Activity Report 2011

Project-Team AVIZ

Analysis and Visualization

RESEARCH CENTER
Saclay - Île-de-France

THEME
Interaction and Visualization

Table of contents

Project-Team AVIZ

Keywords: Visualization, Data Analysis, Interaction, Collaborative Work, Perception, Evolutionary Algorithms

1. Members

Research Scientists

Jean-Daniel Fekete [Team Leader, Senior Researcher (DR2), HdR]
Évelyne Lutton [Research Scientist (CR1), HdR]
Pierre Dragicevic [Research Scientist (CR1)]
Petra Isenberg [Research Scientist (CR2)]

External Collaborators

Anastasia Bezerianos [École Centrale Paris, Assistant Professor]
Tobias Isenberg [University of Groningen, Digiteo Chair of Excellence for 2010–2013]

Technical Staff

Pierre-Luc Hémery [11/2009—11/2011, Engineer ADT]

PhD Students

Charles Perin [10/2011, Co-Advised by Frédéric Vernier (LIMSI) and Jean-Daniel Fekete]
Benjamin Bach [01/2011, Co-Advised by Emmanuel Pietriga and Jean-Daniel Fekete]
Nicolas Heulot [09/2010, Co-Advised by Michael Aupetit (CEA LIST) and Jean-Daniel Fekete]
Samuel Huron [12/2010, Co-Advised by Jean-Daniel Fekete and Vincent Puig]
Yvonne Jansen [12/2010, Co-Advised by Pierre Dragicevic and Jean-Daniel Fekete]
Jeremy Boy [12/2011,Co-Advised by Françoise Detienne and Jean-Daniel Fekete]
Wael Khemiri [09/2008, Co-Advised by Ioana Manolescu (INRIA, Gemo), Véronique Benzaken (Paris-Sud, ProVal), and Jean-Daniel Fekete]

Post-Doctoral Fellows

Nadia Boukhelifa [09/2011, Advised by Evelyne Lutton]
Romain Vuillemot [09/2011, Advised by Jean-Daniel Fekete]
Waldo Cancino [10/2011, Advised by Evelyne Lutton]
Franck Vidal [2/2011–9/2011, Advised by Jean-Daniel Fekete and Tobias Isenberg]

Administrative Assistant

Alexandra Merlin [10/2010]

2. Overall Objectives

2.1. Objectives

All human activities are being transformed by our rapidly increasing abilities to collect, manage and understand vast amounts of data. A 2003 study estimated that the amount of data produced in the world was increasing by 50% each year [1]. According to SearchEngineWatch [2], the amount of information made available through Internet search engines has grown exponentially for the last decade, and major Web search engines currently index more than 2 billion documents. However, since our brains and sensory capacities have not evolved in the meantime, gaining competitive advantage from all this data depends increasingly on the effectiveness with which we support human abilities to perceive, understand, and act on the data.

[1] Peter Lyman and Hal R. Varian. How much information. Retrieved from http://www.sims.berkeley.edu/how-much-info-2003, 2003.
[2] http://www.searchenginewatch.com

With this increase of data, the traditional scientific method of applying model-based analysis to understand the data is no longer sufficient. We have access to data that we have never encountered before and have little or no idea of applicable models. Therefore, we need to explore them first to gain insights and eventually find models. This process has already been promoted by John Tukey in his 1977 book on *Exploratory Data Analysis* [3] which has become a branch of the domain of statistics. Whereas EDA is ultimately interested in finding models, data exploration can also reveal relevant facts that are, in themselves interesting and important.

AVIZ (Analysis and VIsualiZation) is a multidisciplinary project that seeks to improve visual exploration and analysis of large, complex datasets by tightly integrating analysis methods with interactive visualization. It focuses on four research themes:

- *Methods to visualize and smoothly navigate through large datasets;*
- *Efficient analysis methods to reduce huge datasets to visualizable size;*
- *Evaluation methods to assess the effectiveness of visualization and analysis methods and their usability;*
- *Engineering tools for building visual analytics systems that can access, search, visualize and analyze large datasets with smooth, interactive response.*

2.2. Research Themes

AVIZ's research on Visual Analytics is organized around four main Research Themes:

Methods to visualize and smoothly navigate through large data sets: Large data sets challenge current visualization and analysis methods. Understanding the structure of a graph with one million vertices is not just a matter of displaying the vertices on a screen and connecting them with lines. Current screens only have around two million pixels. Understanding a large graph requires both data reduction to visualize the whole and navigation techniques coupled with suitable representations to see the details. These representations, aggregation functions, navigation and interaction techniques must be chosen as a coordinated whole to be effective and fit the user's mental map.

AVIZ designs new visualization representations and interactions to efficiently navigate and manipulate large data sets.

Efficient analysis methods to reduce huge data sets to visualizable size: Designing analysis components with interaction in mind has strong implications for both the algorithms and the processes they use. Some data reduction algorithms are suited to the principle of sampling, then extrapolating, assessing the quality and incrementally enhancing the computation: for example, all the linear reductions such as PCA, Factorial Analysis, and SVM, as well as general MDS and Self Organizing Maps. AVIZ investigates the possible analysis processes according to the analyzed data types.

Evaluation methods to assess their effectiveness and usability: For several reasons appropriate evaluation of visual analytics solutions is not trivial. First, visual analytics tools are often designed to be applicable to a variety of disciplines, for various different data sources, and data characteristics, and because of this variety it is hard to make general statements. Second, in visual analytics the specificity of humans, their work environment, and the data analysis tasks, form a multi-faceted evaluation context which is difficult to control and generalize. This means that recommendations for visual analytics solutions are never absolute, but depend on their context.

In our work we systematically connect evaluation approaches to visual analytics research—we strive to develop and use both novel as well as establish mixed-methods evaluation approaches to derive recommendations on the use of visual analytics tools and techniques. Aviz regularly published user studies of visual analytics and interaction techniques and takes part in dedicated workshops on evaluation.

Engineering tools: for building visual analytics systems that can access, search, visualize and analyze large data sets with smooth, interactive response.

[3] John W. Tukey. *Exploratory Data Analysis*. Addison-Wesley, 1977.

Currently, databases, data analysis and visualization all use the concept of data tables made of tuples and linked by relations. However, databases are storage-oriented and do not describe the data types precisely. Analytical systems describe the data types precisely, but their data storage and computation model are not suited to interactive visualization. Visualization systems use in-memory data tables tailored for fast display and filtering, but their interactions with external analysis programs and databases are often slow.

AVIZ seeks to merge three fields: databases, data analysis and visualization. Part of this merging involves using common abstractions and interoperable components. This is a long-term challenge, but it is a necessity because generic, loosely-coupled combinations will not achieve interactive performance.

AVIZ's approach is holistic: these four themes are facets of building an analysis process optimized for discovery. All the systems and techniques AVIZ designs support the process of understanding data and forming insights while minimizing disruptions during navigation and interaction.

2.3. Highlights

In 2011, AVIZ has been very successful in obtaining funded projects.

Google Research Award: Jean-Daniel Fekete has received an Research Award by Google for a project called "Data Visualization for the People" to be done with Jeremy Boy and AVIZ.

National Equipment of Excellence: The Digiscope project has been selected on the competitive call (acceptance rate of 51/336 or 15%). AVIZ is in charge of setting up a Fab Lab available to all the partners of the Digiscope project.

National ANR Projects: We received 2 projects: ANR FITOC, a 4 years "Starting Grant" project (ANR Jeune Chercheuse) obtained by Petra Isenberg on collaborative information visualization, and the 2 years EASEA-Cloud Infrastructure project obtained by Évelyne Lutton on multi-dimensional visualization for monitoring and steering high-performance evolutionary algorithms.

European Project: the 4 year CENDARI Infrastructure project on integrating digital archives and resources for research on European history.

Publications: this year, members of AVIZ collaborated on 24 publications overall and were present at all the most prestigious conferences in our fields: ACM CHI, ACM UIST, IEEE InfoVis, IEEE VAST.

