Research in the Field of

Visualization and Interactive Systems

Bioinformatics
Visual Computing
High Visual
Digital Med Technology
Infor Networks Art
Analytics Video Data
performance Visualisierung Interactive systems
Communication Powerwall Socio Computergraphik
Relativity Digital Humanities Computer
Particle Systems cultural ePoetics
HCl Biology Systems Protein Dynamics systems Eye-Tracking Physics Vector Software Visualization Protein Dynamics
Research

Cover picture:
High-performance
visualization of a protein
on the Powerwall of the
Visualization Research
Center, University of
Stuttgart.

Simulations

Parallel
Graphics

Vision

Mobile Devices

Our goal:

To ease dealing with data and computers.

Index

Editorial

Prof. Thomas Ertl

Research in Visualization and Interactive Systems is highly dynamic and so are the two Computer Science institutes at the University of Stuttgart which perform world-class research and advanced undergraduate and graduate teaching in these fields.

This booklet provides a compact overview of the activities at the Institute for Visualization and Interactive Systems (VIS) and the Visualization Research Center (VISUS). This is the third edition of such a report. After most of the 1200 copies of the last version, which was printed in 2014 with more than one hundred pages, are already gone, we decided for an edition with less text but for the first time in English. Images are, of course, at the core of our research and we hope that they can motivate many to read about some of our current projects. This booklet is again the result of the design and writing expertise of Tina Barthelmes, our public relations specialist, and of the slight pressure put on the contributors by Rul Gunzenhäuser, our professor emeritus who takes pride in getting the word out on recent successes of the VIS/VISUS ecosystem.

Certainly the most important success since the last edition is the new Collaborative Research Center (SFB-TRR) 161 on Quantitative Methods for Visual Computing which is funded by the German Research Foundation (DFG) since July 2015. This basic research project in collaboration with the University of Konstanz has a funding perspective of twelve years and involves all VIS and VISUS research groups. We are looking forward to report on more results of these research activities in future editions of this booklet.

Now, enjoy browsing through this booklet and if you are interested in more, visit our webpages or contact us directly!

Prof. Thomas Ertl
Institute for Visualization and Interactive Systems (VIS)
Visualization Research Center (VISUS)

Institute for Visualization and Interactive Systems (VIS) and Visualization Research Center (VISUS)

VIS is part of the Department of Computer Science of the University of Stuttgart, VISUS a central research facility.

The Institute for Visualization and Interactive Systems (VIS) is part of the Department of Computer Science of the University of Stuttgart which is responsible for all Informatics research projects as well as for all Computer Science related courses and programs leading to a Bachelor or Master of Science (BSc/MSc) or Doctoral Degree.

VIS originated from the former Dialogue Systems research group which was chaired by Prof. Rul Gunzenhäuser since 1972. In 1999, Thomas Ertl became his successor when he was appointed as a full professor of "Praktische Informatik" at the University of Stuttgart. In 2002, the research group, now specializing in Visualization and Interactive Systems, became the VIS institute of the newly founded Faculty of Computer Science and Electrical Engineering. VIS continued to grow and reached high national and international reputation.

In 2006, Prof. Ertl was able to convince the State Authorities of Baden-Württemberg and the Rector of the University of Stuttgart to further strengthen visualization research at the University of Stuttgart by means of a central research facility. The new "Visualization Research Center (VISUS)" started in 2007 and is now widely visible in its field.

VISUS – as well as VIS – continue to participate in many important research projects. Examples are the Cluster of Excellence in Simulation Technology (SimTech) and the Transregional Collaborative Research Center (SFB-TRR) 161 about Quantitative Methods for Visual Computing. This project is led by the VISUS professor Daniel Weiskopf.

By 2016, VIS has grown to six research groups, each lead by a professor. Three of them are also heading VISUS groups, two others are associated with SimTech groups. More than 75 people work at VIS and VISUS in three modern buildings on the University Campus in Stuttgart-Vaihingen.

Research Groups and People

Graphical-Interactive Systems

VIS, VISUS
Prof. Thomas Ertl

Scientific visualization
Visual analytics
Computer graphics
Interactive systems

Human-Computer-Interaction

VIS, SimTech
Prof. Albrecht Schmidt

Human-computer interaction
Tangible and embedded interaction
Augmenting human perception
and cognition
Physiological interaction

Visualization

VISUS
Prof. Daniel Weiskopf

Scientific visualization
Information visualization
Visual analytics
Eye tracking

Intelligent Systems

VIS
Prof. Andrés Bruhn

Computer vision
Image processing
Scientific computing

Socio-Cognitive Systems

VIS, SimTech
Jun.-Prof. Niels Henze

Mobile human-computer interaction
Ubiquitous computing
Research in the large
Attention and notification
management

Visual Computing

VISUS
Jun.-Prof. Martin Fuchs

Computational imaging
Material measurement and
appearance synthesis
Interactive systems

Visual representations of simulation results are crucial for their efficient analysis. Therefore, we develop new visualization techniques as well as simulation applications for end-users.

Visualization and Interactive Systems for Simulation Technology

SimTech
Cluster of Excellence

PROJECT:
Cluster of Excellence, Simulation
Technology (SimTech), German
Research Foundation (DFG),
2008 – 2017

PRINCIPAL INVESTIGATORS:
Prof. Thomas Ertl
Prof. Daniel Weiskopf
Prof. Albrecht Schmidt
Jun.-Prof. Niels Henze

Simulations play an essential role in numerous disciplines in research and development. For an effective analysis of simulation results visualizations are crucial. The more specific the investigated phenomena are, the more specific visualization tools are required to answer the open questions. Focus of our research lies on new visualization techniques for various applications of simulation technology.

Our scientists concentrate on fluid dynamics and crack propagation in porous media, for example in rock formations. Visualization solutions for those processes might support the development of new geothermal energy technology.

Another team is focusing on electromagnetic fields and their properties. Respective methods are useful for a variety of applications like molecular dynamic simulations or the analysis of astrophysical phenomena.

Due to the complexity of the relevant simulations, the generated data is often analyzed by multiple scientists. But how could the collaborative work with visualizations on large displays be supported? To investigate this challenge we develop new techniques for the representation and specific interaction on the Powerwall of the Visualization Research Center.

However, not only scientists and experts are working with simulations. They are also part of our everyday life. Watching the weather forecast, using navigation systems or predictive health applications in medicine, we all are profiting from simulation technologies. In the field of Human Computer Interaction we explore how we can best communicate uncertain simulation results to non-technical people. Therefore we develop a simulation application that includes input methods and non-expert visualizations for uncertain data.

Furthermore we use modeling and simulation to understand users' behavior. How do users point on interactive objects? How do they use their touch screen when writing on a mobile device? These are only some of the questions we want to answer.

Miriam Greis,
Marcel Hlawatsch

Tiny particles in large
scale – the Powerwall allows
analyzing a simulated and
visualized protein structure
in detail.

