Interact 2011 Workshop WS3

Building Bridges – HCI and Visualization

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Achim Ebert[1], Gitta Domik[2], Nahum Gershon[3], Gerrit van der Veer[4]

[1] University of Kaiserslautern, Gottlieb-Daimler-Strasse, 67663 Kaiserslautern, Germany, ebert@cs.uni-kl.de
[2] University of Paderborn, Fürstenallee 11, 33102 Germany, domik@uni-paderborn.de
[3] The MITRE Corp., 7515 Colshire Drive, McLean, VA 22102-7508, USA, gershon@mitre.org
[4] Open University the Netherlands, Valkenburgerweg 177, 6419 AT Heerlen, The Netherlands, gerrit@acm.org

Abstract. The fields, HCI and visualization, are usually practiced as two separate disciplines by researchers with different backgrounds and capabilities. However, these two disciplines, HCI and visualization, could complement each other and leveraging on the differences and complementary features of the two research fields could be beneficial for both. In this workshop, we are going to discuss the different approaches and capabilities of these two disciplines and we will layout a road map for a unified approach of research using both.

Keywords: HCI, Visualization, Standardization.

1 Workshop objectives

Whenever discussing the relation between HCI and visualization in general or when presenting research results in these areas, questions arise about the differences between these research fields. Aren't both fields just the same? And if not, where is the common ground? Can we combine the separated viewpoints and paradigms in a unified and complementary approach, or are we forced to choose one or the other? How can we provide the general public (the developers and users of visualization and HCI and the engineers implementing our designs) a precise and practical enough idea about what's happening in these fields and what's not? What are the consequences of the answers on the previous: how and what should we teach? What will be the future? This dilemma is a topic of frequent discussion around the water cooler, in lecture halls, as well as in the board room.

One of the major issues is that it is not easy to precisely define the terms visualization and HCI and that there are many interpretations of these two fields that appear to be distinct.

ACM SIGCHI tries to give people a working definition for HCI: "Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them." [1] However, at the same time the applicability of this definition is significantly limited by adding that it "at least permits us to get down to the practical work of deciding what is to be taught".

Similar imprecise descriptions can be found for visualization. One possibility is the classical definition given by ACM SIGGRAPH: "visualization is […] the formation of mental visual images, the act or process of interpreting in visual terms or of putting into visual form" [2], though the visualization subcommittee of the SIGGRAPH Education Committee in 1997 provided an alternative: "a computer generated image or collection of images, possibly ordered, using a computer representation of data as its primary source and a human as its primary target" [3]. Foley [4], in 1994, states "A useful definition of visualization might be the binding (or mapping) of data to a representation that can be perceived. The types of binding could be visual, auditory, tactile, etc. or a combination of these". Kosara [5] tries to better conceptualize the term visualization by defining some criteria forming a minimal set of requirements for any visualization: "visualization is based on (non-visual) data, produces an image, and results in a readable and recognizable output". Finally, some definitions are approaching the concept from the point of view of computing: "Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science" [6].

As already mentioned, questioning similarities, differences, and correlations of HCI and Visualization forms an important part of our daily work life. In order to better (or at all) answer these questions, in our workshop we want to discuss topics like:

- What is HCI? What is Visualization? What is a working description that is practical highlighting the special features of each of the fields?
- Are there other disciplines involved in this struggle (e.g., Visual Analytics)?
- How can we take advantage of the two fields and how can we find ways for people with different inclinations to collaborate and take advantage of the strengths of each other?
- What are the similarities of the disciplines? What are the major differences?
- Do we need to really split the domains? Or do we need to join them and provide a joint curriculum for studying and practicing them?
- Can we give definitions that are better applicable in real situations?
- Does one need to further research the ways to make people take advantage of both disciplines in designing interactive visual systems? In that case, what are the research agenda(s) and what are the Top 10 Research Challenges?

3 Key organizers

The team of organizers is comprised of representatives of both university and industry, giving them a wide multi-disciplinary expertise. They all have significant experience in the main disciplines (HCI and visualization), as well as in related areas and application domains.