3. Scientific Foundations

3.1. Scientific Foundations

The scientific foundations of Visual Analytics lie primarily in the domains of Information Visualization and Data Mining. Indirectly, it inherits from other established domains such as graphic design, Exploratory Data Analysis (EDA), statistics, Artificial Intelligence (AI), Human-Computer Interaction (HCI), and Psychology.

The use of graphic representation to understand abstract data is a goal Visual Analytics shares with Tukey's Exploratory Data Analysis (EDA) [47], graphic designers such as Bertin [36] and Tufte [46], and HCI researchers in the field of Information Visualization [35].

EDA is complementary to classical statistical analysis. Classical statistics starts from a *problem*, gathers *data*, designs a *model* and performs an *analysis* to reach a *conclusion* about whether the data follows the model. While EDA also starts with a problem and data, it is most useful *before* we have a model; rather, we perform visual analysis to discover what kind of model might apply to it. However, statistical validation is not always required with EDA; since often the results of visual analysis are sufficiently clear-cut that statistics are unnecessary.

Visual Analytics relies on a process similar to EDA, but expands its scope to include more sophisticated graphics and areas where considerable automated analysis is required before the visual analysis takes place. This richer data analysis has its roots in the domain of Data Mining, while the advanced graphics and interactive exploration techniques come from the scientific fields of Data Visualization and HCI, as well as the expertise of professions such as cartography and graphic designers who have long worked to create effective methods for graphically conveying information.

The books of the cartographer Bertin and the graphic designer Tufte are full of rules drawn from their experience about how the meaning of data can be best conveyed visually. Their purpose is to find effective visual representation that describe a data set but also (mainly for Bertin) to discover structure in the data by using the right mappings from abstract dimensions in the data to visual ones.

For the last 25 years, the field of Human-Computer Interaction (HCI) has also shown that interacting with visual representations of data in a tight perception-action loop improves the time and level of understanding of data sets. Information Visualization is the branch of HCI that has studied visual representations suitable to understanding and interaction methods suitable to navigating and drilling down on data. The scientific foundations of Information Visualization come from theories about perception, action and interaction.

Several theories of perception are related to information visualization such as the "Gestalt" principles, Gibson's theory of visual perception [40] and Triesman's "preattentive processing" theory [45]. We use them extensively but they only have a limited accuracy for predicting the effectiveness of novel visual representations in interactive settings.

Information Visualization emerged from HCI when researchers realized that interaction greatly enhanced the perception of visual representations.

To be effective, interaction should take place in an interactive loop faster than 100ms. For small data sets, it is not difficult to guarantee that analysis, visualization and interaction steps occur in this time, permitting smooth data analysis and navigation. For larger data sets, more computation should be performed to reduce the data size to a size that may be visualized effectively.

In 2002, we showed that the practical limit of InfoVis was on the order of 1 million items displayed on a screen [38]. Although screen technologies have improved rapidly since then, eventually we will be limited by the physiology of our vision system: about 20 millions receptor cells (rods and cones) on the retina. Another problem will be the limits of human visual attention, as suggested by our 2006 study on change blindness in large and multiple displays [37]. Therefore, visualization alone cannot let us understand very large data sets. Other techniques such as aggregation or sampling must be used to reduce the visual complexity of the data to the scale of human perception.

Abstracting data to reduce its size to what humans can understand is the goal of Data Mining research. It uses data analysis and machine learning techniques. The scientific foundations of these techniques revolve around the idea of finding a good model for the data. Unfortunately, the more sophisticated techniques for finding models are complex, and the algorithms can take a long time to run, making them unsuitable for an interactive environment. Furthermore, some models are too complex for humans to understand; so the results of data mining can be difficult or impossible to understand directly.

Unlike pure Data Mining systems, a Visual Analytics system provides analysis algorithms and processes compatible with human perception and understandable to human cognition. The analysis should provide understandable results quickly, even if they are not ideal. Instead of running to a predefined threshold, algorithms and programs should be designed to allow trading speed for quality and show the tradeoffs interactively. This is not a temporary requirement: it will be with us even when computers are much faster, because good quality algorithms are at least quadratic in time (e.g. hierarchical clustering methods). Visual Analytics systems need different algorithms for different phases of the work that can trade speed for quality in an understandable way.

Designing novel interaction and visualization techniques to explore huge data sets is an important goal and requires solving hard problems, but how can we assess whether or not our techniques and systems provide real improvements? Without this answer, we cannot know if we are heading in the right direction. This is why we

have been actively involved in the design of evaluation methods for information visualization [7] [43], [41], [42], [39]. For more complex systems, other methods are required. For these we want to focus on longitudinal evaluation methods while still trying to improve controlled experiments.

4. Application Domains

4.1. Application Domains

AVIZ develops active collaboration with users from various application domains, making sure it can support their specific needs. By studying similar problems in different domains, we can begin to generalize our results and have confidence that our solutions will work for a variety of applications.

Our current application domains include:

- *Genealogy*, in cooperation with North Carolina State University;
- *Biological research*, in cooperation with Institut Pasteur;
- *Digital Libraries*, in cooperation with the French National Archives and the Wikipedia community;
- *Open Data*, in cooperation with Google Open Data;
- *Agrifood Process Modeling*, in cooperation with the DREAM project;

5. Software

5.1. The Obvious Toolkit

Participants: Pierre-Luc Hémery, Jean-Daniel Fekete [correspondant].

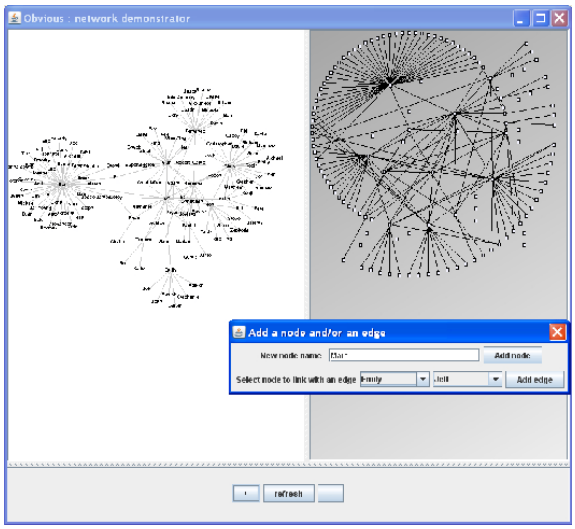

Figure 1. The Obvious toolkit showing the same graph with a Prefuse and an IVTK rendering.

The Obvious Toolkit is a new Interactive Graphics Toolkit written in Java to facilitate the interoperability between Information Visualization toolkits and components (Fig. 1).

The Obvious Toolkit is an abstraction layer above visualization toolkits. Currently, it connects the most popular toolkits in Java: Prefuse, the InfoVis Toolkit, Improvise, as well as other libraries such as the Java Database Communication Toolkit (JDBC) and some others.

It is meant to provide an abstraction layer for information visualization application builders so that they can postpone their choice of a concrete toolkit to use. When faced with the final choice, application builders can use one of the toolkits or connect all of them dynamically to Obvious. Obvious is available at http://code.google.com/p/obvious. A paper on Obvious was presented at the IEEE Visual Analytics Science and Technology conference (VAST 2011).

5.2. GeneaQuilts

Participants: Jean-Daniel Fekete [correspondant], Pierre Dragicevic, Anastasia Bezerianos, Julie Bae, Ben Watson, Maike Gilliot [correspondant].

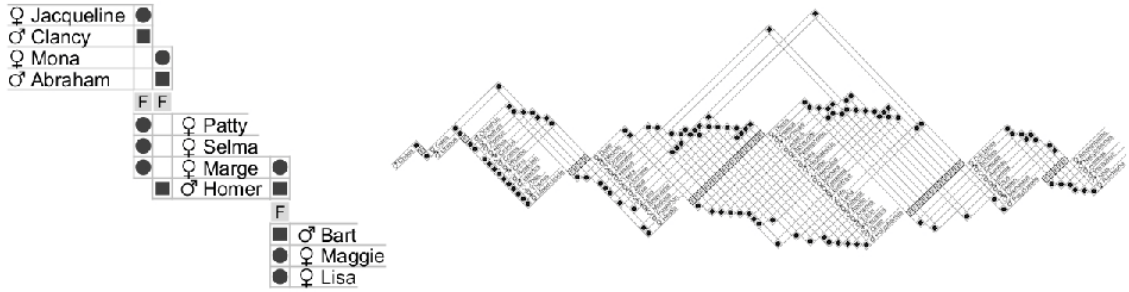

Figure 2. The genealogy of the Simpsons family (left) and of the Greek Pantheon (right), produced by the GeneaQuilts software.