Interactive Visualization of Molecular Dynamics Simulations

SFB ⬤ 716

PROJECT:
Collaborative Research Center (SFB) 716 – Dynamic Simulation of Systems with Large Particle Numbers, German Research Foundation (DFG), 2006 – 2018
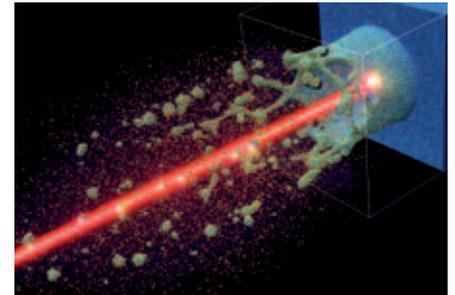
PRINCIPAL INVESTIGATORS:
Prof. Thomas Ertl
Prof. Daniel Weiskopf
Dr. Guido Reina

Large particle simulations are used in various fields of research including physics, mechanical engineering, material science as well as biochemistry. Questions about material properties, biochemistry processes and chemical engineering can be answered – for use in industrial research and further development in future.
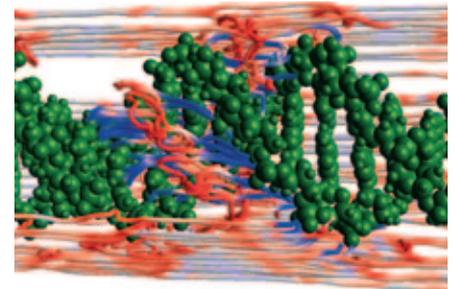
At the Visualization Research Center there are currently three researcher teams that investigate novel visualization methods for data of these areas. In particular our focus lies on DNA processes, proteins and laser ablations or fluid dynamics in different materials.

Despite recent advances in this area, interactive visualization and analysis of systems with large numbers of particles still pose challenges. Increasing data set sizes make it difficult to ensure interactivity. Increasing complexity also calls for methodical advances to allow the user to grasp the structure and temporal development of the data.

Therefore topics of interest are scalable fundamental visualization and analysis methods, specialized visualization approaches for structural biology and biochemistry, and aggregations and multiscale techniques to

Particle cloud caused by a laser ablation.

DNA double helix (green) with streamlines illustrating the ion flux around it.

bridge the gap between discrete and continuous data.

Our research activities are based on the MegaMol visualization software that is developed and maintained by our scientists. It works as a framework for point-based data sets from molecular dynamics simulations.

Guido Reina,
Nora Hieronymus

User studies are one of the research methods to evaluate visualizations, virtual environments, or user interaction.

Quantitative Methods for Visual Computing

SFB-TRR **161**
Quantitative Methods for Visual Computing

PROJECT:
Transregional Collaborative Research Center (SFB-TRR) 161 – Quantitative Methods for Visual Computing, German Research Foundation (DFG), 2015 – 2019

PRINCIPAL INVESTIGATORS:
Prof. Andrés Bruhn
Prof. Thomas Ertl
Jun.-Prof. Martin Fuchs
Jun.-Prof. Niels Henze
Prof. Albrecht Schmidt
Prof. Daniel Weiskopf (Speaker)

TRANSREGIO PARTNERS:
University of Konstanz
Max Planck Institute for Biological Cybernetics

Images play an important role in our society, in which data is generated at amazing speed. The great challenge is to extract relevant information from vast amounts of data and to communicate it effectively. An effective way to represent and analyze complex data are images. We are also able to gain additional information out of images, for example, from digital photos or video recordings, and use them for new applications. In recent years, computer scientists have developed numerous methods and applications in the respective research field called visual computing.

The scientists of the SFB-TRR 161 focus on quantification as a cornerstone to further advance visual computing. They evaluate user studies, optimize methods for interactive visualizations, take physiological measurements, investigate the possibilities of new interaction methods, and develop new algorithms and models.

There are several directions to which these research activities will contribute, including conceptual metrics and models for quantification, new techniques and algorithms for visual computing, respective software, benchmark data that can be used for quantitative evaluation, and improved evaluation methodology.

For instance, one group is working on methods to predict the performance of visual computing applications on available computer hardware to ensure that they can represent big data without time delay and in high quality. Another group investigates the optimization of methods for interactive visualizations to create the best possible user experience and to maximize the task performance.

Further activities concentrate on mobile visualization, motion estimation, computational photography, or on uncertainties throughout the visual computing process.

Marcel Hlawatsch,
Tina Barthelmes

Visualization of the liquid interface, as used in the fluid dynamics solver, helps with the detailed investigation of the simulation results.

Flow Visualization
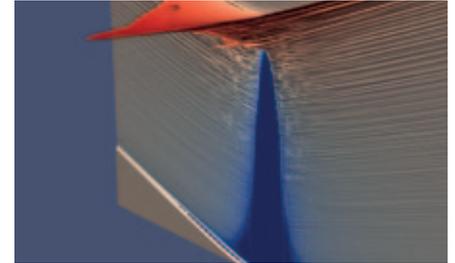
Complex, liquid-gas flows occur in many engineering and natural phenomena, and they are often coupled with intricate physical processes, such as cavitation. Advanced visualization methods are therefore required to gain insight into these problems.

Understanding of droplet dynamics under critical ambient conditions is the research goal of the SFB-TRR 75, where simulations and experiments produce complex data, and many physical phenomena, such as phase transitions, are investigated. Therefore, at VISUS, specially tailored visualization techniques are developed to allow for interactive analysis of large, time-dependent data in the context of droplet dynamic processes. Using graphics processing units (GPUs) and many-core systems, we are able to develop visual analysis methods, such as solver-specific interface visualization or space-time visualization of drop dynamics, necessary to achieve the main project goal.

The Project HONK focuses on the development of techniques for the simulation and analysis of highly complex flows on modern supercomputers. Special emphasis hereby lies on two-phase flows, which occur, for instance, in cavitation phenomena, where parts of the fluid spontaneously evaporate because of a sudden

Visualization of a sudden pressure peak on a wall, triggered by the pressure wave of a collapsing bubble.

Visualization of planar patches that are used to approximate the fluid interface in the two-phase flow simulation.

pressure drop. Cavitation is a very common phenomenon. It occurs in many technical applications, and can cause serious damage due to potential recollapsing. Research at VISUS within this project focuses especially on how the enormous amount of data that is created in the highly resolved simulations of these flows can be coped with. For that purpose, we develop methods that extract relevant information already during the simulation and discard less important data.

Grzegorz Karch,
Sebastian Boblest

Visual analysis of Twitter
messages at the VISUS-
Powerwall.

Visual Social Media Analytics

Social media sources like Twitter, Facebook, or YouTube cover people's observations, opinions and activities. Hence, they gain more and more relevance in different areas such as journalism and market research. Another field of application is urban planning where semantic information from social media helps to improve living conditions and daily commute.

Furthermore, studies have shown that social media contains eyewitness reports for nearly all natural catastrophes in years past. This is especially valuable for disaster prevention and civil defense.