Some of the organizers have already worked together in many workshops of the HCIV series [7]. HCIV is a major program in Human Computer Interaction and Visualization. The aim of that initiative was to establish a study and research program that combines the knowledge of both science and practice in the fields of HCI and Visualization. One of the main steps in organizing that program was a workshop series with world-renowned experts in both fields as well as in application domains. The gained expertise and large number of members will be of a great value for successfully advertising this workshop.

Achim Ebert is professor and co-chair of the Computer Graphics & HCI lab at the University of Kaiserslautern. His research topics include information visualization, immersive scenarios, and human-computer interaction. His current research focuses on the efficient usage of large displays and the application of new device technologies in HCI. Achim is a member of the IFIP Technical Committee on Human-Computer Interaction and is chairing the IFIP Working Group WG 13.7 on "HCI & Visualization" [7].

Gitta Domik is professor of "Computer Graphics, Visualization and Image Processing" at the Institute of Computer Science, University of Paderborn, Germany. She is the sub chair for visualization at the SIGGRAPH Education Committee and member of the Editorial Board at IEEE Computer Graphics and Applications. Her current research interests are in volume visualization of medical data, controlled experiments to measure the benefit of visualizations, Serious Games, and transdisciplinary education. She is a member of IEEE and ACM.

Nahum Gershon works on combining creative expressions like storytelling, film, social media, and visual and interactive design with when appropriate. Nahum is a Senior Principle Scientist at the MITRE Corporation where he focuses on research and practical applications of presentation and visualization of data and information, as it relates to perception, society, storytelling, culture, and new media (social, mobile, real time, community organizing). In his free time, Nahum, among other things, participates in a number of national and international committees.

Gerrit van der Veer moved from cognitive psychology, through cognitive ergonomics, to user centered interaction design. Currently he is a professor of human-computer Interaction at the Dutch Open University, School of Computer Science and a professor of interaction design at the Faculty of Architecture, University of Sassari, Italy. His research is on task modeling for internet-based service design. He is a member of IEEE Computer Society, of the European Association of Cognitive Ergonomics, IFIP WG 13.7, and of ACM SIGCHI.

3 Targeted audience

We welcome participants from various backgrounds interested in research and application of HCI and visualization, including designers, artists, researchers in visualization, interaction, psychology, and usability, and people from all application fields.

4 Workshop organization and duration

Attendees submitted open position papers from their own areas of interest and provided short answers to two pro forma questions asking for (i) the participant's views on the most important existing knowledge in the area, including a position statement on possible definitions, and (ii) key research challenges related to HCI and Visualization issues. These will form a start point for open-discussions during the workshop.

The first half of this one-day workshop will include:

- Introduction of the issues that are relevant for this workshop and overview of planned schedule (given by the session organizers)
- Short self-introductions of participants
- Short talks of selected attendees

After lunch, we intend to break into groups to brainstorm about common ground, definitions, research agenda, and top 10 research questions.

Back into a plenary session we will schedule:

- Short presentations of the group results
- Comparing and merging the results
- Discussions: Lessons learned? Next steps?

After the workshop, all minuted results will be transferred into a summarizing report that will particularly include a first version of a research and development agenda.

5 Expected outcomes

Beside the position papers submitted by the workshop attendances, we will use the already existing HCIV web domain [7] as a starting point for future actions. In parallel to this more or less just informatory media we will start an interactive blog in order to continue the discussions of the workshop. For a better visibility of our actions and progresses made, we will also distribute and discuss those using social media like Facebook groups and Twitter. Furthermore, the results of the discussions should form common ground for at least one high-quality conference or journal paper.

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Teaching Information Visualization: Boltzmann or Brunel?

Bob Spence

Imperial College London, Department of Electrical and Electronic Engineering, Exhibition Road, London SW7 2BT, UK, r.spence@imperial.ac.uk

Abstract. The importance of Information Visualization is reflected in the many courses on that subject taught worldwide. The number of those courses, however, is not of prime importance: what is of real concern is *how* they are presented, and to *whom*.

Students

It is my view that education in information visualization is required primarily by two groups of people: those who will become interaction designers and those who will, at some time in their careers, either commission systems with a significant element of visualization or be responsible for evaluating such systems. I happen to teach both types of student: post-Master professional designers at the Technical University of Eindhoven in the Netherlands and first year undergraduates in Information Systems Engineering at Imperial College London.