GeneaQuilts [2] is a new genealogy exploration software that allows genealogists and historians to visualize and navigate in large genealogies of up to several thousand individuals (Fig. 2). The visualization takes the form of a diagonally-filled matrix, where rows are individuals and columns are nuclear families. The GeneaQuilts system includes an overview, a timeline, search and filtering components, and a new interaction technique called Bring & Slide that allows fluid navigation in very large genealogies. The tool has been featured in several InfoVis and genealogy Websites and the website has been visited over 9000 times.

See also the web page http://www.aviz.fr/geneaquilts/.

- Version: 1.0.4

5.3. Diffamation

Participants: Fanny Chevalier, Pierre Dragicevic [correspondant], Anastasia Bezerianos, Jean-Daniel Fekete.

The Diffamation system [3] allows rapid exploration of revision histories such as Wikipedia or subversion repositories by combining text animated transitions with simple navigation and visualization tools. Diffamation can be used for example to get a quick overview of the entire history of a Wikipedia article or to see what has happened to one's contributions. Diffamation complements classical diff visualizations: once moments of interest have been identified, classical diff visualizations can come in useful to compare two given revisions in detail.

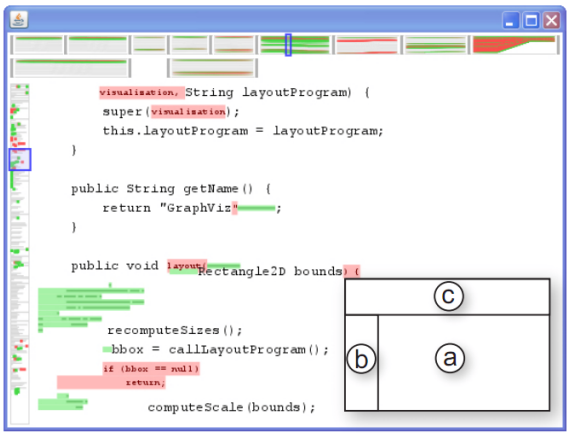

Figure 3. Screenshot the Diffamation system during a transition: (a) the document view, (b) the overview scrollbar and (c) the timeline.

The Diffamation revision exploration system is available at http://www.aviz.fr/diffamation/. It has been presented at the plenary session of the Ubuntu Developer Summit.

5.4. The InfoVis Toolkit

Participant: Jean-Daniel Fekete [correspondant].

The InfoVis Toolkit [5] is an Interactive Graphics Toolkit written in Java to facilitate the development of Information Visualization applications and components.

The InfoVis Toolkit implements several visualization techniques, as well as interaction techniques related. It has been used for teaching the Information Visualization course (Masters level, Univ. of Paris-Sud) and is the basis for all AVIZ contracts. It is our main development platform for information visualization; most of our Information Visualization prototypes rely on it. It is available at http://ivtk.sourceforge.net.

In the forthcoming years, it will be superseded by extensions of the Obvious Toolkit (see 5.1).

- Version: version0.9 beta 2

5.5. GraphDice

Participants: Jean-Daniel FEKETE [correspondant], Pierre Dragicevic, Niklas Elmqvist, Anastasia Bezerianos.

GraphDice [1] is a visualization system for exploring multivariate networks (Fig. 4). GraphDice builds upon our previous system ScatterDice (best paper award at the IEEE InfoVis 2008 conference) [4]: it shows a scatter plot of 2 dimensions among the multiple ones available and provides a very simple paradigm of 3D rotation to change the visualized dimensions. The navigation is controlled by a scatter plot matrix that is used as a high-level overview of the dataset as well as a control panel to switch the dimensions.

While ScatterDice works on any tabular dataset (e. g., CSV file), the GraphDice system show networks using a node-link diagram representation as a scatter plot with links drawn between connected nodes. See the web page http://graphdice.gforge.inria.fr for more information.

- Version: version 1.0

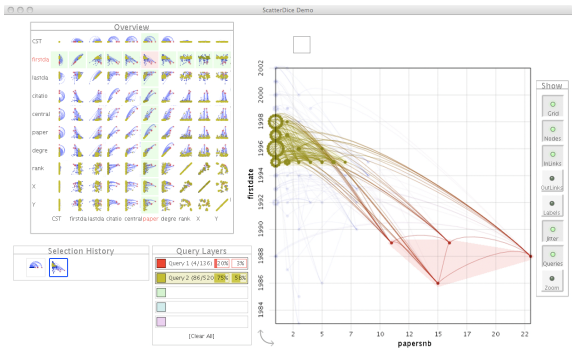

Figure 4. Screenshot the GraphDice system.

5.6. Gliimpse

Participants: Pierre Dragicevic [correspondant], Stéphane Huot, Fanny Chevalier.

Figure 5. Gliimpse: A detail of the animation between an article and its LaTeX source code.

Gliimpse is a quick preview technique that smoothly transitions between document markup code (HTML, LaTeX,...) and its visual rendering. This technique allows users to regularly check the code they are editing in-place, without leaving the text editor. This method can complement classical preview windows by offering rapid overviews of code-to-document mappings and leaving more screen real-estate. A proof-of-concept editor can be downloaded for free at http://www.aviz.fr/gliimpse/.

6. New Results

6.1. Visual Analytics of EA Data

Participants: Jean-Daniel Fekete, Évelyne Lutton [correspondant].

An experimental analysis of Evolutionary Algorithms (EAs) usually generates a huge amount of multidimensional data, including numeric and symbolic data. It is difficult to efficiently navigate in such a set of data, for instance to be able to tune the parameters or evaluate the efficiency of some operators. Usual features of existing EA visualisation systems consist in visualising time- or generation-dependent curves (fitness, diversity, or other statistics). When dealing with genomic information, the task becomes even more difficult, as a convenient visualisation strongly depends on the considered fitness landscape. In this latter case the raw data are usually sets of successive populations of points of a complex multidimensional space.

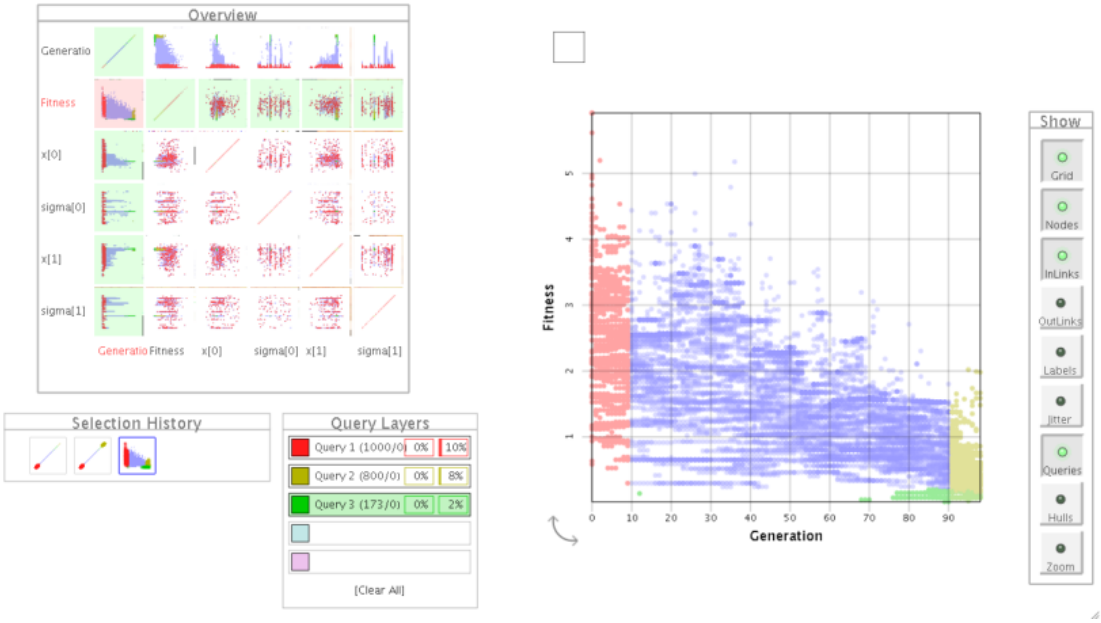

Figure 6. Visual Analytics of EA Data: GraphDice showing fitness versus generation view. Red points correspond to the first 10 generations, yellow points, to the 10 last ones, and green points, to the best fitness areas.

