

AMCS / CS 247 – Scientific Visualization

Lecture 1: Introduction

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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>

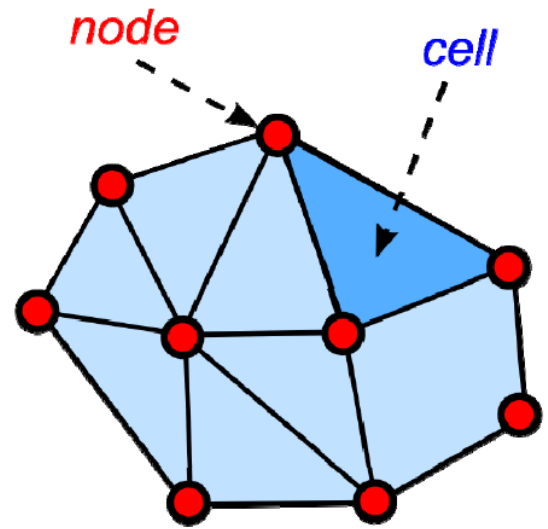
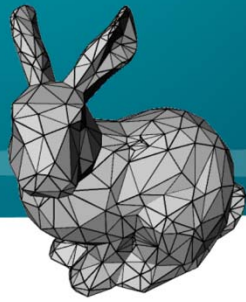
Contact

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

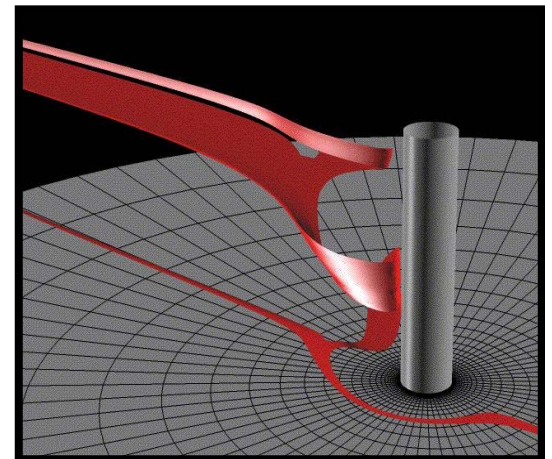
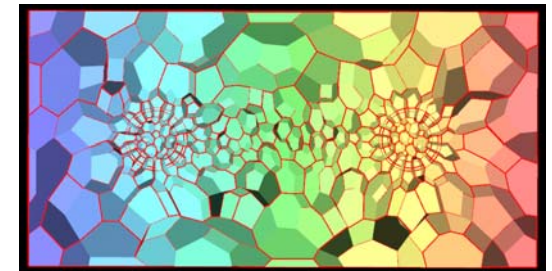
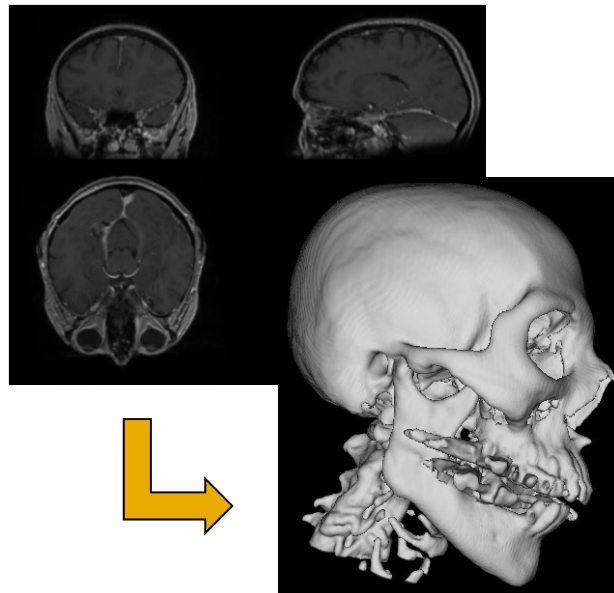
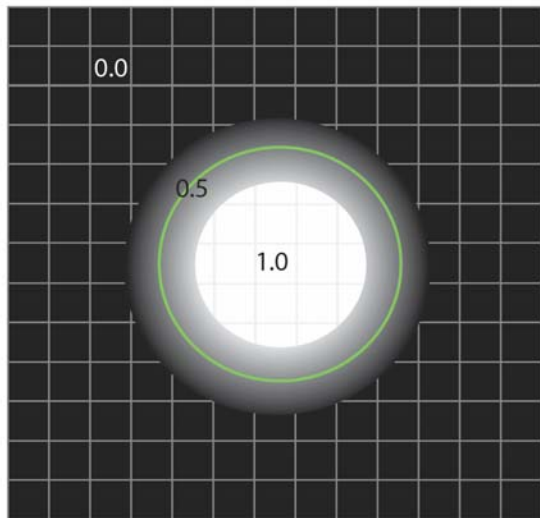
Prerequisites

