European Research Forum Panel Session

Envisioning Research Challenges in Visual Analytics

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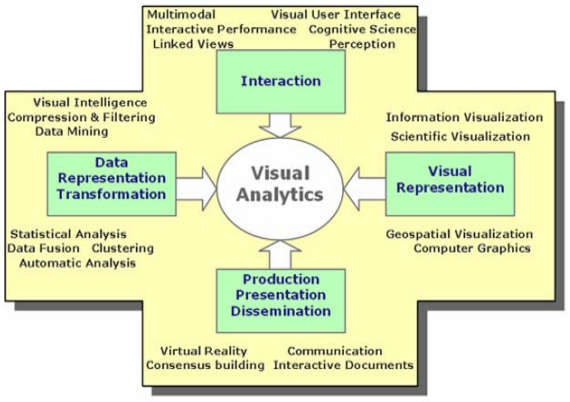
Abstract

Visual Analytics is the science of analytical reasoning supported by interactive visual interfaces. People use visual analytics tools and techniques to synthesize information; derive insight from massive, dynamic, and often conflicting data; detect the expected and discover the unexpected; provide timely, defensible, and understandable assessments; and communicate assessments effectively for action. The issues stimulating this body of research provide a grand challenge in science: turning information overload into the opportunity of the decade. Visual analytics requires interdisciplinary science beyond traditional scientific and information visualization to include statistics, data mining, knowledge and discovery technologies, cognitive science and human-computer interaction, production and presentation, and more. An important research agenda "Illuminating the Path" provides recommendations for the next generation suite of visual analytics technologies and is available at http://nvac.pnl.gov/agenda.stm .

1. Panellists statements

1.1 Mikael Jern

Visual Analytics (VA) is an emerging and interdisciplinary frontier defined as the science of analytical reasoning facilitated by interactive visual interfaces and is now actively pursued by research groups worldwide. VA takes advantage of human perception capabilities and can be described as "find patterns in known and unknown large dataset via visual interaction and thinking". Several new trends are emerging from VA and among the most important one is the fusion of visualization techniques with other areas such as cognitive and perceptual sciences, statistical analysis, mathematics, knowledge representation, data mining and GIS to promote broad-based advances. Another trend, which has often not been well met to date by visualization researchers, is the realization that algorithmic and other technical development should be closely coupled with usability studies to assure that techniques and systems are well designed and that their value is verified and quantified. VA will arise from a combination of four research areas:



Combined types of innovative VA techniques will be used to provide timely, defensible, and understandable assessments and communicate knowledge effectively for action. VA offers the potential to provide managers, analysts and experts in academia, industry and public services with competitive decision-making tools to:

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- Keep pace with increasing model complexity - see essential information more quickly;
- Uncover opportunities, risk and trends which would have gone unnoticed before;
- To develop a pro-active approach to decision making and understand the reasoning and validity behind it;

Bio: During 1970-1976, he worked with Professor Hertz at the University of Lund. Together they invented the Color Graphics System based on the first ink jet plotter for raster based visualisation software in the world. In 1980 he founded UNIRAS to address the industry with a more general-purpose raster graphics approach. UNIRAS became a world-leading supplier of Visual Data Analysis and Presentation graphics software for scientists and engineers with a revenue exceeding $25 million. UNIRAS was also a supplier of raster software to IBM, Tectronix and Versatec. Prof Jern is committed to graphics standards and was the project leader in a joint UNIRAS-IBM project to develop the standard graphics software system (GKS) for IBM in Hursley UK. He has been a member in various graphics metafile committees supporting CGM, CGM*PIP etc. He has coordinated several large EC funded projects in the domain of knowledge-based information visualization. He has published more than 200 technical papers and several books in visual computing and visualization application areas. At SIGGRAPH 93, he was elected "pioneer of computer graphics" based on his breaking new ground research together with professor Hertz in raster graphics. In Sept 1999, he returned to academic research and was appointed professor at Linkoping University, Sweden. His latest research interest includes information visualisation and geovisualisation and now also visual analytics.

1.2 Gennady Andrienko

By definition, Visual Analytics (VA) deals with massive and complex data. However, visualisation tools and techniques are currently rather weak with regard to large data volumes and complex structures. We argue that, besides the imperfection of the existing tools, there is a more fundamental reason for this.

In visual exploration and analysis, it is the mind of a human explorer that is the primary tool of analysis. It is the task of the human mind to derive insights, "detect the expected and discover the unexpected" while the task of visualisation is, according to a dictionary, "to make [information] perceptible to the mind or imagination".

However, the human mind has natural limitations as to the amount of information that can be effectively perceived. Therefore, it is often impossible to visualise all data that need to be analysed in such a way that the analyst can perceive them all without substantial losses. On a very general level, the approach to handling complex data may be presented as follows:

1) "Simplify and abstract". By means of generalisation and aggregation, the data are transformed so as to reduce excessive detail, fluctuations, and occasional peculiarities, which may obstruct the visibility of essential features. In the result, the analyst can get a synoptic view of the whole dataset. However, this inevitably involves a great loss of information.