The purpose of this study was to evaluate GraphDice on complex sets of EA data (for artificial and real test-cases), and to sketch future developements of this tool, in order to better adapt it to the needs of EA experimental analysis (Fig. 6). An output of this study is the acceptation of the EASEA-Cloud ANR-Emergence project, in which developements will aim at adding tools in GraphDice specific for:

- visualisation of Evolutionary Algorithms written in the EASEA language,
- monitoring the execution of these algorithms on a cloud of computers (CPU + GPU).

6.2. Interactive Evolutionary Algorithms for Visual decision making

Participants: Nadia Boukhelifa, Waldo Cancino, Jean-Daniel Fekete, Evelyne Lutton [correspondant].

When dealing with very large datasets with many dimensions, it is often difficult to efficiently navigate and find interesting viewpoints, significative compound variables, unexpected behaviour, and other remarkable characteristics.

Our aim within the System@tic CSDL project (Complex Systems Design Lab, 2009–2012) is to use interative evolutionary algorithm to assist the user in its exploration task. Finding an interesting, non obvious, viewpoint on a complex dataset can be formulated as an interactive optimisation problem. Population-based evolutionary search mechanisms can then efficiently be exploited for suggesting new viewpoints on data, that progressively adapt to the needs of an user.

In September 2011 (arrival of Nadia Boukhelifa and Waldo Cancino) we started to build a prototype based on GraphDice, that proposes new dimensions in the scatterplot matrix. These secondary set of dimensions are compositions of the dimensions of the initial datased. Starting from an initial set of suggested dimensions (PCA analysis of the dataset), an evolutionary algorithm progressively refines the compound dimensions according to a measurement of the activity of the user on the corresponding views.

6.3. Optimisation of Food Models

Participant: Évelyne Lutton [correspondant].

In collaboration with Alberto Tonda and Romain Reuillon, ISC-PIF

The European project DREAM (http://dream.csregistry.org/) managed by INRA-CEPIA, aims at building decision support tools for better managing product quality and, by the way, manufacturing processes in the domain of agrifood industry.

Our contribution to this project is focused on the evolutionary optimisation of Bayesian Networks models, on the development of efficient cooperative-co-evolution schemes to solve some food modeling problems (milk gel, cheese ripening), and on the efficient visualisation of output data of these algorithms.

6.4. A Study on Dual-Scale Data Charts

We presented the results of a user study that compares different ways of representing dual-scale data charts (see Fig. 7). Dual-scale charts incorporate two different data resolutions into one chart in order to emphasize data in regions of interest or to enable the comparison of data from distant regions. While some design guidelines exist for these types of charts, there is currently little empirical evidence on which to base their design. We filled this gap by discussing the design space of dual-scale cartesian-coordinate charts and by experimentally comparing the performance of different chart types with respect to elementary graphical perception tasks such as comparing lengths and distances. Our study suggests that cut-out charts which include collocated full context and focus are the best alternative, and that superimposed charts in which focus and context overlap on top of each other should be avoided.

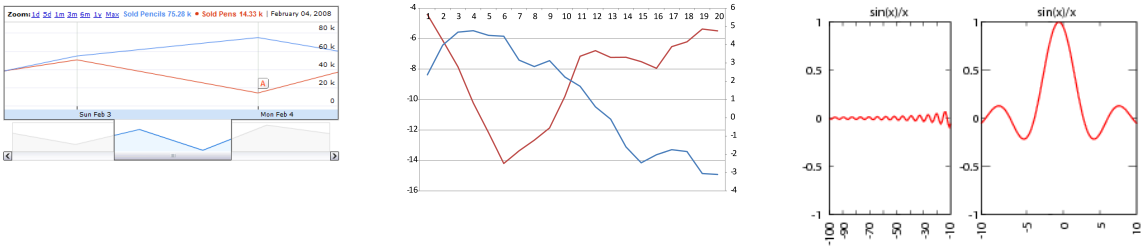

Figure 7. Three different dual-chart techniques made with different publicly available charting tools. The left image shows a cut-out chart made with the Google Charts API in which the top part depicts parts of the data at larger scale. The middle image shows a superimposed chart made by Microsoft Excel where the red line is plotted according to the left and the blue according to the right y-axis. The right chart is a Broken Chart made with Gnuplot in which the left and right panel show parts of the data at different scale.

6.5. Information Visualization Evaluation

AVIZ published several articles on evaluation. Three are related to Psychophysics studies [44] or perception: "*An Extended Evaluation of the Readability of Tapered, Animated, and Textured Directed-Edge Representations in Node-Link Graphs*" [23], "*Temporal Distortion for Animated Transitions*" [19], and "*A Study on Dual-Scale Data Charts*" [11] (see above).

Petra Isenberg has contributed to three articles on evaluation methodologies: The first article "*Collaborative Visualization: Definition, Challenges, and Research Agenda*" [12] deals with challenges of collaborative visual analytics and includes a discussion on the challenges of evaluating tools during multi-person use. The second article,"*Information Visualization Evaluation in Large Companies: Challenges, Experiences and Recommendations*" [14], discusses challenges of evaluating and deploying visual analytics tools in a large company setting. It lists several challenges and provides concrete guidance to others who seek to evaluate tool within domain experts in their work environment. Finally, "*Seven Guiding Scenarios for Information Visualization Evaluation*" [33] is a pre-print of an journal article (in press) which provides a new viewpoint on evaluation in information visualization. Instead of giving an overview of methods, it cites evaluation goals and questions and can, thus, provide clear considerations for practitioners and researchers in the area.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Fitoc: From Individual To Collaborative Visual Analytics

Participants: Petra Isenberg [correspondant], Jean-Daniel Fekete, Pierre Dragicevic.

The project addresses fundamental problems of technological infrastructure and the design of data representation and interaction to build a bridge between individual and team work for visual data analysis. We will tackle this challenge through a stream of interconnected research modules, starting from fundamentally extending visualization toolkits for collaborative work and researching the necessary interaction and visualization mechanisms that will allow for a seamless and effortless setup of face-to-face data analysis with visualizations. We will provide both fundamental and applied contributions and evaluate our work in order to ensure its validity.

7.1.2. CSDL, Complex Systems Design Lab.

Participants: Nadia Boukhelifa, Waldo Cancino, Jean-Daniel Fekete, Evelyne Lutton [correspondant].

CSDL, Complex Systems Design Lab (2009–2012) is a project of the System@tic pole whose main contractor is Dassault Aviation, together with 27 academic and industrial partners. The aim of CSDL is to settle a complete collaborative environment for decision making in the framework of complex systems design (http://www.teratec.eu/activites/projetsR_D_systematic.html). CSDL funds have been used to hire a two post-doctoral researchers (Nadia Boukhelifa and Waldo Cancino).

7.2. Avenir: Advanced Visual Exploration with Non-photorealisitic and Interactive Rendering

Participants: Tobias Isenberg, Jean-Daniel Fekete [correspondant], Pierre Dragicevic.

AVIZ and CNRS/LIMSI have invited Tobias Isenberg on a Digiteo Chair of Excellence, a very prestigious and competitive position offered by the Digiteo Consortium on the Saclay area. Tobias will be collaborating with both teams on a project call AVENIR: “Advanced Visual Exploration with Non-photorealisitic and Interactive Rendering”.