Emergency services can make use of these reports by increasing overview of crisis situations and by coordinating rescue operations. In epidemic research social media data is used to understand the spreading of illnesses.
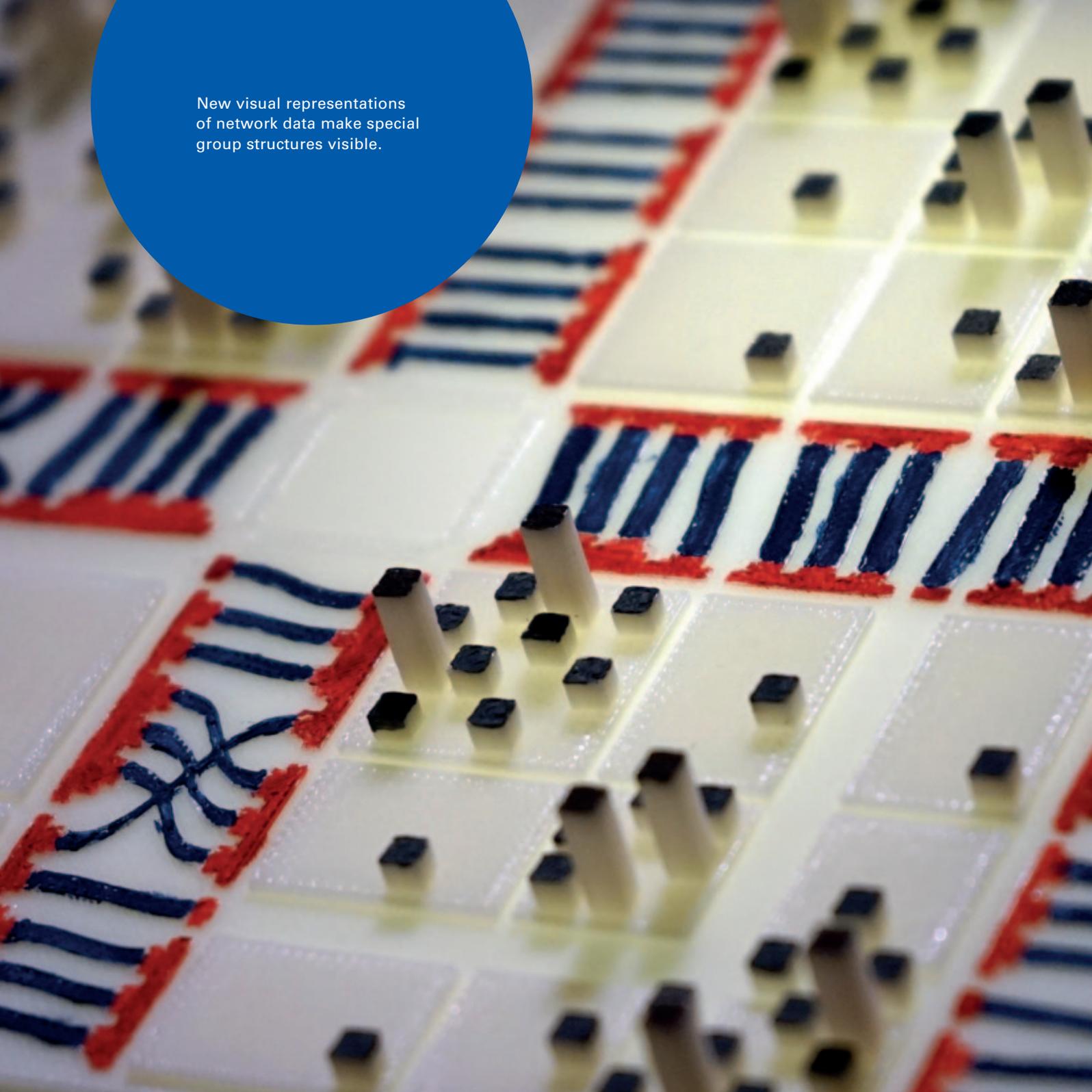
However, massive and noisy data in different forms and format make the analysis challenging. We integrate state-of-the-art approaches from information and geographic visualization with machine learning techniques to enable acquisition, processing, and exploration of massive social media data.

ScatterBlogs – a visual analytics system for spatio-temporal social media analysis. It consists of multiple coordinated views such as a geographic map, a timeline, and different visual filter interfaces. This application, developed at the Institute of Visualization and Interactive Systems, is now being enhanced by a start-up of three graduates.

Highly interactive interfaces allow analysts to add their domain knowledge, i.e., assessments, experience, and intuition, especially necessary for critical decision making. We evaluated our approaches with experts from research and industry as well as with the federal office for civil protection and disaster assistance.

Robert Krüger

New visual representations of network data make special group structures visible.

Network Visualization

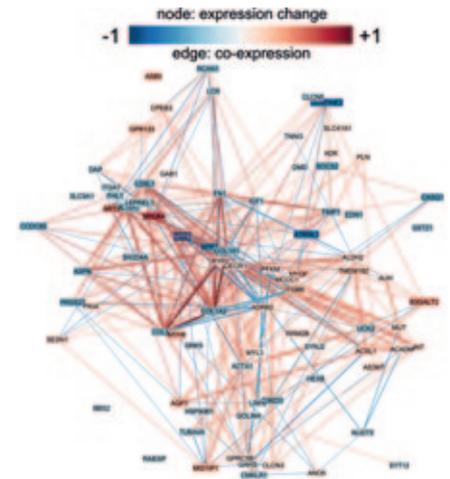RenoDoi – a visualization software for the analysis of a medical long-term study at the School of Medicine of the University of Colorado.

Networks are omnipresent in our modern world – digital social networks connect us to friends and family, variously linked software systems support work processes, and the analysis of gene and disease networks drive bio-medical research. Understanding complex networks is a key challenge in many scientific disciplines.
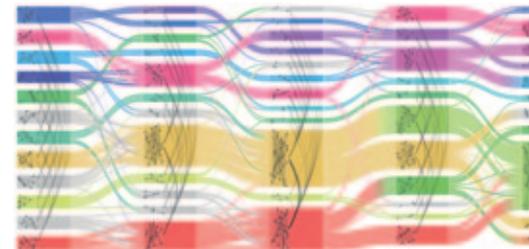
We, as visualization researchers, aim at supporting the analysis of such networks. Traditional representations of networks as node-link diagrams, however, have reached a scale and complexity barrier.

We introduce advanced approaches to network visualization that explore alternative representations of networks, including matrices, lists, or partially drawn links. A special challenge is the visualization of changes within networks, in particular, providing a good overview of network evolution. Dynamic group structures visualized as part of the network help the users to abstract individual changes to higher-level characteristics. Leveraging novel encodings, data abstractions, and advanced interaction techniques, we overcome previous scale and complexity limits.

