جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Scientific Visualization - CS 247

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	CS 247
Course Title	Scientific Visualization
Academic Semester	Spring
Academic Year	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Wed , 04:00 PM - 05:30 PM | Mon

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Markus Hadwiger	markus.hadwiger@kaust.edu.sa	+966128080260		Come by my office (Bldg 1, Room 2119) or send me an email to make an appointment.

Teaching Assistant(s)

Name	Email
Matej Mlejnek	matej.mlejnek@kaust.edu.sa

Course Information

Comprehensive Course Description	Prerequisites: Linear algebra, multivariable calculus, C/C++ programming experience. Recommended additional prerequisites: AMCS/CS 248 Computer Graphics, CS 380 GPU and GPGPU Programming, OpenGL programming experience. Techniques for generating images and interactive visualizations of various types of experimentally measured, computer generated, or gathered data. Grid structures. Scalar field and volume visualization. Vector field and flow visualization. Tensor visualization. Applications in science, engineering, and medicine. Syllabus: - Introduction - The Visualization Pipeline - Data Representation + Data Structures - Structured and Unstructured Grids - Scalar Fields - Iso-contours and iso-surfaces; Marching Squares + Marching Cubes - Iso-surface Lighting+Shading; Gradient Computation - GPU Basics; The Graphics Pipeline; GPU Texturing - Volume Visualization: - Volume Rendering Integral + Optical Models - Ray-Casting - Classification + Transfer Functions - Vector Field / Flow Visualization: - Direct + Indirect Flow Visualization - Integral Curves: Streamlines, Pathlines, Streaklines, Timelines - Vector Calculus - Line Integral Convolution - Texture Advection Methods; Lagrangian-Eulerian Methods; Image-Based Flow Visualization - Fluid Simulation - Tensor Field Visualization; Diffusion Tensor Imaging - Medical Visualization - Illustrative Visualization
Course Description from Program Guide	This course covers the basics and applications of scientific visualization. It covers techniques for generating images and interactive visualizations of various types of experimentally measured, computer-generated (simulated), or gathered data. It covers grid structures, scalar field and volume visualization, vector field and flow visualization, and tensor field visualization. It covers applications in science, engineering, and medicine.
Goals and Objectives	Students will have learned the most important methods of Scientific Visualization both theoretically and practically. The course is very practically-oriented, and the programming assignments of the course are an integral part of learning these techniques. After the course, students will not only be able to understand and explain the most important methods of Scientific Visualization, but also be able to implement them in detail themselves in C++ and OpenGL (or other GPU APIs).
Required Knowledge	Prerequisites: Linear algebra, multivariable calculus, C/C++ programming experience. Since the course is very practical, programming experience is the most essential prerequisite. Ideally students have already some background in computer graphics and/or GPU programming (OpenGL or CUDA), but the necessary background can also be acquired during the course homeworks. A good grasp of the basics of vector calculus (multivariable derivatives, gradients, curl, divergence) and integration will also be very helpful.
Reference Texts	- Data Visualization: Principles and Practice, Alexandru Telea, 2nd edition https://www.amazon.com/Data-Visualization-Principles-Practice-Second/dp/1466585269/ - Real-Time Volume Graphics, Engel et al. https://www.amazon.com/Real-time-Graphics-Markus-Hadwiger/dp/1568812663/
Method of evaluation	**60.00**% - Homework /Assignments **40.00**% - Quiz(zes)
Nature of the assignments	There will be weekly reading assignments, programming assignments, and quizzes. Quiz questions cover both the lectures and the reading assignments. There usually are 4 quizzes throughout the semester. Programming assignments are small programming projects for the most important algorithms in Scientific Visualization. We will use C/C++ and OpenGL. There will be five programming assignments throughout the semester.
Course Policies	Class attendance is mandatory. All assignments and quizzes are mandatory. Programming assignments have to be submitted on time, late submission reduces the number of points by 10% per late day. Programming assignments have to be implemented by each student individually. Submissions need to include a short report and must be followed by a short personal presentation of the assignment solution (working implementation). More details will be given in the lecture.
Additional Information	The course webpage is here: https://faculty.kaust.edu.sa/sites/markushadwiger/pages/cs247.aspx This will be our main hub for the lecture, the slides, etc.

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/28/2019 Wed 01/30/2019	- Introduction + Lab sign-up (for programming assignments)
2	Mon 02/04/2019 Wed 02/06/2019	- The Visualization Pipeline + Programming assignment 1: Volume slice viewer
3	Mon 02/11/2019 Wed 02/13/2019	- Data Representation + Data Structures - Structured and Unstructured Grids + Programming assignment 2: Iso-contours and iso-surface rendering
4	Mon 02/18/2019 Wed 02/20/2019	- Scalar Fields + Programming assignment 2: Iso-contours and iso-surface rendering
5	Mon 02/25/2019 Wed 02/27/2019	- Iso-contours and iso-surfaces; Marching Squares + Marching Cubes - Iso-surface Lighting+Shading; Gradient Computation + Programming assignment 2: Iso-contours and iso-surface rendering
6	Mon 03/04/2019 Wed 03/06/2019	- GPU Basics; The Graphics Pipeline; GPU Texturing
7	Mon 03/11/2019 Wed 03/13/2019	- Volume Visualization: - Volume Rendering Integral + Optical Models + Programming assignment 3: Volume ray-casting
8	Mon 03/18/2019 Wed 03/20/2019	- Ray-Casting + Programming assignment 3: Volume ray-casting
9	Mon 03/25/2019 Wed 03/27/2019	Spring Break
10	Mon 04/01/2019 Wed 04/03/2019	- Vector Field / Flow Visualization: - Direct + Indirect Flow Visualization + Programming assignment 4: Flow Vis 1 (hedgehog plots, streamlines, pathlines)
11	Mon 04/08/2019 Wed 04/10/2019	- Integral Curves: Streamlines, Pathlines, Streaklines, Timelines + Programming assignment 4: Flow Vis 1 (hedgehog plots, streamlines, pathlines)
12	Mon 04/15/2019 Wed 04/17/2019	- Vector Calculus + Programming assignment 4: Flow Vis 1 (hedgehog plots, streamlines, pathlines)
13	Mon 04/22/2019 Wed 04/24/2019	- Line Integral Convolution + Programming assignment 5: Flow Vis 2 (LIC with color coding)
14	Mon 04/29/2019 Wed 05/01/2019	- Texture Advection Methods; Lagrangian-Eulerian Methods; Image-Based Flow Visualization - Fluid Simulation + Programming assignment 5: Flow Vis 2 (LIC with color coding)
15	Mon 05/06/2019 Wed 05/08/2019	- Tensor Field Visualization; Diffusion Tensor Imaging
16	Mon 05/13/2019 Wed 05/15/2019	- Medical Visualization - Illustrative Visualization
17	Mon 05/20/2019 Wed 05/22/2019	Final Exam Week

Note

The instructor reserves the right to make changes to this syllabus as necessary.