This project will take a unique research approach to visualization that is situated at the intersection of several related directions: scientific and information visualization, non-photorealistic and illustrative rendering, and interaction on large displays. It aims to establish this area as a new research direction within the scope of the newly emerging domain of illustrative visualization which takes inspiration both from traditional illustration and computer-driven visualization. For this purpose we will investigate how to integrate both direct-touch interaction and non-photorealistic rendering into traditional scientific and information visualization applications.

On the one side, we will use techniques from non-photorealistic and illustrative rendering to provide abstraction and emphasis as well as make use of its ability to provide clear and understandable depictions. In addition, we will investigate the possibility for data reduction. Some non-photorealistic techniques can provide faster rendering than their photorealistic counterparts and can, thus, inspired the transfer of these techniques to visualization applications. This will greatly improve the visualization of large amounts of data.

On the other side, we will use direct-touch interaction on large displays to provide an intuitive and easily approachable platform for integrated visualization applications that allow the exploration of the large amounts of data we want to visualize. This specific setting not only allows a person to interact with a visualization in a very direct way but also affords collaborative visualization for small groups of scientists. This will create synergies from discussions between colleagues or in the context of small research teams which otherwise would not be possible for a single person.

This integration of visualization with non-photorealistic rendering and large-display interaction will not only integrate well with existing research directions of the two participating Digiteo teams, but also provide them with exciting new application domains: it will use concepts from both scientific visualization (VENISE) and information visualization (AVIZ) and will apply large display concepts (VENISE). Through this collaboration this grant will lead the way toward a new way of presenting and exploring scientific data.

7.3. European Initiatives

7.3.1. FP7 Project

Program: FP7

Project acronym: **DREAM**

Project title: Design and development of REAlistic food Models with well-characterised micro- and macro-structure and composition

Duration: 2009–2013

Coordinator: INRA - CEPIA department, Monique Axelos

Other partners: Technical Research Centre of Finland, Actilait France, ADRIA Développement France, CNRS, INRA Transfert, Société de Recherche et Développement Alimentaire Bongrain, Campden BRI Magyarország Nonprofit Kft. Hungary, Central Food Research Institute Hungary, Teagasc - Agriculture and Food Development Authority Ireland, Consiglio Nazionale delle Ricerche - Istituto di Scienze delle Produzioni Alimentari Italy, Top Institute Food and Nutrition The Netherlands, Wageningen University (WUR) The Netherlands, University of Ljubljana, Biotechnical Faculty Slovenia, Institute for Food and Agricultural Research and Technology Spain, Campden BRI UK, Institute of Food Research UK, United Biscuits (UK) Limited.

Abstract:

The overall goal of DREAM (Design and development of REAlistic food Models with well-characterised micro- and macro-structure and composition) is to develop realistic, physical and mathematical models to be used as standards that can be exploited across all major food categories to facilitate development of common approaches to risk assessment and nutritional quality for food research and industry.

The partnership involves 18 partners from 9 european countries, among which two multinationals. The project is lead by INRA, CEPIA department, and INRIA participation is managed by delegation by the ISC-PIF (CNRS-CREA, UMR 7656).

See more on http://dream.aaeuropae.org/.

Program: Infrastructures

Project acronym: **CENDARI**

Project title: Collaborative EuropeaN Digital/Archival Infrastructure

Duration: 01/2012 - 12/2015

Coordinator: Trinity College, Dublin (IE),

Other partners: Freie Universitaet Berlin (DE), Matematicki Institut Sanu u Beogradu (Serbia), University of Birmingham (UK), King's College London (UK), Georg-August-Universitaet Goettingen Stiftung Oeffentlichen Rechts (DE), Narodni Knihovna Ceske Republiky (Czech Republic), Societa Internazionale per lo Studio del Medioevo Latino-S.I.S.M.E.L. Associazione (IT), Fondazione Ezio Franceschini Onlus (IT), Ministerium fur Wissenschaft, Forschung und Kunst Baden-Wurttemberg (DE), Consortium of European Research Libraries (UK), Koninklijke Bibliotheek (NL), UNIVERSITA DEGLI STUDI DI CASSINO (IT).

Abstract:

The Collaborative EuropeaN Digital Archive Infrastructure (CENDARI) will provide and facilitate access to existing archives and resources in Europe for the study of medieval and modern European history through the development of an 'enquiry environment'. This environment will increase access to records of historic importance across the European Research Area, creating a powerful new platform for accessing and investigating historical data in a transnational fashion overcoming the national and institutional data silos that now exist. It will leverage the power of the European infrastructure for Digital Humanities (DARIAH) bringing these technical experts together with leading historians and existing research infrastructures (archives, libraries and individual digital projects) within a programme of technical research informed by cutting edge reflection on the impact of the digital age on scholarly practice.

The enquiry environment that is at the heart of this proposal will create new ways to discover meaning, a methodology not just of scale but of kind. It will create tools and workspaces that allow researchers to engage with large data sets via federated multilingual searches across heterogeneous resources while defining workflows enabling the creation of personalized research environments, shared research and teaching spaces, and annotation trails, amongst other features. This will be facilitated by multilingual authority lists of named entities (people, places, events) that will harness

user involvement to add intelligence to the system. Moreover, it will develop new visual paradigms for the exploration of patterns generated by the system, from knowledge transfer and dissemination, to language usage and shifts, to the advancement and diffusion of ideas.

7.3.2. Major European Organizations with which you have followed Collaborations

Fraunhofer IGD: Fraunhofer Institute, IGD (DE)

We are collaborating on visual analytics, setting up European projects and coordinating European initiatives on the subject.

Jarke van Wijk: Eindhoven University of Technology, Department of Mathematics and Computer Science (NL)

We have been collaborating on the readability of visual links and we [23] and on the VisMaster European project.

7.4. International Initiatives

7.4.1. INRIA International Partners

INRIA researchers collaborate with a number of international partners, including:

- Google, Mountain View, USA
- Microsoft Research, Redmond, USA
- New York University, USA
- North Carolina State University, USA
- OCAD University, Toronto
- Purdue University, USA
- University of Calgary, Canada
- University of Eindhoven, The Netherlands
- University of Kaiserslautern, Germany
- University of Kent, UK
- University of Konstanz, Germany
- University of Magdeburg, Germany
- University of Manitoba, Canada

7.4.2. Visits of International Scientists

AVIZ is hosted the following international researchers for multi-week research stays:

- Pourang Irani (University of Manitoba, Canada)
- Nathaly Henry-Riche (Microsoft Research, USA)
- Claudio Silva (University of Utah / now New York University, USA)
- Juliana Freire (University of Utah / now New York University, USA)

AVIZ organized hosted the following international visitors for a one-day visit:

- Michael McGuffin (École de technologie supérieure, Canada)
- Catherine Plaisant (University of Maryland, USA)
- Georges Grinstein (University of Massachusetts Lowell, USA)
- Raimund Dachselt (University of Magdeburg, Germany)
- Koji Yatani (University of Toronto, Canada)

7.4.2.1. Internship

AVIZ is hosted the following international interns in 2011:

- Stefanie Klum (University of Magdeburg, Germany)
- Luana Micallef (University of Kent, UK)

8. Dissemination

8.1. Animation of the scientific community

AVIZ members are active in the Information Visualization, Visual Analytics, and HCI domain worldwide.

8.1.1. Keynotes and Invited Talks

- Jean-Daniel Fekete: *Advanced Interaction for Information Visualization*; SIGCHI Toulouse, France
- Jean-Daniel Fekete: *Advanced Interaction for Information Visualization*; Tufts CS Colloquium, USA
- Jean-Daniel Fekete: *Visualisation Exploratoire de réseaux sociaux : avancées récentes et défis*; Institut Farman, France
- Jean-Daniel Fekete: *Visualisation d'information et SHS*; Conférence-démo ENS Lyon, France
- Petra Isenberg: *Interactive and Collaborative Information Visualization*; University of Kaiserslautern, Germany
- Petra Isenberg: *New Contexts for Information Visualization*; University of Granada, Spain
- Petra Isenberg: *Moving Information Visualization Off the Desktop*; University of Konstanz, Germany
- Evelyne Lutton was invited speaker at the "Village des Sciences" 15 octobre 2011, Tournon-sur-Rhône, Ardèche.