While our approaches are usually applicable to a wide range of scenarios, we study some application areas
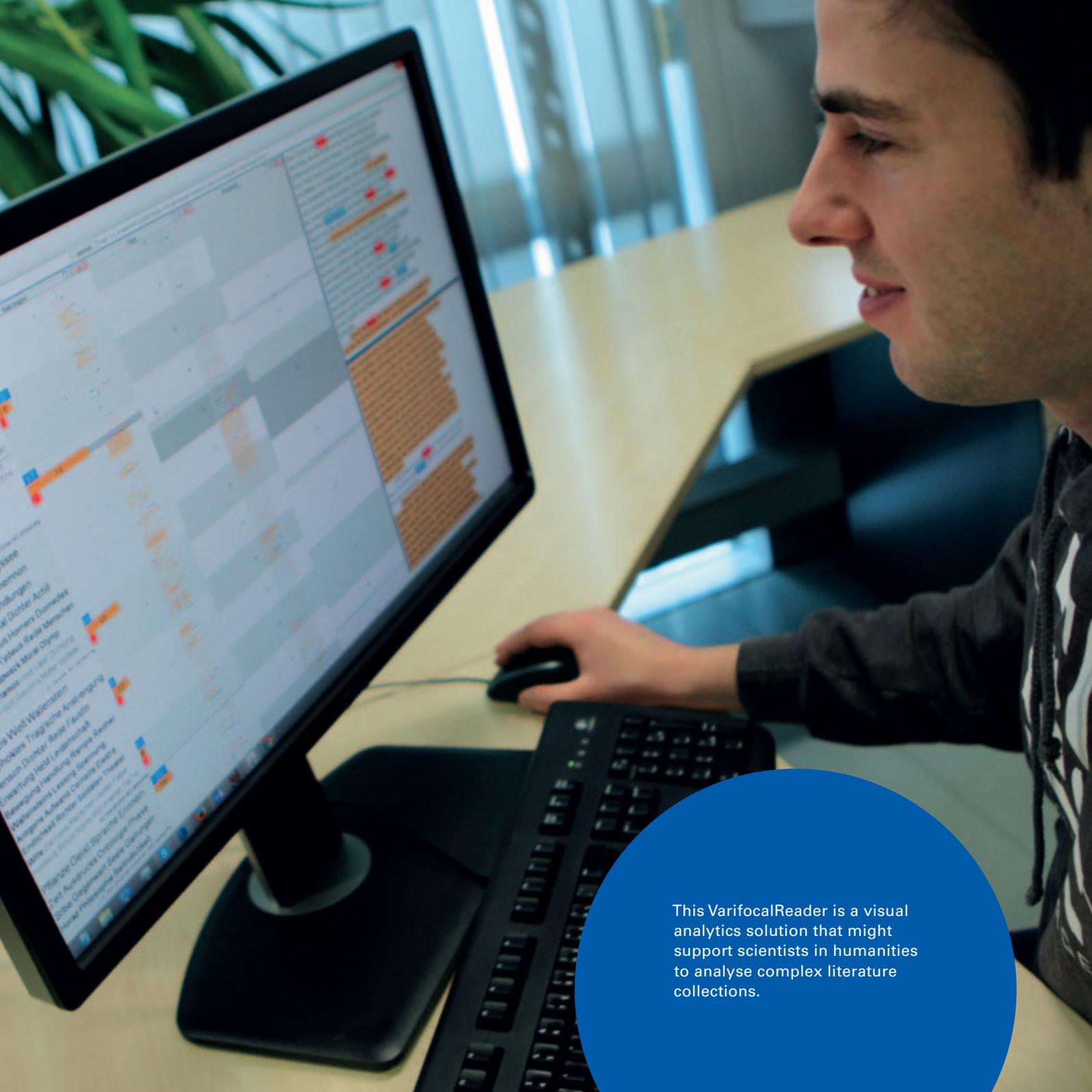

Visual representation of the social behaviours of different groups of people during a conference.

in greater detail. Within the bio-medical domain, for instance, we analyze complex networks that show how diseases are connected to specific gene expressions. Insights gained are the starting point to advance the diagnosis or treatment of specific diseases.

To support software engineers maintain their complex codes, we develop visualizations of the evolution and execution of software systems. These visualizations help monitor project progress, find bugs, or optimize software performance.

Fabian Beck

This VarifocalReader is a visual analytics solution that might support scientists in humanities to analyse complex literature collections.

Digital Humanities

Humanities and social sciences have
issued visualization ever since, but
often in a broader, different sense, for
example as illustrations or further
manually created, non-interactive
visualizations. With Digital Humanities,
also named eHumanities, the idea
of tackling research questions in the
humanities with computer methods
gains rising interest.

The advent of visual analytics and
its intrinsic integration of automatic
methods, such as natural language
processing, makes interactive visua-
lization an interesting means for
presenting results, understanding and
driving analysis, as well as explo-
ring huge data sets from humanities
research.

The Institute for Visualization and
Interactive Systems aims to analyze
and visualize a set of twenty German-
language poetics from the period
of 1770 to 1960 with information
technological methods. For that pur-
pose we work on integrating visual
analysis with traditional hermeneutic
approaches.

Another group develops computer
science methods that are specifically
useful in the context of text-centric
eHumanities endeavors.

A huge challenge for eHumanities
is the different knowledge and skills
of the involved scientists. Useful
applications need a close cooperation
between computer scientists and their
colleagues in literature, sports, or lin-
guistics. For that reason we organized
a lecture series in Digital Humanities
and established a new study program
at the University of Stuttgart.

Besides this, we concentrate on
methods for retrieving facsimiles of
paintings from electronic reposito-
ries by simulating a human viewer's
behavior in looking at a picture, or
support historians with visual repre-
sentations as well as text processing.

But our institute has much deeper
roots in the field of digital humanities.
Prof. Rul Gunzenhäuser, founder of
our predecessor institute (Dialogue
Systems) was one of the first com-
puter scientists working in this field.

Steffen Koch

Eye tracking studies allow us to find out where people look. The analysis of huge user studies needs new visualization methods and software solutions.

Eye Tracking

PRINCIPAL INVESTIGATOR:
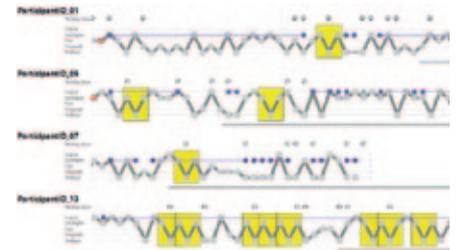Prof. Thomas Ertl
Prof. Daniel Weiskopf

How do people look at visual stimuli? An answer to this question and a fundamental understanding of those processes plays an important role in many research fields such as psychology, marketing, software development as well as in visualization research.

Eye tracking technologies allows us to detect, record, and analyze where people are looking at during experiments or user studies. With this knowledge, we are able to improve existing visualization techniques, or develop new ones with respect to the perceptive and cognitive processes of the human user. Here, we are not limited to scenarios with people looking at a monitor. With mobile eye tracking glasses we can also investigate how people work on handheld devices, on large screens, or in different settings.

Although eye tracking data is a very complex and established analysis method, it cannot always provide an answer to all research questions. Therefore, we work on new visualization techniques to gain more insight from the eye tracking data. With our techniques, analysts have the possibility to compare many participants of an experiment easier than by pure statistical analysis.

Evaluation of the reading strategies in metro maps by applying eye tracking techniques. The maps are overlaid with a visual attention map and a gaze plot.

Visual analysis of eye tracking and interaction data of multiple participants using a timeline visualization to find common eye-interaction patterns amongst participants.

However, this research is still a wide open space for further improvements. Especially for mobile eye tracking, where videos of a person's field of view are combined with their point of regard, future research will provide advanced techniques to better understand such data.

Kuno Kurzhals

Exploration of events and social trends based on geo-located Twitter data in a multidisplay environment. Application based on ScatterBlogs.

Human Computer Interaction

Our research in human computer interaction explores how we can improve the abilities of people to interact with computing systems and digital information. We experimentally explore new input and output devices and investigate how new interaction modalities can improve the user experience. On a technical as well as on a conceptual level we contribute to technologies, models, and frameworks that enable new forms of human technology interaction that are intuitive and enjoyable to use.

Human computer interaction has a direct impact on people's lives and how they experience their personal and work environments. Computing technologies are ubiquitous. Phones, household appliances like coffee makers, TVs, and cars, or even entire houses, factories, and cities have essentially become computers with specific input and output capabilities.

Since computing technologies and digital media have become an integral part of our everyday life it is essential to make them easy-to-use and enjoyable. The interfaces we design increasingly shape how we perceive the world and how we interact with each other. By creating user interfaces for ubiquitous computing technologies we essentially have the means to change what people can do in the real

Interactive projection of adaptive information about an object in an exhibition.

Supporting interaction with large high-resolution displays through eye-tracking.

world, what information they have access to, and how they interact with other people.

The research is constructive and experimental, as we envision, design, implement, and evaluate systems in real world contexts. Our work ranges from new mobile interaction devices, to wearable user interfaces, and to smart environments.

Albrecht Schmidt

An impaired worker is assembling a clamp with in-situ feedback from an assistive system using contour visualizations.