Theory or Practice

It is my strong belief that the best way to become educated in Information Visualization (and HCI in general) is to *do it*. For that reason my condition for presenting those courses is that there be no examination paper, favouring as it does those with photographic memories rather than those whose creativity and design ability we wish to stimulate. Instead I ask my students to undertake design exercises (mostly individually and once as a group) and one design critique. I want to develop creativity and the ability to make design decisions, not merely encourage the memorisation of facts.

Teaching Environment

The *environment* of my teaching of Information Visualization is of great importance to me. I strive for – and largely achieve – a 'studio' environment, first to approximate that of a real design house and, second, to avoid the traditional ‘me and them’ attitude: I certainly learn from the course as well as teach it. For example, in keeping with a studio environment I ensure that students paste their early designs on a wall, provide a one minute explanation and then for two minutes respond to questions from anyone who cares to ask them. They thereby receive instant and valuable feedback. Sketching on large sheets of paper with thick pens is encouraged to capture design ideas in the early exploration and design stages: the use of laptops at this stage is frowned upon and virtually forbidden.

Content

My emphasis on *design* (the Brunel of my title) is not at odds with a concern with theory (the Boltzmann of my title), though it is theory to *support design* rather than for its own sake that is my concern. However, difficult decisions must be made about the *content* of a course on Information Visualization: what theory is relevant and the appropriate mix of theory and design. One decision I found easy to make – the need for clear definitions.

Definitions

A student would surely be surprised, and disappointed in their teacher, if that teacher cannot provide precise definitions for important concepts. My first concern is to provide definitions where possible, even if they may be contentious. For example, the definition of information visualization I have always used is not shared by most leaders in the field: I refer to two respected dictionaries for the following definition:

> **visualization** (v): the formation of a mental model of something.

with the implication that visualization is a cognitive activity of a human being and has nothing fundamentally to do with computers. I am pleased that recent publications are recognising the importance of this definition, instead of taking the attitude that the letters v-i-s-u-a-l in the term visualization implies that data can only be encoded graphically. My attitude may seem pedantic, but if we forget what the user is trying to achieve we tread a dangerous path.

Examples

In view of the paucity of relevant theory, Information Visualization is largely taught by a critical review of illustrative examples and the discussion of concepts. For example, a student undertaking their first design of a representation (the marks out of ten in 8 subjects taken by 5 students) may be informed by Bertin’s work and the concepts of object and attribute visibility, but will find that there is no ‘algorithm’ guaranteed to lead to the ‘best’ design (there simply isn’t one) and that a design’s effectiveness depends upon the ultimate user(s) of the representation.

The human user

Information Visualization as a discipline acquired a very bad name in its early years by the preponderance of displays that took no account whatsoever of the human user: they were often primarily exercises in programming. I therefore lay considerable stress on the characteristics of the human user, initially by providing actual – and to my students surprising – examples of phenomena such as Change Blindness, Attention Blindness and Preattentive Processing, but these topics are introduced in context rather than being taught within a separate set of lectures. Similarly, I emphasise the importance of considering the human user by ensuring that the first stage of an interaction design (the final group project) is a careful consideration of who the user is and what their goal and *modus operandi* are. Some students are not aware of the need for this first step and immediately propose, in detail, their 'final' design.

Restrictions

Occasionally the result of a student project identifies an omission in the teaching of Information Visualization. For example, in response to an exercise asking for a proposal for a new kind of family tree – a task normally interpreted as requiring a visual display – one group of students proposed a family tree made of wood. That tree had embedded communication facilities such that a family member in one part of the world could easily maintain social contact with another member located many miles away, perhaps with a simple touch and the utterance "Hi Gran!" Examples such as these are a reminder that a (perhaps unconscious) emphasis on computers needs to be guarded against.

Visualization and HCI: Body of Knowledge

Gitta Domik
University of Paderborn, Germany
domik@upb.de

Abstract. To build bridges between HCI and visualization we have to understand the body of knowledge comprising each field to find overlaps and connections.

Keywords: Visualization, Scientific Visualization, Information Visualization, Visual Analytics, HCI.