8.1.2. Scientific Associations

- Jean-Daniel Fekete is the president of the French Speaking HCI Association 2009–2012
- Evelyne Lutton is the president of the EA steering committee (http://ea.inria.fr),
- Evelyne Lutton is founding member of the « Task Force on Evolutionary Computer Vision and Image Processing » within the IEEE CIS Evolutionary Computation Technical Committee (ECTC),
- Evelyne Lutton is member of the french-WIE chapter,

8.1.3. Conference Organization

- Jean-Daniel Fekete is in the Steering Committee of IEEE InfoVis 2011–2018,
- Jean-Daniel Fekete was Conference Chair for IEEE InfoVis 2011,
- Jean-Daniel Fekete was Paper Co-Chair for IEEE PacificVis 2011,
- Jean-Daniel Fekete was member of the Conference Management Committee in charge of Data Analysis for ACM SIGCHI
- Petra Isenberg was Visualization in Other Venues Chair for IEEE VisWeek 2011,
- Petra Isenberg co-organized a workshop on data analysis for interactive surfaces at ACM ITS 2011,
- Evelyne Lutton was member of the organisation committee of IDEAS 2011 (Design, knowledge Engineering Applied to living complex Systems), Automn thematic school of the ISC-PIF.

8.1.4. Conference Program Committees

- Pierre Dragicevic was a member of the program committee for IEEE InfoVis 2011,
- Pierre Dragicevic was a member of the program committee for 3DUI 2011,
- Pierre Dragicevic was a member of the program committee for IHM 2011,
- Jean-Daniel Fekete was member of the program committee for ACM CHI 2012
- Jean-Daniel Fekete was member of the program committee for EuroVis 2011
- Jean-Daniel Fekete was member of the program committee for the UK Workshop on Visual analytics 2011
- Jean-Daniel Fekete was member of the program committee the JOBIM 2011
- Petra Isenberg was member of the program committee for IEEE InfoVis 2011,
- Petra Isenberg was member of the program committee for EG EuroVis 2011,
- Petra Isenberg was member of the program committee for EG EuroVA 2011,
- Petra Isenberg was member of the program committee for TAVA 2011,
- Petra Isenberg was member of the program committee for IVS 2011,
- Evelyne Lutton was member of the program committee of EuroGP2011,
- Evelyne Lutton was member of the program committee of EvoIASP2011,
- Evelyne Lutton was member of the program committee of GECCO2011,
- Evelyne Lutton was member of the program committee of CEC 2011,
- Evelyne Lutton was member of the program committee of NICSO 2011,
- Evelyne Lutton was member of the program committee of EA2011

8.1.5. Journal Editorial Board

- Pierre Dragicevic was co-Editor in Chief for the Journal d'Interaction Personne-System (JIPS),
- Jean-Daniel Fekete was Guest Editor of IEEE Computer Graphics and Applications on the special issue on "Visualization Applications and Design Studies"
- Jean-Daniel Fekete was associate editor of the IEEE Transactions on Visualization and Computer Graphics
- Jean-Daniel Fekete was associate editor of the International Journal of Human-Computer Studies
- Jean-Daniel Fekete was co-editor in chief of the "Journal d'Interaction Personne-Système" (JIPS) published by AFIHM

8.1.6. Conference Reviewing

3DUI IEEE Symposium on 3D User Interfaces: Pierre Dragicevic

CEC IEEE Congress on Evolutionary Computation: Evelyne Lutton

CHI ACM Conference on Human Factors in Computing Systems: Pierre Dragicevic, Jean-Daniel Fekete, Petra Isenberg

CSCW ACM Computer Supported Cooperative Work: Petra Isenberg

EA Artificial Evolution: Evelyne Lutton

EICS ACM SIGCHI Symposium on Engineering Interactive Computing Systems: Jean-Daniel Fekete

EuroGP European Conference on Genetic Programming: Evelyne Lutton

EuroVA Eurographics Symposium on Visual Analytics: Petra Isenberg

EuroVis Eurographics European Symposium on Visualization: Jean-Daniel Fekete, Petra Isenberg

EvoIASP Evolutionary Computation in Image Analysis and Signal Processing: Evelyne Lutton

EvoMusArt European Event on Evolutionary and Biologically Inspired Music, Sound, Art and Design: Evelyne Lutton

GECCO Genetic and Evolutionary Computation Conference: Evelyne Lutton

ICDE IEEE International Conference on Data Engineering: Jean-Daniel Fekete

IHM Interface Homme Machine IHM: Pierre Dragicevic

Interact Conference on Human-Computer Interaction: Petra Isenberg

InfoVis IEEE Conference on Information Visualization: Pierre Dragicevic, Petra Isenberg

ISVC International Symposium on Visual Computing: Petra Isenberg

ITS International Conference on Interactive Tabletops and Surfaces: Pierre Dragicevic, Petra Isenberg, Yvonne Jansen

NISCO Nature Inspired Cooperative Strategies for Optimization: Evelyne Lutton

PacificVis IEEE Pacific Visualization Symposium: Petra Isenberg

TAVA Theory and Applications of Visual Analytics: Petra Isenberg

UbiComp International Conference on Ubiquitous Computing: Pierre Dragicevic

UIST ACM Symposium on User Interface Software and Technology: Pierre Dragicevic, Yvonne Jansen

VAST IEEE Conference on Visual Analytics, Science, and Technology: Petra Isenberg

8.1.7. Journal Reviewing

DAMI Data Mining and Knowledge Discovery: Jean-Daniel Fekete

CG&A Computers and Graphics: Pierre Dragicevic

CGF Computer Graphics Forum: Petra Isenberg

GPEM Genetic Programming and Evolvable Machines: Evelyne Lutton

IJHCS International Journal of Human-Computer Studies: Pierre Dragicevic

IVS Information Visualization Journal: Petra Isenberg

JVLC Journal of Visual Languages and Computing: Petra Isenberg

TEC IEEE Transactions on Evolutionary Computation: Evelyne Lutton

TOCHI ACM Transactions on Computer-Human Interaction: Pierre Dragicevic

TVCG IEEE Transactions on Visualization and Computer Graphics: Pierre Dragicevic

8.1.8. Scientific Dissemination

- Nadia Boukhelifa, Jean-Daniel Fekete and Pierre Dragicevic animated a panel on visual perception at the Science Fair 2011
- Samuel Huron co-organized the “ACM SigCHI Paris Video Showcase” at Espace Pompidou, Paris

8.2. Teaching

Master (or equivalent) :

- « Artificial Evolution in Robot vision » , modules Robotic and IRV, at l’EFREI (engineering school, 2nd year, level M1) nov-déc 2010 (12h).
- Module “Artificial Evolution” of ENSTA (first year, level M1, 21h, taught by Evelyne Lutton).
- Module “Visualisation Interactive d’Information” of Univ. Paris-Sud (M2, 18h, taught by Pierre Dragicevic, Jean-Daniel Fekete and Petra Isenberg).

Doctorat (or equivalent) :

- Information Visualization: Making Data Understandable, 8 hours, University of Zurich, Switzerland (summer school course, taught by Petra Isenberg)
- IDEAS autumn thematic school of ISC-PIF, “Heuristic optimisation” (4h, taught by Evelyne Lutton).

PhD & HdR :

PhD : Wael Khemiri, *Data-intensive Interactive Workflows for Visual Analytics*, Université Paris-Sud 11, Dec. 12, 2011, Véronique Benzaken, Ioana Manolescu, Jean-Daniel Fekete.

