

# 2016 Geilo | Scientific Winter School | Visualization

January 17-22, 2016, Geilo, Norway



# SCHEDULE

## At a glance:

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	
07:30 - 09:00	X	Breakfast					
09:00 - 09:45		Gordon Kindlmann	Ingrid Hotz	Torsten Möller	Hans-Jörg Schulz	Ingrid Hotz	
09:45 - 10:30							Checkout
10:30 - 11:00		Break					Gordon Kindlmann
11:00 - 11:45		(Lunch 12:30 - 14:00)					
11:45 - 12:30							
12:30 - 15:00							
15:00 - 15:45		Hans-Jörg Schulz	Hans-Jörg Schulz	Ingrid Hotz	Torsten Möller	X	
15:45 - 16:30		Coffee					
16:30 - 17:00		Introduction (Multiple)	Andrea Brambilla	Andrea Brambilla	Gordon Kindlmann		Andrea Brambilla
17:00 - 17:45					Poster		
17:45 - 18:30		Dinner					
19:30							

## Detailed program:

### Sunday:

16:30 – 17:00: Coffee  
 17:00 – 17:15: André R. Brodtkorb, Helwig Hauser: Welcome & Introduction  
 17:15 – 18:45: Scientific Visualization Panel (Helwig Hauser, Andrea Brambilla, Ingrid Hotz, Gordon Kindlmann, Torsten Möller, Hans-Jörg Schulz)  
 19:30: Dinner

### Monday:

09:00 – 10:30: Gordon Kindlmann: Algebraic Visualization  
 10:30 – 15:00: Break  
 15:00 – 16:30: Hans-Jörg Schulz: Information Visualization  
 16:30 – 17:00: Coffee  
 17:00 – 18:30: Andrea Brambilla: Paraview tutorial 1  
 19:30: Dinner

### Tuesday:

09:00 – 10:30: Ingrid Hotz: Topology-based visualization 1  
 10:30 – 15:00: Break  
 15:00 – 16:30: Hans-Jörg Schulz: Interaction  
 16:30 – 17:00: Coffee  
 17:00 – 18:30: Andrea Brambilla: Paraview tutorial 2  
 19:30: Dinner

### Wednesday:

09:00 – 10:30: Torsten Möller: Visualization tools for decision making 1  
 10:30 – 15:00: Break  
 15:00 – 16:30: Ingrid Hotz: Topology-based visualization 2  
 16:30 – 17:00: Coffee  
 17:00 – 18:30: Gordon Kindlmann: Diderot  
 18:30 – 19:15: Poster session  
 19:30: Dinner

### Thursday:

09:00 – 10:30: Hans-Jörg Schulz: Visual analytics  
 10:30 – 15:00: Break  
 15:00 – 16:30: Torsten Möller: Visualization tools for decision making 2  
 16:30 – 17:00: Coffee  
 17:00 – 18:30: Andrea Brambilla: Paraview tutorial 3  
 19:30: Dinner

### Friday:

09:00 – 10:30: Ingrid Hotz: Tensor visualization  
 10:30 – 11:00: Break (Remember check out by 11:00)  
 11:15 – 12:45: Gordon Kindlmann: Space-scale particles  
 13:00 – 14:30: Lunch  
 15:19 Train to Oslo  
 15:41 Train to Bergen

The 2016 winter school is organized by **Helwig Hauser**, **André R. Brodtkorb**, and the scientific committee consisting of **Inga Berre** (University of Bergen), **Xing Cai** (Simula, University of Oslo), **Anne C. Elster** (Norwegian University of Science and Technology), **Margot Gerritsen** (Stanford), **Helwig Hauser** (University of Bergen), **Knut-Andreas Lie** (SINTEF, Norwegian University of Science and Technology), **Hans Ekkehard Plessner** (Norwegian University of Life Sciences), **Geir Storvik** (University of Oslo), and **Ståle Walderhaug** (SINTEF, University of Tromsø).

