Specialization Overview

Visualization & Scientific Computing

Christoph Garth
Weather forecasting & reporting is an example of everyday Visualization & Scientific Computing
Problem: Need umbrella now?
Data: Temperature & Precipitation
Visualization: Weather Map
Image: Yes / No

highest information bandwidth
Need umbrella now tomorrow?

Temperature & Precipitation

Weather Forecast Simulation

Computational Model

Image

Best time to go out?

Optimization

Yes / No

Insight
More complex questions...

Engineering & Physical Sciences

Social Science, Business & Finance

Medicine

And many others...
Computational Science – third pillar of Science

Visualization
Scientific Computing
Visualization & Scientific Computing

**Optimization**

Scientific Computing Group
Prof. Nicolas Gauger

**Visualization**

Scientific Visualization Lab
Prof. Christoph Garth

Visual Information Analysis Group
Prof. Heike Leitte

**Human-Computer Interaction**
apl. Prof. Achim Ebert
Fundamentals

Data Visualization
Prof. Leitte

• theoretical and practical knowledge of fundamental techniques in data visualization

• data analysis for visualization purposes

• evaluate visualizations

• design and implement visualizations for specific problems
Fundamentals

Human Computer Interaction

apl. Prof. Ebert

- overview of state-of-the-art in human computer interaction (HCI) techniques
- interaction techniques and devices
- design and prototype human-centered man-machine interfaces
- evaluate HCI systems
Core Course

Visual Analytics
Prof. Leitte

- theoretical and practical knowledge of **advanced techniques** in data visualization
- graph and network data
- build visual analytics systems
- design new visualization algorithms
Scientific Visualization

Prof. Garth

• theoretical and practical knowledge of advanced techniques in data visualization for scientific computing

• (geo-)spatial, medical, flow data

• high-performance visualization and rendering

• design and implement visualization algorithms
Core Course

Algorithmic Differentiation

Prof. Gauger

- algorithmic techniques for differentiating complex functions and programs
- applications to optimization in complex real-world problems
More Courses

Computational Topology
Prof. Garth

- fundamental concepts of algebraic topology
- algorithms to compute topological properties
- topological analysis and simplification of real-world data
Optimization in Fluid Mechanics

Prof. Gauger

- Governing equations for fluid mechanics
- Reynolds-averaging and turbulence modeling
- Finite volume method
- Objective functions and constraints
- Shape optimization in fluid mechanics
- Optimal active flow control
- Continuous and discrete adjoint methods
- One-shot methods
Topology Optimization
- Optimization of structural design in engineering and science.

Computer Graphics
- Fundamentals and algorithms for modeling and rendering

Computational Geometry
- Design & analysis of algorithms for geometric problems

3D Computer Vision
- Recovery of 3D structure from images and videos

Distributed Data Management
- Storing and querying very large datasets

Parallel Computing
- Fundamentals of parallel computation and algorithms

Intro to HPC
- Basic techniques of high-performance computing

HPC with GPUs
- Using GPUs for high-performance computing
Specialization Overview

Foundations

- Data Visualization 4
- Computer Graphics 8
- Human Computer Interaction 4

Visualization

- Visual Analytics 5
- Scientific Visualization 5
- Computational Topology 5

Scientific Computing

- Optimization in Fluid Mechanics 4.5
- Algorithmic Differentiation 5
- Topologische Strukturoptimierung 4.5

High-Perf. Computing

- Distributed Data Management 4
- Parallel Computing 4
- Intro to HPC 5
- HPC with GPUs 6

VIS & HCI

- Vis & HCI Seminar 4
- Vis & HCI Project 8

Geometric Modeling

- Computational Geometry 4
- 3D Computer Vision 4

Project + Seminar

- SciComp project 8
- SciComp Seminar 4

4.5
Examples study plan subsets

Master Thesis (30 CP)

Electives (56 CP or more)
- **Specialization 1 in Computer Science** (28 CP or more)
- **Specialization 2 in Computer Science** (12 CP or more)
- Computer Science Theory (8 CP or more)
- Formal Fundamentals (8 CP or more)

Free Choice (up to 34 CP)

Supplement (up to 34 CP)
Specialization I
Flavor: General Visualization

18 ECTS lectures
4 ECTS seminar
8 ECTS project
Specialization I

Flavor: Visual Analytics

18 ECTS lectures
4 ECTS seminar
8 ECTS project
Specialization I
Flavor: Scientific Visualization

20 ECTS lectures
4 ECTS seminar
8 ECTS project
Specialization I

Flavor: Scientific Computing

18 ECTS lectures
4 ECTS seminar
8 ECTS project

Optimization in Fluid Mechanics
4.5
Topologische Strukturoptimierung
4.5
Algorithmic Differentiation
5
SciComp project
8
SciComp seminar
4
Distributed Data Management
4
Parallel Computing (4)
4
Intro to HPC
5
HPC with GPUs
6
High-Perf. Computing

Data Visualization
4
Visual Analytics
5
VIS & HCI seminar
4
VIS & HCI project
8

Computer Graphics
8
Scientific Visualization
5

Human Computer Interaction
4
Computational Topology
5

Foundations
Visualization

Project + Seminar

Computational Geometry
4
3D Computer Vision
4

Scientific Visualization

Computational Topology

Scientific Visualization
Specialization I

Flavor: Mixed Vis & SciComp

18 ECTS lectures
4 ECTS seminar
8 ECTS project
Master Thesis (30 CP)

Electives (56 CP or more)

- **Specialization 1**
  - in Computer Science
  - (28 CP or more)

- **Specialization 2**
  - in Computer Science
  - (12 CP or more)

- Computer Science Theory
  - (8 CP or more)

- Formal Fundamentals
  - (8 CP or more)

Free Choice (up to 34 CP)

Supplement
- (up to 34 CP)
Specialization II
Flavor: High-Perf. Computing
15 ECTS lectures
Specialization II

Flavor: Visualization

14 ECTS lectures
Specialization II

Flavor: Visual Analytics

14 ECTS lectures

Foundations

Visualization

Scientific Computing

High-Perf. Computing

Geometric Modeling
Specialization II

Flavor: Visual Analytics

14 ECTS lectures
Master Thesis (30 CP)

Electives (56 CP or more)

- Specialization 1 in Computer Science (28 CP or more)
- Specialization 2 in Computer Science (12 CP or more)
- Computer Science Theory (8 CP or more)
- Formal Fundamentals (8 CP or more)

Free Choice (up to 34 CP)

- Supplement (up to 34 CP)
Example:
Specialization in ML +
Basics in Visualization

Supplement
PSA

ONE DOES NOT SIMPLY TAKE COURSES

WITHOUT TALKING TO A MENTOR

garth@cs.uni-kl.de  leitte@cs.uni-kl.de  gauger@cs.uni-kl.de  ebert@cs.uni-kl.de
MACHINE LEARNING

VISUALIZATION +
SCIENTIFIC COMPUTING

MAYBE YOU