1 Extended Abstract

Computer-Generated Visualization: In the mid 1980's, data rates increased enormously due to new supercomputing centers and measuring devices, e.g. of space missions. To support data analysis with the "human-in-the-loop", NSF sponsored a workshop which resulted in recommendations to research communities to develop new concepts and techniques for "Visualization in Scientific Computing" [1]. The report defined this new scientific area as "Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science".

In the mid 1990's, the ACM SIGGRAPH Education committee developed eight core topics (themes) as a basis to teach Visualization [2]: (1) Introduction to Visualization (including definitions, history, distinction of various characteristics of visualization, such as scientific visualization, information visualization, software visualization); (2) The Data (including data generated from mathematical models or computations and from human and machine collections); (3) The User and the Visualization Tasks; (4) Mapping (from data characteristics to visual attributes); (5) Visual Representation Techniques; (6) Interaction issues; (7) Concepts of the Visualization Process; and (8) Systems and Tools supporting the visualization process. Visualization was defined as "a computer generated image or collection of images, possibly ordered, using a computer representation of data as its primary source and a human as its primary target."

Since then, visualization has matured in many ways: first and foremost, it has matured to the point of being able (to some extent) to evaluate the quality of the outcome of the visualization process: effectiveness and expressiveness of visual presentations are being measured by the specific visualization task that drives the visualization process. The power of interactive systems has increased due to new technology, and Visual Analytics, “the science of analytical reasoning facilitated by interactive visual interfaces”, expanded visualization processes to support human judgment to make the best possible use of collections of data to fend off danger to the US in the battle against terrorism.

Thus the core topics of visualization are in need of an update to include “evaluation” and “analytical reasoning” and emphasize interactivity.

Human-Computer Interaction: The body of knowledge of HCI is best described in the IEEE and ACM Computer Science Curricula. Using the update of 2008 [4], the following knowledge units comprise a full knowledge of HCI: (1) Foundations; (2) Building GUI Interfaces; (3) User Centered Software Evaluation; (4) User Centered Software Development; (5) GUI Design; (6) GUI Programming; (7) Multimedia and Multimodal Systems; (8) Collaboration and Communication; (9) Interaction Design For New Environments; (10) Human Factors and Security. Searching for detailed descriptions in [2] and [4], we find strong correspondence between units HCI-(3), HCI-(5), HCI-(7) and HCI-(9) to units Vis-(3), Vis-(4), and Vis-(6).

The Body of Knowledge of Computer Science is described by 14 knowledge areas, of which HCI is one [4]. Another knowledge area is “Graphics and Visual Computing”, including “Visualization” as a knowledge unit. This unit relates to (only) Vis-(5) of above curriculum recommendation.

Further knowledge units needed for Visualization or Visual Analytics can be found in the knowledge areas of Intelligent Systems (“Machine Learning” for Visual Analytics and “Perceptions” for both Visualization and Visual Analytics), and in the knowledge area of Information Management (unit “Data Mining” for Visual Analytics).

Therefore both Visualization and Visual Analytics (closely related but not the same) heavily rely on knowledge from the HCI department. This is rightly so: the quality of products derived from visualization and visual analytics processes are closely dependent on abilities and disabilities of users. User and task are equally important to the methods and algorithms used in the processes. Foley [5] even suggests “Visual analytics, to my mind, is a specialized HCI domain”, which could be also true for Visualization.

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The Role of Design in Visualization and HCI

Andrew Vande Moere[1] and Martin Tomitsch[2]

[1] Design Lab, Department of Architecture, Urbanism & Planning, K.U.Leuven, Belgium
[2] Design Lab, Faculty of Architecture, Design & Planning, University of Sydney, Australia
andrew.vandemoere@asro.kuleuven.be, martin.tomisch@sydney.edu.au

Abstract. In this position paper, we propose that HCI has the affinity to appreciate the role of design in visualization, and has the expertise to investigate valuable design-related aspects in visualization without the direct aim to optimize the performance of data analytical tasks.

As data is becoming more complex in terms of size, dimensionality and time-dependency, the visualization field has been challenged to create ever more sophisticated techniques, in addition to evaluative methods that are able to benchmark these techniques against each other. Because of its strong historical roots in scientific reasoning, the field has mainly focused on optimizing complex data exploration and analysis tasks, so that the relevance whether a visualization should be designed to be attractive, engaging or enjoyable to use, has been largely neglected. Instead, inspired by Norman's famous mantra "*attractive things work better*" [1], most research endeavors in the context of visualization and user experience – a subfield of HCI – have typically focused on discovering the specific properties that make a visual representation more appealing or memorable, with the general aim to exploit such features to make future visualizations even more task-effective.