Augmenting Human Perception and Cognition

How to create technologies and interfaces that improve people's cognitive and perceptual abilities? – This is one of the central research questions, we focus on. Using novel devices and user interfaces we experimentally explore how to augment people's memories and how to increase their ability to acquire and retain information. For example, within the project RECALL, we have created user interfaces for live-logging technologies and novel ways to present written text to facilitate faster and more comprehensive reading. In the project MotionEAP, we explore the use of projected augmented reality to enhance the ability of workers in manual assembly processes. New artificial senses from technical sensors will be developed in the project AMPLIFY.

Physiological sensing allows us to create implicit user interfaces. Observing the user's actions and reactions on the basis of a variety of bio-signals enables us to create intuitive interfaces. In the context of the SFB-TRR 161, we focus on solutions that adapt to the user's cognitive load and take the user's attention into account. Using wearable technologies, as explored in the project SimpleSkin, we use a variety of wearable sensing technologies to understand the user's activities.

Working station that uses motionEAP technology to display projected assembling feedback as a work assistance.

Human computer interaction has moved from niche to main stream. With the continued digital transformation of our society it is of utmost importance to develop optimal user interfaces and interaction concepts. The potential of what people can do in a world of unlimited digital information and processing power is only limited by our abilities to interact with it. For this reason, human computer interaction will remain at the center of the forthcoming innovations.

Albrecht Schmidt

Attention is scarce when interacting with mobile devices. We study attentiveness and develop methods to manage users' attention.

Ambient Notification and Attention Management

PRINCIPAL INVESTIGATOR:
Jun.-Prof. Niels Henze

Digital devices have reached all aspects of people's life. One development that made this pervasive interaction with computers possible is the increasing diversity of digital devices. Desktop computers, notebooks, smartphones, and tablets are used to access digital information at any time and place. In the future, additional devices will add to the pool of available devices. Personal devices such as smartwatches, fitness trackers, and smart glasses as well as shared devices such as smart TVs, digital signage, and smart cars will further increase the number of computers used to access information.

What changed in recent years is that the device can initiate the interaction and push information to the user. This interaction is currently realized through so-called notifications. On mobile phones, for example, notifications inform about a variety of events, such as the arrival of a mail, a short message, a comment on a social network or an application update. Today, notifications are the main mechanisms to proactively communicate with the user.

Research showed that users appreciate the awareness that notifications provide and are sometimes even eager to receive them. However, notifications also cause distraction, higher workload, and task interruptions. With more smart devices, notifications' negative effects will increase. A single mail typically results in a notification on each of the user's devices. A user with just four devices such as a smartphone, a tablet, a smartwatch and a desktop PC can receive four notifications for a single event.

To prevent an information overload, it is necessary to develop new methods to proactively provide information to the user. In our work, we develop methods for notifying users in the ubiquitous computing era. We study how people currently deal with the increasing number of notifications. The gained insights are used to investigate approaches for managing notifications in smarter ways. Furthermore, we develop novel multimodal approaches for notifying users.

Niels Henze

Real-time motion estimation with a webcam. Motion to the right is visualized using green colors.

Motion Estimation from Image and Stereo Sequences

PRINCIPAL INVESTIGATOR:
Prof. Andrés Bruhn

Video cameras become more and more part of technology systems such as roboter navigation, monitoring systems for the surveillance of public places or drivers assistenz systems in cars. Permanently record image data are basis for the functionality of these innovations.

Typically, the pixelwise motion of objects between two consecutive images of the image sequence – the so-called optical flow – has to be determined for such applications. Optical flow methods are also relevant for video processing and compression or image matching tasks such as stereo reconstruction and medical registration.

We are working on precise and robust optical flow methods that allow to adapt in a flexible manner to different scenarios including challenging realworld conditions.

From a conceptual viewpoint this is achieved by integrating prior knowledge on possible scenes and the related type of motion into a global optimization approach. So-called variational methods have already proven to be a successful tool for modelling many other tasks in computer vision such as image restoration, object segmentation or the reconstruction of a 3D scene from a single moving camera (structure-from-motion).

Our current research comprises, amongst others, the estimation of large object displacements using pre-computed point correspondences, the joint estimation of motion information and illumination changes, the reliable extraction of camera poses, the computation of short-term trajectories using multiple frames, as well as the automatic learning of suitable representations for image and motion information. Moreover, the extension of optical flow approaches to multiple cameras enables the joint estimation of motion and depth information which in turn allows the recovery of the actual motion in 3D (scene flow).

Finally, a last important field of our work is the design and implementation of efficient algorithms for the aforementioned tasks both on sequential and parallel architectures, including multi-core systems and graphics processing units (GPUs).

Andrés Bruhn

Computational Photography: In order to record a light field, many different camera views of a scene are necessary. Here, a machine vision camera is recording a scene on a rotation stage.

Computational Photography

Synthetic renderings created from a densely recorded light field with different focus distances.

PRINCIPAL INVESTIGATOR:
Jun.-Prof. Martin Fuchs

Digital cameras had a far reaching impact on our photography. Digital images can be easily stored, transmitted and processed, enabling us to take more pictures cheaper. Together with the expanding accessability to the Internet, it became quite easy to share moments with expressive pictures. This trend has been intensified with picture recording devices being ubiquitous. But integrating a camera into a cell phone is a challenging task as the optical design is bound to a tight constraint in size, resulting in subpar imaging properties. Efficient imaging algorithms can alleviate these disadvantages so that even small devices like our cell phones can provide high quality images.

The idea behind computational photography is enhancing standard photography with suitable algorithms but not limited to just producing higher-quality images. Introducing additional devices in the optical path of the imaging sensor, like lenslet arrays or small mirrors, it is possible to increase the dimensionalty of the photography. The resulting 4D data sets, called light fields, enable a wider array of image creation and posthoc manipulation techniques or even allow the reconstruction of the 3D geometry of a scene.

We work on several aspects of light field imaging. Our focus is on optical designs with mirrors, unconventinal optics and dense light fields. We developed an automatic pipeline for the design of faceted mirror arrays which enables light field recording with off-the-shelf cameras. In another project, we investigate how to use even common household devices as optical devices[*]. Precise calibration enables us to not only look through structured glass, but even use it to reconstruct views with varying focus.

Different designs of computational cameras have been proposed, but comparing them is difficult. We intend to capture all of the light leaving a scene with an accuracy high enough to simulate arbitrary computational cameras. An example of such a recording can be seen above. With such data sets we will perform a quantitative analysis of available techniques.