## LECTURE ABSTRACTS

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### **Andrea Brambilla (GexCon AS)**

Email: andrea.bram@gmail.com

Andrea Brambilla is a Sr. Research Engineer at GexCon AS. He received his PhD degree from the University of Bergen in 2014, on the topic of illustrative flow visualization. His research interests include vector and tensor field visualization, computational fluid dynamics and visualization of risk and uncertainty.

This will be an interactive tutorial, with exercises, for using ParaView for scientific visualization. ParaView is an open-source software that supports analysis and visualization tasks over large 2D and 3D data sets. By exploiting the features of the Visualization Toolkit (VTK) library, ParaView is able to handle a multitude of data formats, provides extensive data processing capabilities, and implements a large number of rendering modalities. The tutorial will start by introducing the basic architecture of ParaView and the fundamental concepts required for working with this software. Participants will learn to set up a visualization pipeline and to tune the available rendering techniques. Selected data representations and data processing filters will be presented. The Python scripting capabilities of ParaView will also be discussed, and participants will have the chance to solve several hands-on exercises. The tutorial is mainly targeting beginners, and no previous experience with the application is required. A basic knowledge of Python can be helpful for solving the most advanced exercises.

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### **Gordon Kindlmann (Univ. of Chicago)**

Email: glk@uchicago.edu

Gordon Kindlmann is Assistant Professor at the University of Chicago, where he researches image analysis and data visualization to improve the computation of imaging-based science. His research interests include informative direct volume renderings, inspired by traditional techniques of edge detection; ways of translating mathematical principles of image processing; and computer vision to practical methods of detecting, measuring, and

understanding biological or physical structure in modern imaging data.

This session will show how a range of techniques in different areas of visualization can be understood and evaluated with some common underlying ideas. We will establish a functional vocabulary for talking about what does and doesn't work in a visualization, and because we believe the value of a visualization lies in its practical application, we propose general principles for good visualization design.

We will further show visualization of symmetric second-order tensors in two and three dimensions using superquadric glyphs, gracefully and unambiguously depicting any combination of positive and negative eigenvalues. We will cover example uses including stress tensors from mechanics, geometry tensors and Hessians from image analysis, and rate-of-deformation tensors in computational fluid dynamics.

We will also introduce and demonstrate Diderot: a Domain-Specific Language for Portable Parallel Scientific Visualization and Image Analysis. The basic idea is to start with Taylor's theorem and Newton's method of root-finding, and to use that to show why we shade isosurfaces with the gradient of the function; how Levoy's 2D transfer function is derived from Newton's method; how generalizations of the same approach are used to visualize extremal features including ridges/valleys and maxima/minima; and how extremal features of scalar attributes of vector and tensor fields are used to show their structure.

Finally, we will present Scale-Space Particles, and why scale-space matters for visualizing and extracting features. We will start by reviewing some of the related knowledge from computer vision and statistics, and continue by showing how it can be used for biomedical applications, such as extracting structure from chest CT scans. This will be based on the Teem software, which is released under an open source license.

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## **Ingrid Hotz (Linköping University)**

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Ingrid Hotz is professor in interactive visualization at Linköping University, Sweden, where she also coordinates the Visualization Community of the Swedish eScience Research Centre. Her research interests include vector and tensor field visualization.

With the increasing complexity of data, efficient methods for filtering and abstraction of the data become more and more important. Feature based methods, which try to extract interesting structures or patterns from the data, are one way to approach this challenge. In this lecture we will discuss different concepts of feature extraction in scientific applications. Thereby we will focus on methods motivated by examples from fluid mechanics and mechanical engineering. In detail we will cover the following topics:

**Topological data analysis:** The use of topological methods for visualization has led to many very powerful techniques for feature extraction. In this lecture I will give an introduction to basic topological methods for scalar and vector fields. We will discuss the use of these methods for some examples in the field of fluid mechanics.