In recent years, the increasing popularity of software development skills and the public accessibility of data has had a significant effect on the visualization practice, as an increasing number of journalists, designers and artists are applying visualization principles as communicative and even artistic means of expression [2]. As a result, the graphical representation of complex data is now reaching beyond the skilled and experienced data experts, and has started to impact the everyday life of a large, lay audience. Instead of facilitating predefined tasks, these more ambiguous though equivocal visualizations typically allow non-expert users to reach open-ended, reflective insights based on data that has some sort of personal or social relevance [3].

In this context, we propose that HCI should not only focus on how such visualizations might "*work better*" in terms of executing high-level tasks, but also should take into account that they essentially might "*work differently*". Motivated by the belief that subjective aspects such as visual style, contemplation and joy are useful beyond increasing performance measures, and inspired by the hypothesis that such 'casual' visualizations "*… provide other kinds of insight that complement … [analytical insights]*" [3], we propose to discover and measure what these "*other kinds*" of insight consist of, and what their value could be for real-world applications.

The field of HCI is an ideal candidate for discovering this potential value of 'popular' visualization, for its extensive experience with design thinking, which exists next to well-established research in task optimization. For instance, in visualization, all methods should lead to the most efficient and effective way of representing data (and nothing more). But in interaction design, it is now at least accepted to propose that "*aesthetics [is] an integral part of functionality, with pleasure a criterion for design equal to efficiency or usability*" [4], that one can develop for activities that are "*motivated by curiosity, exploration, and reflection rather than externally defined tasks*" [5], or that design can help us create solutions that inspire us to be smarter, more curious, and more inquisitive, rather than simply solving complex problems [6]. HCI makes the explicit distinction between pragmatic attributes, which relate to the utility and usability of an interface, and hedonic attributes, which relate to psychological well-being (the affective state) [7]: the perceived beauty of an interface relates to its hedonic attributes, while the perceived goodness depends on both hedonic and pragmatic qualities. Accordingly, while a less 'effective' but more 'enjoyable' visualization might perform significantly worse in discovering or communicating insights that relate to data trends and patterns, it might be (significantly) better in conveying meaningful connotations associated to the driving principles behind the same data phenomena. As the open and free access of data, statistics and facts is becoming increasingly important in our society, we believe both aspects are worthwhile for rigorous scientific investigation.

The field of visualization today consists not only of scientific *research*, but also enjoys an active *practice* (ranging from large data analytical firms, to individual free-lance 'infographic' designers) as well as a lively *avant-garde* (ranging from self-initiated projects that attempt to innovate, to more artistic provocations) [8]. Visualization can benefit by crossing these traditional boundaries and actively considering the opinions, perspectives or findings of other communities. As its typical application domain is particularly broad and inherently multidisciplinary, the matter of the popularization and rising uptake of visualization should be a continuous and active concern.

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How to Investigate Interaction with Information Visualization – an Overview of Methodologies

Margit Pohl[1], Sylvia Wiltner[1]
[1]Institute for Design and Assessment of Technology, Vienna University of Technology
margit@igw.tuwien.ac.at, s.wiltner@aon.at

Extended Abstract

1 Introduction

Zhicheng Liu et al. [2] point out that it is necessary to investigate the relationship between external and internal representations to get a more comprehensive overview of how users interact with information visualisations. So far, the analysis of internal representations (e.g. mental models) is the domain of cognitive psychology, and the analysis of external representations (visualisation tools) the domain of the discipline of information visualisation. How these two are related is still not well understood. Analysis of user interactions may yield interesting insights to clarify this issue.

To analyse the relationships between user and information visualisation tool in detail, interaction processes have to be studied more extensively. Most evaluation studies described in the literature report results only on a very general level (e.g. measure time to fulfil tasks, number of errors). This can yield important insights, but it is not sufficient to describe interaction processes in a comprehensive manner. When explaining the usefulness of a certain information visualisation tool, we may, for example want to know which strategies users adopt to solve a given task. Such strategies might be described as a sequence of specific activities (activities might be: find value, compare, identify cluster). If such strategies are adopted by a large number of users, they should probably be supported by information visualisation tools specifically. In addition, such strategies can give some insight into the thought processes of the user.