Martin Fuchs, Alexander Wender

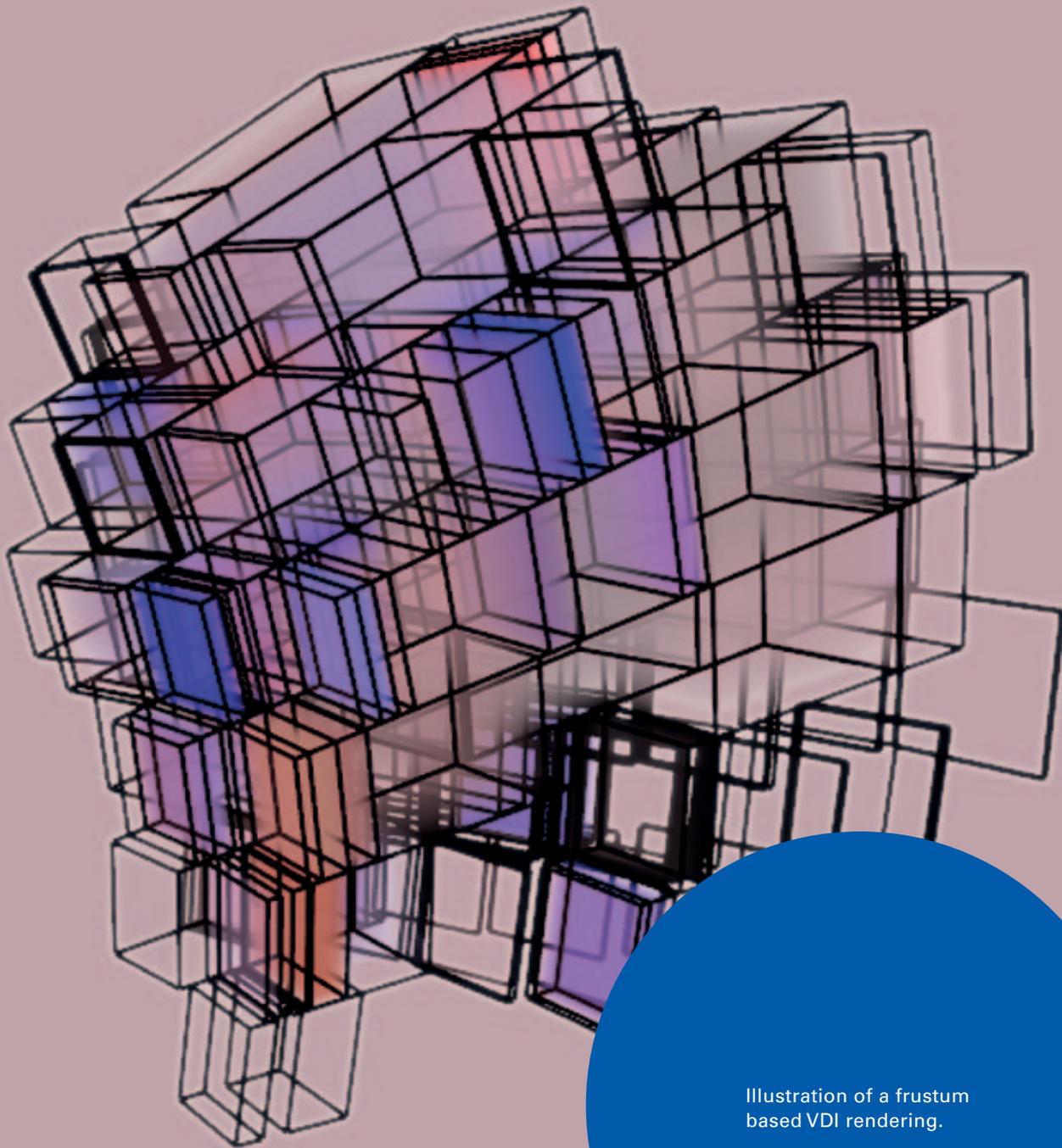[*] Collaboration with the Universities of Bonn and Konstanz

Illustration of a frustum based VDI rendering.

High Performance Visualization

Large-scale simulations making use of increasingly powerful distributed compute environments generate an ever growing volume of data. As a result of this development, storage and network bandwidth constraints more and more become the limiting factor for overall compute performance.

One popular approach to alleviate this bottleneck is in-situ (latin for on site) visualization that transforms the data locally on the respective simulation node into an intermediate visualization representation of reduced size. This allows to generate and store visualizations at a much higher resolution, both with respect to space and time, than what the simulation node would otherwise be able to store permanently in terms of full raw data.

In-situ visualization can further maintain the flexibility for interactive exploration, that has shown to be indispensable in the finding of new insights beyond the original focus of analysis.

An integral part of this process are the intermediate visualization representations, which usually not only allow for reduced cost for storage and transfer but also for image synthesis.

In-situ visualization representations typically achieve this by restricting the degrees of freedom that can be adjusted interactively during the final display stages. Naturally, this is also depending on the requirements of specific domains and areas.

For instance, our volumetric depth images (VDIs) follow a view-dependent approach, i.e., they are optimized with respect to a certain camera position, with the goal to combine the high quality of images and the explorability of interactive techniques. We further extended VDIs to a space-time representation to allows for more efficient compression.

Steffen Frey

The high-resolution stereo projection system at VISUS permits examining large areas of the high-resolution digital elevation model of the state of Baden-Württemberg at once.

Visualization Laboratory
Large High-Resolution Stereo Display

DIMENSION:
Size: 6 x 2.26 m
Pixel size: 0.56 mm

RESOLUTION:
10,800 x 4,096 stereo pixel,
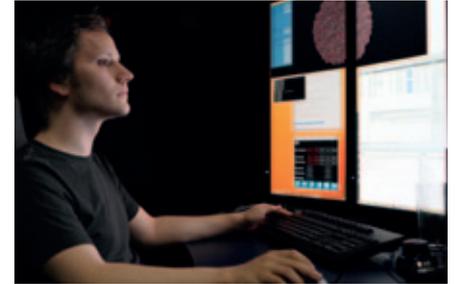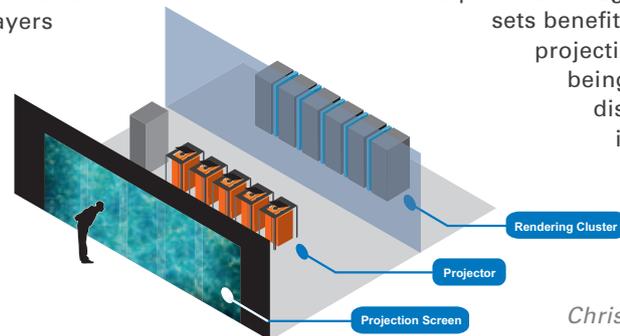about 100 million pixel in total

INSTALLATION: 2010
TECHNOLOGY UPGRADE: 2016

FUNDED BY:
German Research Foundation (DFG)

A core research facility of VISUS is the Powerwall, a bespoke 44-megapixel rear-projection system. Ten individual video projectors, typically used in cinemas, are combined to form a single image on a screen area of 6 × 2.25 metres. Each of them is capable of displaying 4,096 × 2,400 pixels, which consequently have a size of about 0.56 millimetres that is unique for a large stereoscopic display. The small size of a pixel permits an unprecedented perception of depth. A graphics cluster comprising around 100 machines not only utilised for rendering imagery on the Vvand, but also provides the computational power for solving Visual Computing problems.