**Tensor field visualization:** In comparison to vector field visualization the state of the art in tensor field visualization is much less advanced. The notion of features is less clear and thus data filtering relies more on exploration. In this part of the lecture we will start with an introduction to tensor fields and basic tensor visualization methods. Then we will discuss one specific application to highlight related challenges.

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## **Hans-Jörg Schulz (Fraunhofer, TU Graz)**

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Hans-Jörg Schulz is Research Coordinator at the University of Rostock, Institute of Computer Science, and Senior Researcher at Fraunhofer. His expertise lies in developing visual and analytical approaches which facilitate the understanding of structured data with an emphasis on graph and hypergraph structures. In his current position at the Fraunhofer Institute for Computer Graphics Research, he also researches structural aspects of data, such as heterogeneous, multiscale, and multilevel data. He frequently applies his research in the domains of biomedicine, climatology, and recently also in the domain of manufacturing and automation, all of which have a high demand for Visual Analytics solutions for structured data.

**Information Visualization:** The term "information visualization" is often defined as visualization of data without a given spatial reference, as opposed to scientific visualization which depicts data that has such a spatial reference. Yet this distinction becomes hard to uphold as nowadays already 60%-80% of all data is geospatially referenced – including document collections and network data, whose depiction is usually considered to be part of Information Visualization. Reason enough to have a look into this field of visualization to better understand the particularities of depicting data classes, such as text, hierarchies and networks, and categorical data, as well as data with additional properties, such as multi-scale, multi-level, or multi-dimensional data. This lecture will give a short introduction into the field of information visualization, before presenting visualization solutions for the key data classes and data properties that are most often encountered in the wild.

**Human-Computer Interaction:** As visual representation realizes the communication of data and computational results from the computer to the user, so does interaction realize the communication of the users' intentions and tasks to the computer. Only in concert, visual representation and interaction form the bidirectional communication between computer and user that is called visualization. While the visual communication channel from the computer to the

user has a high throughput, the channels facilitated by interaction (mouse clicks, key presses, touch gestures) are rather limited. This imbalance is the origin of many of the scientific questions in interaction research for visualizations. This lecture will provide an overview over interaction and its research challenges based on the model of communication. For those challenges most relevant to visualization, it will then discuss exemplary solution approaches and illustrate them with software demos and videos.

**Visual Analytics:** Visual Analytics is the science of analytical reasoning supported by interactive visual interfaces. To this end, it realizes a tight integration of algorithmic computation and interactive visual exploration. This lets the computer and the human user each do what they can do best, thereby achieving faster and deeper insight into data than any discipline could by itself. Well, at least in theory... Achieving such a tight integration with a fluid back and forth between computer and user poses a tremendous computational, visual, and ergonomical challenge in practice. After covering the fundamentals of Visual Analytics, this lecture will look specifically at these challenges,

present current State-of-the-Art approaches to address them, and exemplify them by showcasing Visual Analytics systems.

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## **Torsten Möller (University of Vienna)**

Email: torsten.moeller@univie.ac.at

Torsten Möller has been a professor at the University of Vienna, Austria, since 2013, and is the head of the research group of Visualization and Data Analysis. He received his PhD in Computer and Information Science from Ohio State University in 1999, is a member of Eurographics, and a senior member of IEEE and ACM. He has received several awards, and served as the appointed Vice Chair for Publications of the IEEE Visualization and Graphics Technical Committee (VGTC) from 2003 to 2012. His research interests include algorithms and tools for analyzing and displaying data with principles rooted in computer graphics, image processing, visualization and human-computer interaction.

This session will highlight the power of visual supported analysis of computational simulations. I will first give a detailed example from our own work — a tool for fisheries managers (Vismon). Based on an analysis of numerous other tools we have created as well as a review of 21 different application scenarios, I will make the case that visual support greatly facilitates the understanding of these complex systems leading to faster workflows and a better decision process. Some of the challenges to be tackled include the communication of uncertainty as well as the consideration of multiple objectives.