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

Syllabus (1)

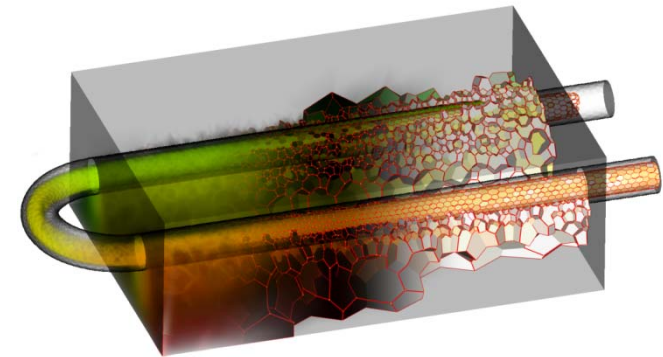
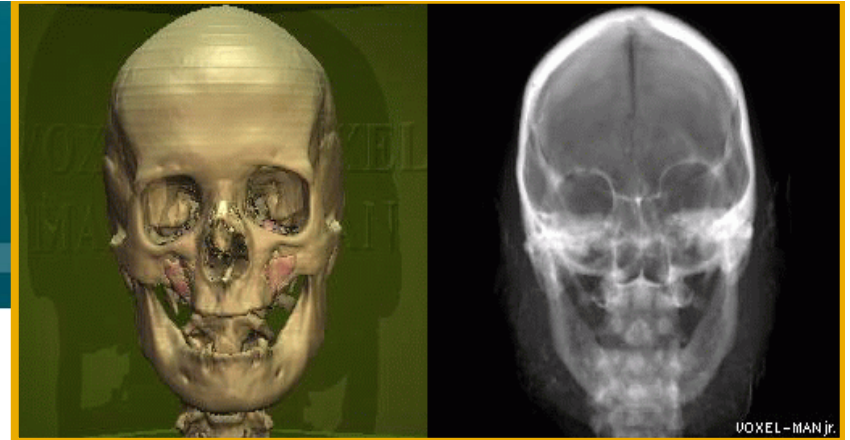


- Introduction
- Visualization basics, pipeline, and examples
- First scalar visualization example: iso-contouring
- GPU and computer graphics primer
- Data representation (grid types, data structures)



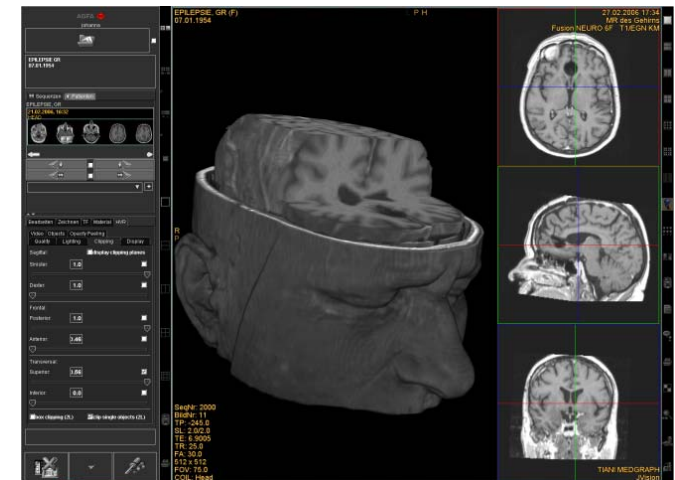
Syllabus (2)