While design and operation of such systems are research topics on their own, opportunities and benefits of the large physical size and the available resolution need to be investigated, too. For instance, it is unclear how the capability to show many depth layers quantitatively relates to the stereoacuity of the human visual system.
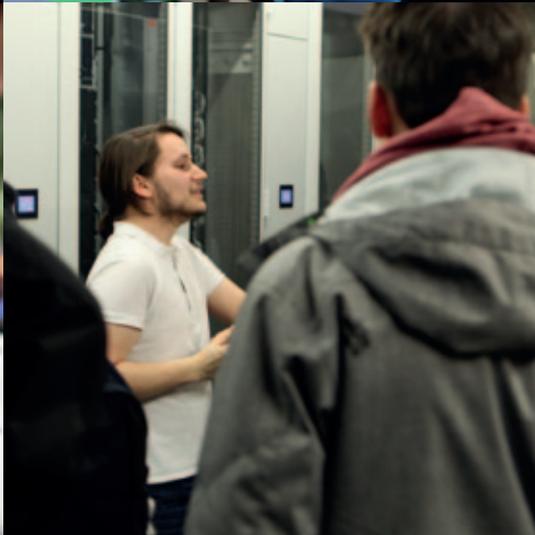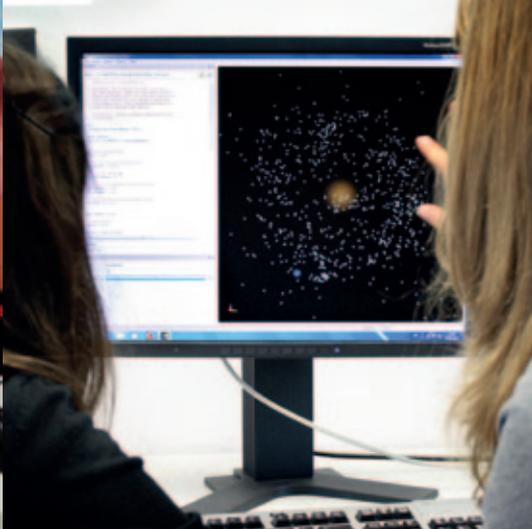

Scientists are controlling the 80-node GPU cluster of the powerwall using a dedicated operator workstation.

Likewise, not all kinds of applications can benefit from the characteristics of the display in the same way. The installation at VISUS enables researchers to delve into such questions.

As the amount of digital data produced by mankind grows faster every year, the output capacity of computers did not keep pace with the computational power used for producing the data. This pertains, for example, to computer simulations carried out by physicists, biologists and researchers from further domains. Visualization applications developed at VISUS to explore such huge data sets benefit from the projection system being able to display more information at the same time.

Rendering Cluster

Projector

Projection Screen

Christoph Müller

Science for the Public

The Institute for Visualization and Interactive Systems and the Visualization Research Center do not only conduct research in Visualization, Visual Analytics, Visual Computing, Intelligent Systems, and Human Computer Interaction, they also campaign for public relations.

Since years our scientists offer computer science courses and hold presentations or demonstrations at various public events at the University of Stuttgart. Our aim is to present reserach activities to people that are interested in our work and our visions for our future. Beyond that we want to provide an insight into academic life and study programs.

Live demonstrations at the VISUS Powerwall as well as lab tours in the Visualization Laboratory with its projector technique and rendering cluster make our scientific work transparent and comprehensible. Programming courses, and workshops in human computer interaction, simulation technologies and visual computing give young people the possibility to test their skills and help them to make their decision about their future plans.

Besides that we hold public lectures for kids and adults and discussed the benefits as well as the challenges of our current developments and visions with the general public during the last years. For instance, Prof. Albrecht Schmidt hold a Kinder-Uni (Children's University) lecture about the question "Do computer make us stupid?", as well as a talk about the "Digital Society" at the event series "Fragen an die Wissenschaft" (Questions to Science) at the adult education center VHS Stuttgart.

Tina Barthelmes

Keep in touch with us and read about our research activities online on

VISUAL COMPUTING BLOG
www.visual-computing.org

TWITTER
www.twitter.com/VIS_VISUS

YOUTUBE
www.youtube.com/
UniStuttgartVISUS.

Facts and Figures

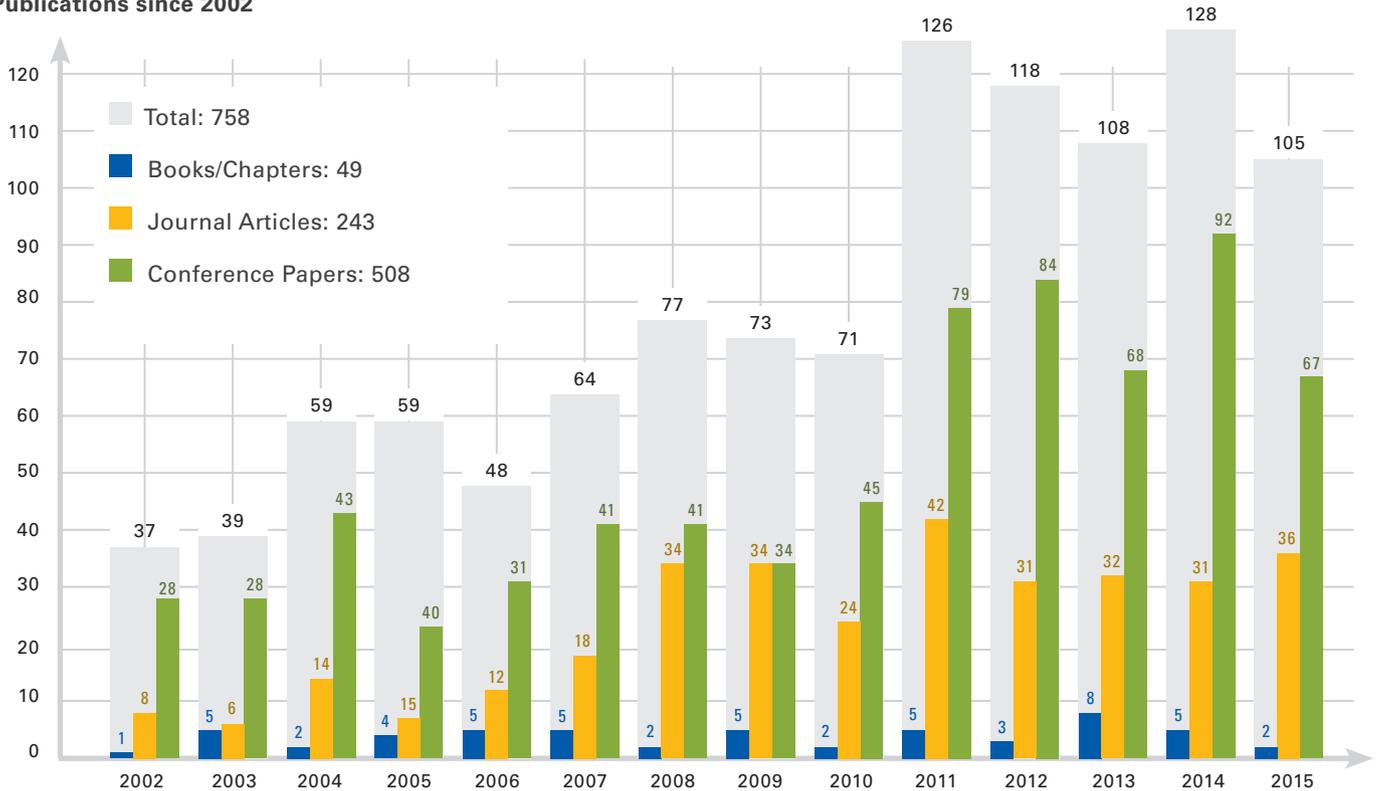**About VIS and VISUS**

Founding year
 VIS   2002
 VISUS   2006

Research Groups   6

Staff   79

Professors   6

Postdocs and PhD Researchers   62

Administration, Public Relations, IT   11

Publications since 2002

Total: 758
Books/Chapters: 49
Journal Articles: 243
Conference Papers: 508

Year	Total	Books/Chapters	Journal Articles	Conference Papers
2002	37	1	8	28
2003	39	5	6	28
2004	59	2	14	43
2005	59	4	15	40
2006	48	5	12	31
2007	64	5	18	41
2008	77	2	34	41
2009	73	5	34	34
2010	71	2	24	45
2011	126	5	42	79
2012	118	3	31	84
2013	108	8	32	68
2014	128	5	31	92
2015	105	2	36	67

