Dagstuhl Seminar 07291
Scientific Visualization
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Introduction

Scientific visualization (SV) is concerned with the use of computer-generated images to aid the understanding, analysis and manipulation of data. Since its beginning in the early 90's, the techniques of SV have aided scientists, engineers, medical practitioners, and others in the study of a wide variety of data sets including, for example, high performance computing simulations, measured data from scanners (CAT, MR, confocal microscopy), internet traffic, and financial records. One of the important themes being nurtured under the aegis of Scientific Visualization is the utilization of the broad bandwidth of the human sensory system in steering and interpreting complex processes and simulations involving voluminous data sets across diverse scientific disciplines. Since vision dominates our sensory input, strong efforts have been made to bring the mathematical abstraction and modeling to our eyes through the mediation of computer graphics. This interplay between various application areas and their specific problem solving visualization techniques was emphasized in the proposed seminar.

Reflecting the heterogeneous structure of Scientific Visualization, we focused on the following:

Visual Analytics:

The fields of information analysis and visualization are rapidly merging to create a new approach to extracting meaning from massive, complex, evolving data sources and stream. Visual analytics is the science of analytical reasoning facilitated by interactive, visual interfaces. The goal of visual analytics is to obtain insight into massive, dynamic and often conflicting pieces and formats of information; to detect the expected and to discover the unexpected; and to yield timely assessments with evidence and confidence levels.

Quality Measures:

It is vital for the visualization field to establish quality metrics. An intrinsic quality metric will tremendously simplify the development and evaluation of various algorithms. The establishment of quality metrics will also advance the acceptance and use of visualization in industrial and medical applications.

Ubiquitous Visualization:

As ubiquitous computing is getting increased attention, also visual display of everywhere available data is necessary. Challenges include: heterogeneous output devices, novel interaction metaphors, network bandwidth (availability, reliability), graceful degradation of algorithms with respect to largely varying resources, invivo visualization (real time, no pre-processing, robust).

Multifield and multiscale visualization:

The output of the majority of computational science and engineering simulations is typically a combination of fields, so called multifield data, involving a number of scalar fields, vector fields, or tensor fields. Similarly, data collected experimentally is often multifield in nature (and from multiple sources). The ability to effectively visualize multiple fields simultaneously, for both computational and experimental data, can greatly enhance scientific analysis and understanding. Multiscale problems with scale differences of several orders of magnitude in CFD, nanotechnology, biomedical engineering and proteomics pose challenging problems for data analysis. The state of the art in multiscale visualization considerably lags behind that of multiscale simulation. Novel solutions to multiscale and multifield visualization problems have the potential for a large impact on scientific endeavors.

Summary of Workshop

Our Dagstuhl workshop was arranged into three general types of sessions: **Senior Short Talks, In-Depth Research Talks,** and **Break-out Sessions.** The senior short talks were designed to pose research challenges and approaches for the future and had a very short presentation followed by long, lively discussions. The in-depth research talks allowed for detailed presentation of research approaches and projects, as well as a special session on education challenges/approaches within scientific visualization. The break-out sessions were used to stimulate group focused discussions on important topics and actions for the future.

Below are summaries from our four break-out groups:

1) Integrating Visualization into Discovery, Analysis and Problem Solving Networks: Co-leads – Kelly Gaither and Penny Rheingans

The goal of this breakout session was to document the process that the domain scientist takes when analyzing their data -- a flow chart for an example user, and to document what in this process is easy and what is difficult. This documentation will make it easier to ascertain what pieces of that process should be more tightly integrated from the domain scientist's point of view, and what should be more tightly integrated into the science itself.

2) Quantifying the Impact of Visualization: Co-leads – Chris Johnson and Torsten Moeller

The goal of this breakout session was to collect community thoughts on "Quantifying the Impact of Visualization." The major questions that were addressed were the following:

A) How do we get users to use our tools? The members of the group discussed the process of transferring a research code to a useful tool in the broader user community and the social and pragmatic issues that we as visualization researchers/practitioners have to worry about.

B) How do our tools improve effectiveness and how is this measured? A discussion ensued regarding what tools currently exist to evaluate effectiveness and how we can quantify this effectiveness within the user's workflow.

C) How do we measure the collective impact of our field at large? The measure of collective impact of our field is the sum of the measure of how effective we are both internally to our community and to the external user community as well. We must publish constraint problems and solicit focused solutions, enumerate success stories and determine how to assess the impact in both the scientific community and in the mainstream.

3) Complexity and Scale of Visualization: Co-leads – Valerio Pascucci and Gerik Scheurrman

This breakout session discussed the field of visualization as a whole including topics such as multi-scale problems, temporal data, abstraction and feature detection, and multi-source, multi-type, multivariate and time-evolving data fusion. The group summarized current approaches, open challenges, and directions for future research.

4) Interaction and Cognition: Co-leads – Joerg Meyer and Jim Thomas

The purpose of this breakout session was to discuss the science of interaction and visualization and corresponding metrics, dynamic and adaptive visualization and visual cognition. The breakout session created a taxonomy of interaction science as well as laid out the scope and roadmap for this emerging new field.