- 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



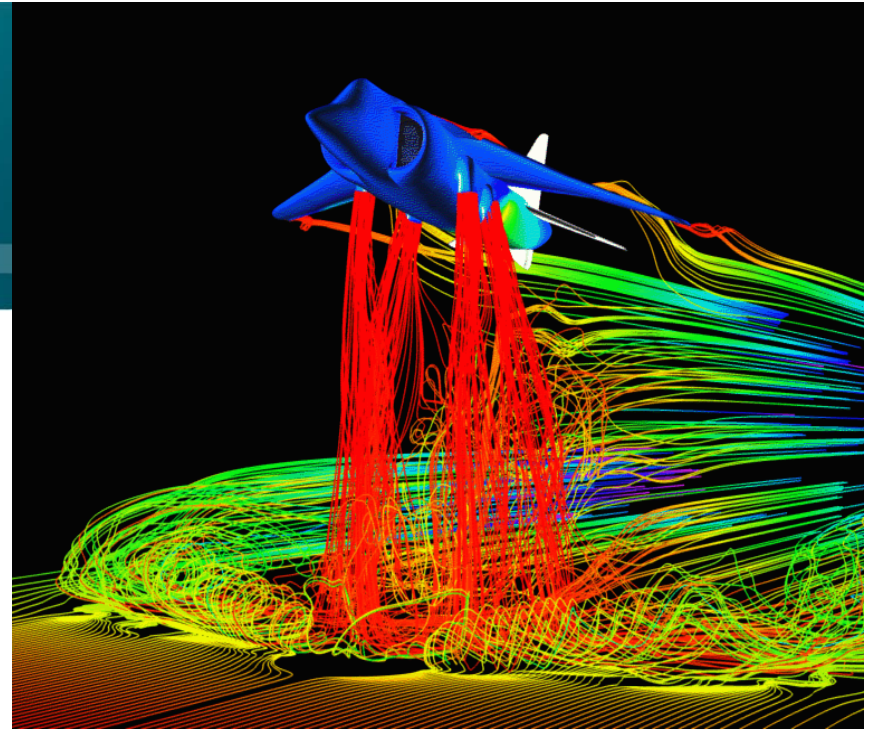
Syllabus (3)

- 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:

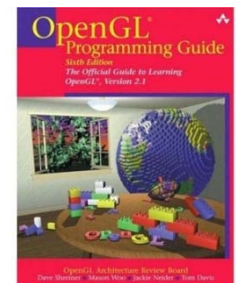
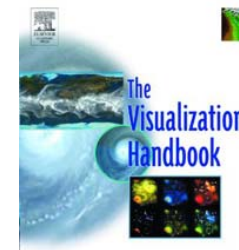
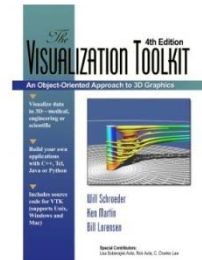
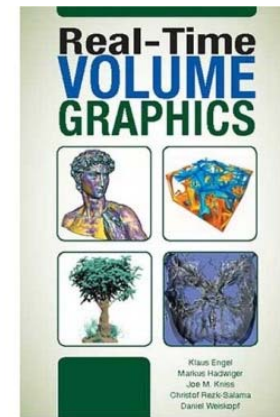
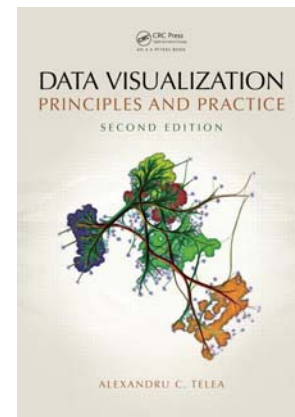
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Textbooks:

- 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