2) "Divide and group". For a more comprehensive analysis, the analyst decomposes the data into parts and examines these parts. Again, it may be necessary to apply simplification to each part in order to grasp its essential features.

3) "See in relation". For a proper understanding of the data divided into parts, the analyst needs to reveal the substantial differences as well as the similarities between the parts.

4) "Attend to particulars". Due to data aggregation and simplification, potentially valuable information may be lost. While it may be impossible to consider each individual data item, various "particulars" such as outstanding attribute values, atypical temporal behaviours, or incongruities encountered in a spatial distribution require the analyst's attention.

While it is necessary that VA tools properly support these activities, this is certainly not enough. The result of the steps 1-4 consists, in general, of a number of unconnected knowledge fragments. The analyst needs to put these fragments together so that they make a whole picture. This is analogous to assembling multiple diverse tiles into a mosaic image or to reconstructing a complex three-dimensional shape from a set of projections and slices. Hence, another step must be added to the description of the data analysis procedure:

5) "Establish linkages and structure". The observations and partial patterns derived from the investigation of various parts and aspects of the data (steps 1-4) must be integrated into a coherent overall model of the entire dataset and the underlying phenomenon.

Unlike the activities 1-4, the activity 5 is synthetic rather than analytic (in the sense of division of a whole into parts). Due to its extreme importance, it cannot be left out of the scope of VA. As it appears, current visualisation tools and techniques are better capable to support analysis than synthesis. Hence, one of the research directions in VA should be finding proper ways to support synthetic activities in data analysis.

Bio: Dr. Gennady Andrienko is a senior researcher at the Fraunhofer Institute for Autonomous Intelligent Systems in Sankt-Augustin, Germany. He received his Ph.D. in Computer Science from Moscow State University in 1992. He did a research on knowledge-based systems at the Mathematics Institute of Moldavian

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Academy of Sciences (Kishinev, Moldova), then specialised in knowledge-based information retrieval and visualisation at the Institute on Mathematical Problems of Biology of Russian Academy of Science (Pushchino Research Center, Russia). Since 1997 Dr. Andrienko has a research position at GMD (German National Research Centre for Information Technologies; now Fraunhofer Institute AiS). He led workpackages in numerous international R&D projects, including EU-funded projects CommonGIS, SPIN!, GIMMI, OASIS, and GeoPKDD. He is a co-author of the monograph "Exploratory Analysis of Spatial and Temporal Data. A Systematic Approach" (Springer-Verlag, 2006) and of more than 100 refereed papers. He is an active member of several commissions of the International Cartographic Association. His research interests and experiences include visual analytics, exploratory data analysis, knowledge-based visualisation design, and spatial and temporal data mining. For more information, see http://www.ais.fraunhofer.de/and

1.3 Daniel A. Keim

Never before in history has data been generated at such high volumes as it is today. While the capacity to collect and store new data rapidly grows, exploring and analyzing the vast volumes of data has become increasingly difficult. This gap leads to new challenges in the analysis process, since analysts, decision makers, engineers, or emergency response teams depend on information hidden in the data. The emerging field of visual analytics focuses on handling these massive, heterogeneous, and dynamic volumes of information by integrating human judgement by means of visual representations and interaction techniques in the analysis process. The new requirements make an extension of Ben Shneiderman's Information Seeking Mantra necessary. The new Visual Analytics Mantra requires a tight integration of goal-driven automatic analysis techniques into the information analysis pipeline. This presentation will introduce the Visual Analytics Mantra and discuss its scope and concepts. It will address the most important visual analytics research challenges and illustrate those using examples from a wide variety of applications.

Bio: Dr. is full professor and head of the Information Visualization and Data Analysis Research Group at the University of Konstanz, Germany. He has been actively involved in information visualization research for more than 10 years and developed a number of novel visual exploration techniques for very large data sets. He has been program co-chair of the IEEE InfoVis and IEEE VAST symposia as well as the SIGKDD conference, and he is member of the IEEE InfoVis steering committee. He is an associate editor of the IEEE Transactions on Knowledge and Data Engineering (since 2002) and Palgrave's Information Visualization Journal (since 2001), and has been an associate editor of the IEEE Transactions on Visualization and Computer Graphics (1999 – 2004). Dr. Keim got his masters degree in computer science from the University of Dortmund and his Ph.D. and habilitation degrees in computer science from the University of Munich. Before joining the University of Konstanz, Dr. Keim was associate professor at the University of Halle, Germany and Technology Consultant at AT&T Shannon Research Labs, NJ, USA.

1.4 Wolfgang Mueller

Bio: Wolfgang Mueller is a Professor for Media Education and Visualization at the University of Education Weingarten, Germany. He studied Computer Science at Darmstadt University of Technology and got a Doctorate (Dr-Ing.) in the field of Visualization in 1999. Since then, he has been an active researcher and educator in the fields of Information Visualization, Visual Analytics, and Human-Computer Interaction. In this context, he led research groups for instance at Fraunhofer IGD, Darmstadt University of Technology, and the University of Frankfurt/Main. He is also the co-author of a German textbook on Visualization.

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