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## **POSTERS**

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*Visualization of magnetically induced current densities in molecules*, **Heike Fliegl**, Centre for Theoretical and Computational Chemistry (CTCC), University of Oslo — *Applied Topology Optimization for Large Scale Problems*, **Said Zeidan**, Department of Mechanical Engineering, Technical University of Denmark — *Interhemispheric climate variability in a pre-industrial control simulation of CCSM4*, **Jonathan Rheinländer**, Department of Earth Science, Bjerknes Centre, ice2ice, and Prof. **Markus Jochum** — *Patient Specific Modeling of Cardiac Mechanics*, **Henrik Nicolay Finsberg**, Simula Research Laboratory — *Visualization methods for fracture flow problems*, **Piotr Olkiewicz**, Polish Geological Institute – NRI — *Kalkulo Expert Solutions*, **Yvon Halbwachs**, Kalkulo AS — *Social Characteristics of Marriage Breakdown in Hawassa Zuria Woreda, Ethiopia*, **Nigatu Degu Terye**, Hawassa University — *Scalable Heterogeneous CPU-GPU Computations for Unstructured Tetrahedral Meshes*, **Johannes Langguth**, Simula — *Visualizing and comparing In-Situ, Model and EO data*, **Aleksander Vines**, Nansen Environmental and Remote Sensing Center — *Cloud Lightning project*, **Anne C. Elster**, NTNU — *NTNU HPC-Lab GPU-Based Snow Simulator*, **Anne C. Elster**, **Inge Halsane** and **Thomas Schmid** — *Predictive Statistical Analysis of Cardiac Structural and Functional Remodelling*, **Kristin Mcleod**, Simula research laboratory.

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### The Geilo Winter Schools in eScience

The very first winter school was organized in 2001 by Knut-Andreas Lie, then Research Director for SINTEF Applied Mathematics. He wanted to create a meeting place for Ph.D. students and young researchers to foster interaction and catch up on recent developments within eScience. This was at a time when a 1.6 MB file was considered “huge”, and the first school topic was “Cluster computing”.



Having organized the winter school for over 10 years, Knut-Andreas Lie gradually passed on the responsibility to André R. Brodtkorb who is the current organizer. The first seven schools were funded by the Research Council of Norway through the BeMatA program, and continued with nine years of funding by the eVITA program. The school is currently a project funded by the IKTPLUSS program for the period 2016-2020.

The school has provided hundreds of lectures on topics relevant to the Norwegian eScience community over the last 15 years, ranging from parallel computing and Big Data to Monte Carlo simulations and continuum mechanics. The schools have attracted over 800 participants from industry, research, and academic institutions in Norway, Scandinavia, and the world.

### Dr. Holms hotel

Geilo is renowned as one of the best winter sports resorts in Northern Europe, located in the mountains between Oslo and Bergen. Geilo lies at an altitude of 800 meters with its highest alpine slope starting at 1178 meters above sea level. This ensures good snow conditions throughout the winter. Geilo offers 35 varied and well groomed downhill slopes and 18 lifts with a capacity of 25.000 trips pr. hour. Moreover, there are excellent possibilities for cross country, with approximately 500 km of trails, both in the valley and in the mountains.



Dr. Holms Hotel is a distinguished hotel situated right next to the ski slopes. It was opened in 1909 by Dr. Ingebrikt Christian Holm, coinciding with opening of the railway. The intended use was for asthmatic city dwellers from Oslo and Bergen to refresh with the clear and unpolluted mountain air (Dr. Holm was a specialist in respiratory diseases). It has been occupied during the second World War, expanded multiple times, and even sports its own hotel ghost, the gray lady. If you're lucky, you might meet her in the staircase in the gray hours of the morning.

The Geilo Winter Schools in eScience are organized by SINTEF ICT,  
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