

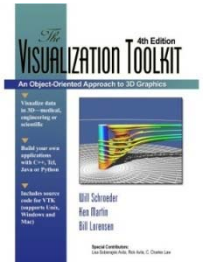
- Data Visualization: Principles and Practice
- Real-Time Volume Graphics

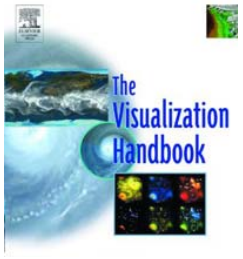


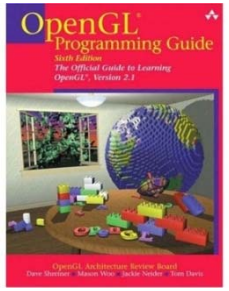




Additional books:

- The Visualization Toolkit:
  An Object-Oriented Approach
  to 3D Graphics (4th Edition)
- The Visualization Handbook
- OpenGL Programming Guide (8th edition, OpenGL 4.3)
  **`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)

5 assignments

- Based on C/C++ and OpenGL

  (if you know CUDA or OpenCL, you can also use it)

Organization

1. Use *bitbucket/git* to get material and submit solution (**`bitbucket.org/kaust_cs247/cs247_2015`**)
2. Get assignment info and framework by forking the git project
3. Separate Q&A session for each assignment (attendance optional)
4. Submit solution and report via git by submission deadline (Sundays)
5. Personal presentation after submission (Tuesday afternoon after deadline)

# 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 (Tuesday after submission), present your program live and explain source code (10-15 min)
  - Sign up for presentation slot in advance
  - Use your own laptop (preferred!) or test on lab machine to guarantee it runs!

# 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 direct copies from the Internet!
  You have to understand what you program:
  your explanations during the presentations will be part of the grade!

# Programming Assignments (4)

Teaching Assistant:

- Ali Awami (**ali.awami@kaust.edu.sa**) – main contact for assignments; assignment presentations

  Open lab space, opposite bldg 1, room 2119

Help in programming assignments (in this order!):

1. **Think about it, read about it, google it!**
2. **Ask other students! (it especially helps to discuss major problems in groups!)**
3. Ask TA (Ali)

# Programming Assignments Schedule (tentative)

Lab sign-up

- Setup bitbucket account, fork repository — until Aug 30

Assignment 1:

- Volume slice viewer — due: Sep 6

Assignment 2:

- Iso-contours and iso-surface rendering — due: Sep 27

Assignment 3:

- Volume ray-casting — due: Oct 25

Assignment 4:

- Flow vis 1 (hedgehog plots, streamlines, pathlines) — due: Nov 15

Assignment 5:

- Flow vis 2 (LIC with color coding) — due: Dec 6

# Q&A Sessions Schedule (tentative)

Tuesday (except first one) from 17:00 – 18:00, Bldg 1, Room 2114

| | |
|---|---|
| Assignment 1: | |
| • Volume slice viewer | Aug 30 (Sun) |
| Assignment 2: | |
| • Iso-contours and iso-surface rendering | Sep 15 (Tue) |
| Assignment 3: | |
| • Volume ray-casting | Oct 6 (Tue) |
| Assignment 4: | |
| • Flow vis 1 (hedgehog plots, streamlines) | Nov 2 (Tue) |
| Assignment 5: | |
| • Flow vis 2 (LIC) | Nov 23 (Tue) |

# Reading Assignment #1 (until Aug 31)

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://vgtc.org/wpmu/techcom/national-initiatives/nihnsf-visualization-research-challenges-report-january-2006**

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

# What is Scientific Visualization? (1)

**The use of computer graphics for the analysis and presentation of computed or measured scientific data**

- Started in 1987 by the US National Science Foundation (NSF) in the "Visualization in Scientific Computing" report

  **`http://www.evl.uic.edu/core.php?mod=4&type=3&indi=348`**

- First IEEE Visualization conference 1990

- 2006 NIH/NSF Visualization Research Challenges Report, Chris Johnson et al.

  **`http://vgtc.org/wpmu/techcom/national-initiatives/nihnsf-visualization-research-challenges-report-january-2006`**

"The purpose of computing is insight, not numbers"
*Richard Hamming, 1971*

# Thank you.

Thanks for material

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