Study and Teaching

The research groups of VIS and VISUS contribute to the following study programs:

B.Sc. Informatik (German)

B.Sc. Softwaretechnik (German)

B.Sc. Medieninformatik (German)

B.Sc. Simulation Technology (German)

M.Sc. Informatik (German)
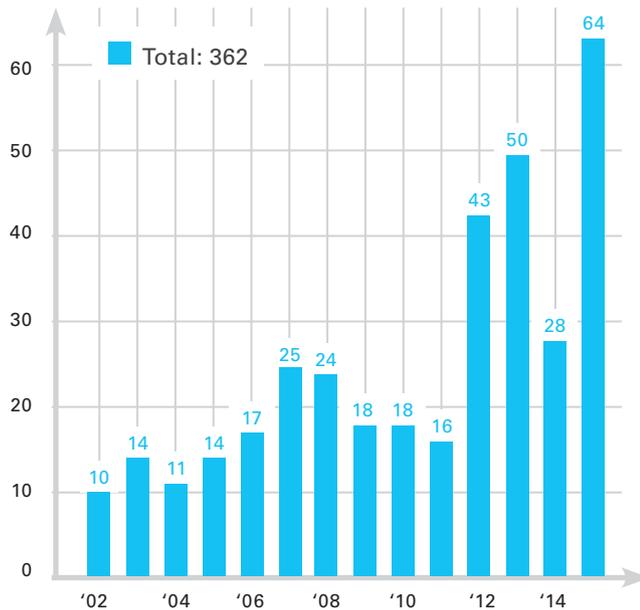
M.Sc. Computer Science (English)

M.Sc. Softwaretechnik (German)
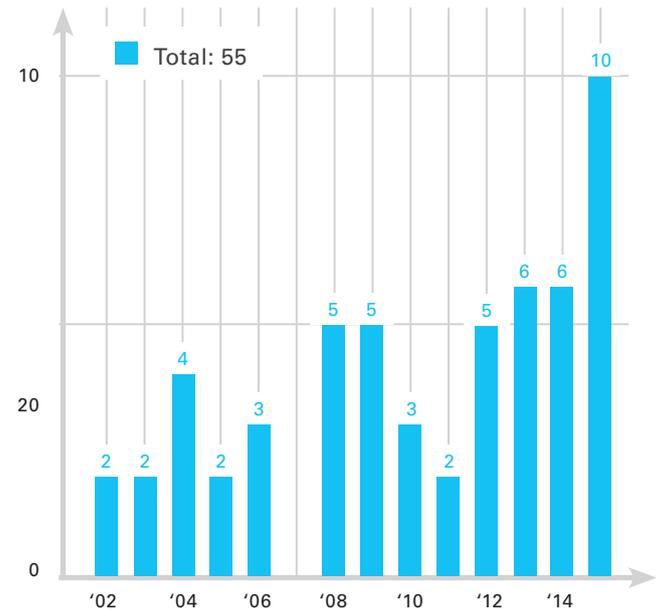
M.Sc. Information Technology (English)

M.Sc. Simulation Technology (German)

M.A. Digital Humanities (German)

Diploma, Bachelor, Master Theses

Total: 362

PhD Theses

Total: 55

Where to Find Us

1 **Informatik Building**

Institute for Visualization and Interactive Systems

Research Groups
Graphical-Interactive Systems
Intelligent Systems

Address
Universitätstr. 38
70569 Stuttgart
Germany

Phone: +49 711 685-88404
         +49 711 685-88454
Fax: +49 711 685-88340

2 **VISUS Building**

Visualization Research Center of the University of Stuttgart

Research Groups
Visualization
Visual Computing

Address
Allmandring 19
70569 Stuttgart
Germany

Phone: +49 711 685-88600
         +49 711 685-88606
Fax: +49 711 685-88610

3 **SimTech Building**

Institute for Visualization and Interactive Systems

Research Groups
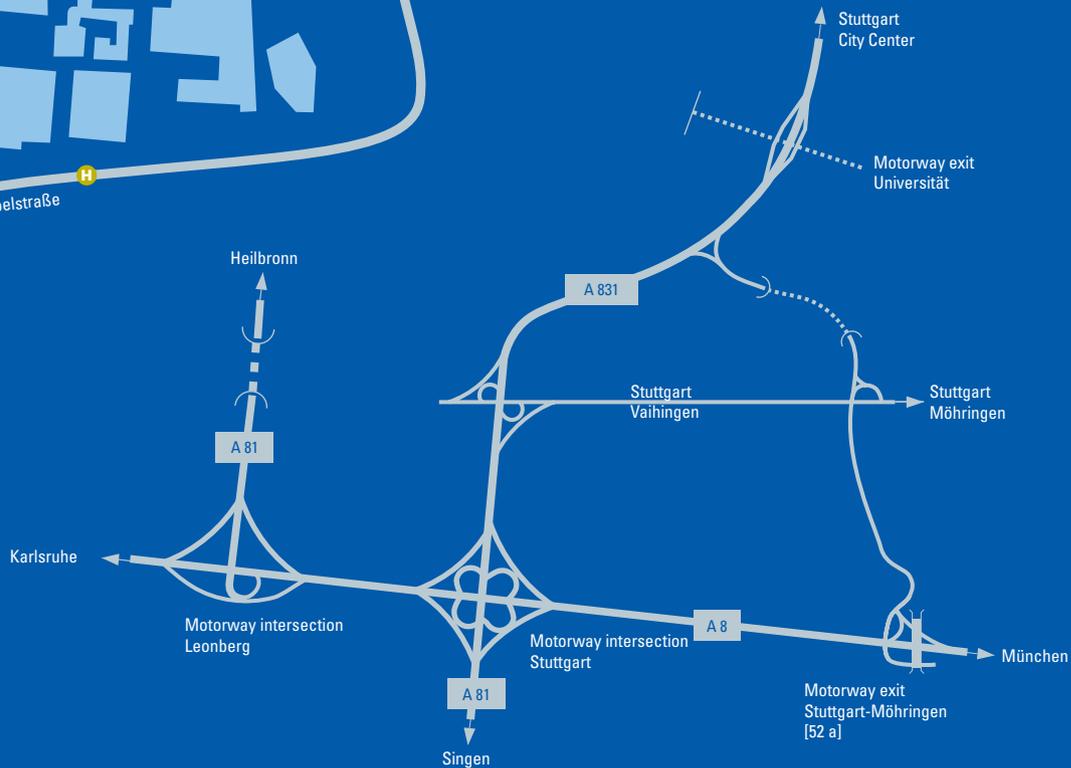Human-Computer-Interaction
Socio-Cognitive Systems

Address
Pfaffenwaldring 5a
70569 Stuttgart
Germany

Phone: +49 711 685-60049
         +49 711 685-60096
Fax: +49 711 685-50053

Pfaffenwaldring

3

Subway Station
(S-Bahn) University

S S1, S2, S3

Allmandring

1

P

S
H
82, 84, 93

Universitätsstraße

P

2

H

Nobelstraße

H

Stuttgart
City Center

Motorway exit
Universität

A 831

Heilbronn

Stuttgart
Vaihingen

Stuttgart
Möhringen

A 81

A 81

Karlsruhe

Motorway intersection
Leonberg

Motorway intersection
Stuttgart

A 8

München

A 81

Motorway exit
Stuttgart-Möhringen
[52 a]

Singen

www.vis.uni-stuttgart.de
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www.visual-computing.org