PhD in progress: Benjamin Bach, *Collaborative Visualization of Large Web-based Linked Datasets*, 01/2011, Emmanuel Pietriga and Jean-Daniel Fekete

PhD in progress: Nicolas Heulot, *A Study of The Interactive Process of Visual Data Mining for Multidimensional Data*, 09/2010, Michael Aupetit and Jean-Daniel Fekete

PhD in progress: Samuel Huron, *Navigation and Annotation of Heterogeneous Time-Stamped Data*, 12/2010, Jean-Daniel Fekete and Vincent Puig

PhD in progress: Yvonne Jansen, *Tangible Information Visualization*, 12/2010, Pierre Dragicevic and Jean-Daniel Fekete

PhD in progress: Charles Perin, *Visualization and Collaborative Control of Massive Multi-Structured Temporal Data*, 10/2011, Frédéric Vernier and Jean-Daniel Fekete

9. Bibliography

Major publications by the team in recent years

[1] A. BEZERIANOS, F. CHEVALIER, P. DRAGICEVIC, N. ELMQVIST, J.-D. FEKETE. *GraphDice: A System for Exploring Multivariate Social Networks*, in "Computer Graphics Forum - Eurographics/IEEE-VGTC Symposium on Visualization 2010 (EuroVis 2010)", June 2010, vol. 10, n° 3, p. 863-872 [*DOI :* 10.1111/J.1467-8659.2009.01687.X], http://www.aviz.fr/graphdice/graphdice.pdf.

[2] A. BEZERIANOS, P. DRAGICEVIC, J.-D. FEKETE, J. BAE, B. WATSON. *GeneaQuilts: A System for Exploring Large Genealogies*, in "IEEE Transactions on Visualization and Computer Graphics", Nov-Dec 2010, vol. 16, n° 6, p. 1073–1081, http://doi.ieeecomputersociety.org/10.1109/TVCG.2010.159.

[3] F. CHEVALIER, P. DRAGICEVIC, A. BEZERIANOS, J.-D. FEKETE. *Using Text Animated Transitions to Support Navigation in Document Histories*, in "CHI '10: Proceedings of the 28th international conference on Human factors in computing systems", New York, NY, USA, ACM, 2010, p. 683–692 [*DOI :* 10.1145/1753326.1753427], http://www.aviz.fr/diffamation/diffamation-CHI2010.pdf.

[4] N. ELMQVIST, P. DRAGICEVIC, J.-D. FEKETE. *Rolling the Dice: Multidimensional Visual Exploration using Scatterplot Matrix Navigation*, in "IEEE Transactions on Visualization and Computer Graphics", 2008, vol. 14, n° 6, p. 1141-1148, (Best Paper Award), http://doi.ieeecomputersociety.org/10.1109/TVCG.2008.153.

[5] J.-D. FEKETE. *The InfoVis Toolkit*, in "Proceedings of the 10th IEEE Symposium on Information Visualization (InfoVis 04)", Austin, TX, IEEE Press, October 2004, p. 167-174, http://www.lri.fr/~fekete/ps/ivtk-04.pdf.

[6] N. HENRY-RICHE, J.-D. FEKETE, M. J. MCGUFFIN. *NodeTrix: a Hybrid Visualization of Social Networks*, in "IEEE Transactions on Visualization and Computer Graphics", 2007, vol. 13, n° 6, p. 1302-1309, http://doi.ieeecomputersociety.org/10.1109/TVCG.2007.70582.

[7] C. PLAISANT, J.-D. FEKETE, G. GRINSTEIN. *Promoting Insight-Based Evaluation of Visualizations: From Contest to Benchmark Repository*, in "IEEE Transactions on Visualization and Computer Graphics", 2008, vol. 14, n° 1, p. 120–134, http://doi.ieeecomputersociety.org/10.1109/TVCG.2007.70412.

Publications of the year

Doctoral Dissertations and Habilitation Theses

[8] W. KHEMIRI. *Data-intensive interactive workflows for visual analytics*, Université Paris-Sud 11, December 2011.

Articles in International Peer-Reviewed Journal

[9] O. CHAPUIS, P. DRAGICEVIC. *Effects of Motor Scale, Visual Scale and Quantization on Small Target Acquisition Difficulty*, in "ACM Transactions on Computer-Human Interaction", July 2011, vol. 18, n° 3, p. 13:1–13:32, http://dx.doi.org/10.1145/1993060.1993063.

[10] N. ELMQVIST, P. DRAGICEVIC, J.-D. FEKETE. *Color Lens: Adaptive Color Scale Optimization for Visual Exploration*, in "IEEE Transactions on Visualization and Computer Graphics", 2011, vol. 17, n° 6, p. 795-807, http://doi.ieeecomputersociety.org/10.1109/TVCG.2010.94.

[11] P. ISENBERG, A. BEZERIANOS, P. DRAGICEVIC, J.-D. FEKETE. *A Study on Dual-Scale Data Charts*, in "Transactions on Visualization and Computer Graphics", December 2011, vol. 17, n° 12, p. 2469–2478, http://dx.doi.org/10.1109/TVCG.2011.238.

[12] P. ISENBERG, N. ELMQVIST, J. SCHOLTZ, D. CERNEA, K.-L. MA, H. HAGEN. *Collaborative Visualization: Definition, Challenges, and Research Agenda*, in "Information Visualization Journal (IVS), Special Issue on Information Visualization: State of the Field and New Research Directions", October 2011, vol. 10, n° 4, p. 310–326, http://dx.doi.org/10.1177/1473871611412817.

[13] P. ISENBERG, D. FISHER, S. A. PAUL, M. RINGEL MORRIS, K. INKPEN, M. CZERWINSKI. *Collaborative Visual Analytics Around a Tabletop Display*, in "IEEE Transactions on Visualization and Computer Graphics", 2011, To appear.

[14] M. SEDLMAIR, P. ISENBERG, D. BAUR, A. BUTZ. *Information Visualization Evaluation in Large Companies: Challenges, Experiences and Recommendations*, in "Information Visualization Journal", July 2011, vol. 10, n° 3, p. 248–266, http://dx.doi.org/10.1177/1473871611413099.

[15] L. TRUJILLO, G. OLAGUE, É. LUTTON, F. FERNÁNDEZ DE VEGA, L. DOZAL, E. CLEMENTE. *Speciation in Behavioral Space for Evolutionary Robotics*, in "Journal of Intelligent & Robotic Systems", 2011, p. 1-29, http://dx.doi.org/10.1007/s10846-011-9542-z.

[16] T. VON LANDESBERGER, A. KUIJPER, T. SCHRECK, J. KOHLHAMMER, J. J. VAN WIJK, J.-D. FEKETE, D. W. FELLNER. *Visual Analysis of Large Graphs: State-of-the-Art and Future Research Challenges*, in "Computer Graphics Forum", 2011, vol. 30, n° 6, p. 1719-1749, http://dx.doi.org/10.1111/j.1467-8659.2011.01898.x.

Invited Conferences

[17] G. DI BATTISTA, J.-D. FEKETE, H. QU. *Preface*, in "Proceedings of the Pacific Visualization Symposium", G. D. BATTISTA, J.-D. FEKETE, H. QU (editors), IEEE, March 2011, http://dx.doi.org/10.1109/PACIFICVIS.2011.5742360.

International Conferences with Proceedings

[18] V. BENZAKEN, J.-D. FEKETE, P.-L. HÉMERY, W. KHEMIRI, I. MANOLESCU. *EdiFlow: data-intensive interactive workflows for visual analytics*, in "International conference on Data Engineering", Hannover, Germany, IEEE, April 2011, http://hal.inria.fr/inria-00532552/en.

[19] P. DRAGICEVIC, A. BEZERIANOS, W. JAVED, N. ELMQVIST, J.-D. FEKETE. *Temporal Distortion for Animated Transitions*, in "Proceedings of the Conference on Human Factors in Computing Systems (CHI)", Vancouver, Canada, ACM, May 2011, http://hal.inria.fr/inria-00556177/en.

[20] P. DRAGICEVIC, S. HUOT, F. CHEVALIER. *Gliimpse: Animating from Markup Code to Rendered Documents and Vice-Versa*, in "Proceedings of the Symposium on User Interface Software and Technology (UIST)", New York, NY, USA, UIST, ACM, 2011, p. 257–262, http://doi.acm.org/10.1145/2047196.2047229.

[21] J.-D. FEKETE, P.-L. HÉMERY, T. BAUDEL, J. WOOD. *Obvious: A Meta-Toolkit to Encapsulate Information Visualization Toolkits — One Toolkit to Bind Them All*, in "Visual Analytics Science and Technology (VAST), 2011 IEEE Symposium on", Los Alamitos, CA, USA, IEEE Computer Society, 2011, p. 89–98, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6102446.

[22] J.-D. FEKETE, W. KHEMIRI, I. MANOLESCU, V. BENZAKEN. *Provenance Management in the EdiFlow VA Workflow*, in "CHI Workshop on Analytic Provenance: Process+Interaction+Insight", Held in conjunction with the ACM Conference on Human Factors in Computing Systems (CHI), Vancouver, Canada, 2011.

[23] D. HOLTEN, P. ISENBERG, J. VAN WIJK, J.-D. FEKETE. *An Extended Evaluation of the Readability of Tapered, Animated, and Textured Directed-Edge Representations in Node-Link Graphs*, in "Pacific Visualization Symposium (PacificVis), 2011 IEEE", Hong Kong, China, IEEE Press, March 2011, 8, http://hal.inria.fr/inria-00548180/en.

[24] S. HUOT, O. CHAPUIS, P. DRAGICEVIC. *TorusDesktop: Pointing via the Backdoor is Sometimes Shorter*, in "Proceedings of the Conference on Human Factors and Computing Systems (CHI)", Vancouver, Canada, May 2011, p. 829–838 [*DOI :* 10.1145/1978942.1979064], http://hal.inria.fr/hal-00559194/en.

[25] P. ISENBERG, D. FISHER. *Cambiera: Visual Analytics on the Surface*, in "Videos of the ACM Conference on Computer Supported Cooperative Work (CSCW)", New York, NY, USA, ACM Press, 2011, http://www.aviz.fr/~isenberg/publications/papers/Isenberg_2011_CVA.pdf.

[26] P. ISENBERG, D. FISHER. *Pairgrams: Understanding Collaborative Analysis Behavior with Visualization*, in "CHI Workshop on Analytic Provenance: Process+Interaction+Insight", Held in conjunction with the ACM Conference on Human Factors in Computing Systems (CHI), Vancouver, Canada, 2011, http://www.aviz.fr/~isenberg/publications/papers/Isenberg_2011_PUC.pdf.

[27] É. LUTTON, J.-D. FEKETE. *Visual analytics of EA data*, in "Proceedings of the 13th Annual Conference Companion on Genetic and Evolutionary Computation", New York, NY, USA, GECCO '11, ACM, 2011, p. 145–146, http://doi.acm.org/10.1145/2001858.2001940.

[28] É. LUTTON, J. FOUCQUIER, N. PERROT, J. LOUCHET, J.-D. FEKETE. *Visual Analysis of population scatterplots*, in "10th Biannual International Conference on Artificial Evolution (EA-2011)", Angers, France, 2011, http://evelyne.lutton.free.fr/Papers/LuttonEA2011.pdf.

[29] M. SEDLMAIR, P. ISENBERG, D. BAUR, M. MAUERER, C. PIGORSCH, A. BUTZ. *Cardiogram: Visual Analytics for Automotive Engineers*, in "Proceedings of Conference on Human Factors in Computing Systems (CHI)", ACM Press, 2011, p. 1727–1736, http://dx.doi.org/10.1145/1978942.1979194.

[30] A. TONDA, É. LUTTON, G. SQUILLERO. *Lamps : A Test Problem for Cooperative Coevolution*, in "NICSO 2011, the 5th International Workshop on Nature Inspired Cooperative Strategies for Optimization", Cluj Napoca, Romania, October 20-22 2011, http://evelyne.lutton.free.fr/Papers/TondaNICSO2011.pdf.

Books or Proceedings Editing

[31] G. D. BATTISTA, J.-D. FEKETE, H. QU (editors). *Pacific Visualization Symposium (PacificVis), 2011 IEEE*, IEEE, March 2011, http://dx.doi.org/10.1109/PACIFICVIS.2011.5742360.

Research Reports

[32] M. HASCOËT, P. DRAGICEVIC. *Visual Comparison of Document Collections Using Multi-Layered Graphs*, Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier (LIRMM), June 2011, http://hal.inria.fr/lirmm-00601851/en.

[33] H. LAM, E. BERTINI, P. ISENBERG, C. PLAISANT, S. CARPENDALE. *Seven Guiding Scenarios for Information Visualization Evaluation*, Department of Computer Science, University of Calgary, Calgary, AB, Canada, January 2011, n^{o} 2011-992-04, http://www.aviz.fr/~isenberg/publications/papers/Lam_2011_SGS.pdf.

[34] É. LUTTON, J.-D. FEKETE. *Visual analytics and experimental analysis of evolutionary algorithms*, INRIA, April 2011, n^{o} RR-7605, http://hal.inria.fr/inria-00587170/en.

References in notes

[35] S. K. CARD, J. D. MACKINLAY, B. SHNEIDERMAN (editors). *Readings in information visualization: using vision to think*, Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1999.

[36] J. BERTIN. *Sémiologie graphique : Les diagrammes - Les réseaux - Les cartes*, Les réimpressions, Editions de l'Ecole des Hautes Etudes en Sciences, Paris, France, 1967.

[37] A. BEZERIANOS, P. DRAGICEVIC, R. BALAKRISHNAN. *Mnemonic rendering: an image-based approach for exposing hidden changes in dynamic displays*, in "UIST '06: Proceedings of the 19th annual ACM symposium on User interface software and technology", New York, NY, USA, ACM, 2006, p. 159–168, http://doi.acm.org/10.1145/1166253.1166279.

[38] J.-D. FEKETE, C. PLAISANT. *Interactive Information Visualization of a Million Items*, in "Proc. IEEE Symposium on Information Visualization 2002 (InfoVis 2002)", Boston, USA, IEEE Press, October 2002, p. 117-124.

[39] J.-D. FEKETE, C. PLAISANT. *Les leçons tirées des deux compétitions de visualisation d'information*, in "Proceedings of IHM 2004", Namur, Belgium, International Conference Proceedings Series, ACM Press, September 2004, p. 7-12.

[40] J. J. GIBSON. *The Ecological Approach to Visual Perception*, Lawrence Erlbaum Associates, New Jersey, USA, 1979.

[41] Y. GUIARD, Y. DU, J.-D. FEKETE, M. BEAUDOUIN-LAFON, C. APPERT, O. CHAPUIS. *Shakespeare's Complete Works as a Benchmark for Evaluating Multiscale Document-Navigation Techniques*, in "Proceedings of BEyond time and errors: novel evaLuation methods for Information Visualization (BELIV'06)", Venice, Italy, ACM Press, May 2006, p. 65-70.

[42] N. HENRY-RICHE, J.-D. FEKETE. *Evaluating Visual Table Data Understanding*, in "Proceedings of BEyond time and errors: novel evaLuation methods for Information Visualization (BELIV'06)", Venice, Italy, ACM Press, May 2006, 6 pages, to be publised.

[43] B. LEE, C. PLAISANT, C. SIMS PARR, J.-D. FEKETE, N. HENRY-RICHE. *Task taxonomy for graph visualization*, in "BELIV '06: Proceedings of the 2006 AVI workshop on BEyond time and errors", New York, NY, USA, ACM, 2006, p. 1–5, http://doi.acm.org/10.1145/1168149.1168168.

[44] S. S. STEVENS. *Psychophysics: Introduction to Its Perceptual, Neural, and Social Prospects*, Transction Publishers, 1986.

[45] A. TRIESMAN. *Preattentive Processing in Vision*, in "Computer Vision, Graphics, and Image Processing", August 1985, vol. 31, n^{o} 2, p. 156-177.

[46] E. TUFTE. *The Visual Display of Quantitative Information*, Graphics Press, 1983.

[47] J. W. TUKEY. *Exploratory Data Analysis*, Addison-Wesley, 1977.