It should be pointed out that it is comparatively easy to analyse overt activities of the users. It is much more difficult to derive an understanding of the users' internal representations and thought processes.

2 Logfiles, Thinking Aloud, Eye-Tracking, Analysis of Results/ Artefacts

Several different methods can be adopted to analyse interactive behaviour. We discuss logfiles, thinking aloud, eye-tracking and analysis of results/artefacts. There are other relevant methodologies, but this discussion can only cover a few.

Logfiles can give insights into the users' actual behaviour at a detailed level. We get information about low-level activities, but interpretation is difficult. We often cannot derive from logfiles what users really had in mind when doing something. A combination with thinking aloud can give important insights about the users' intentions and help to interpret the activities. In addition, not all the users' activities are made on purpose. Scrolling or moving the mouse across the screen might be a desultory action leading to biased results.

Thinking aloud [1] has been discussed extensively and is a valuable methodology in the context of analysing information visualisation. It can yield information about the users' thought processes and mental models. Nevertheless, it has been criticized because it can interfere with demanding cognitive tasks. In addition, it can be argued that subjects often cannot describe their motives or activities. Combining it with screen capture can give some information when thought processes occur and give some indication concerning the content and organisation of users' thought processes.

Eye-tracking provides us with information about the users' focus of attention and the sequence in which users look at different areas of interest on the screen. Insights can be derived concerning the attention or interest of users, but it is sometimes problematic to interpret the data. If users look at a specific area of the screen fairly long this might indicate that this area is especially pleasing, but also that it is difficult to understand. In addition, the interpretation of gaze paths is sometimes difficult, because it is not entirely clear what such a path means from a cognitive point of view.

Analysis of results/artefacts: In complex problem solving tasks where no clear and well-defined results can be achieved, the results themselves can indicate how reasoning processes took place. Visualisations may support specific results and preclude others. Artefacts produced in this context (e.g. notes, screenshots) might provide additional information on reasoning processes.

It seems plausible to combine some of the above-mentioned approaches to get a more comprehensive idea of how users interact with information visualisations and what strategies they adopt. Results from such research may inform design for complex problem solving. The existence of increasing amounts of complex data makes this issue more pressing in HCI, not only in information visualisation [3].

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An Interdisciplinary Approach for the Study of Cognitive Aspects in Visualization and Human-Computer-Interaction

Michael Raschke[1] and Thomas Ertl[1]

[1] Institute for Visualization and Interactive Systems, University of Stuttgart, Universitätsstrasse 38, 70569 Stuttgart, Germany
{Michael.Raschke, Thomas.Ertl}@vis.uni-stuttgart.de

Keywords: visualization, HCI, cognition, cognitive simulation, eye-tracking, cognitive models, visual analytics

1 Extended Abstract

Our interdisciplinary approach is inspired by the question:

What are the cognitive processes behind the understanding of geometric forms?

This question gives an interesting starting point for a discussion where the common ground of HCI and Visualization could be found. Asking for cognitive processes is a very general question. To precise the question and to use advantages of application environments we study this question in the domains of visualization and HCI. Interaction between humans and computers can be generalized as a mental interaction with artificial objects. HCI mostly works with pixel based dialogues, buttons, menus, status bars and other GUI elements. Sometimes they look like real world objects, sometimes not. Visualization is a transformation of data into geometric shapes and gives us a better overview or insight into data[1]. Often the data structure is very abstract or of high dimensions. Challenges arise due to the transformation to two or three dimensions of geometrical forms and due to that humans gather information through perceptual and cognitive processes. On a basic level, HCI and visualization intersects in the usage of cognitive processes behind the perception of geometric forms that represent data.

In our approach we use techniques from cognitive science, mainly eye-tracking combined with cognitive inspired models of visualization. A cognitive simulation realized with a cognition simulation framework (e.g. ACT-R[2][3], EPIC[4] or SOAR[5]) connects both techniques.

Eye-Tracking is the state of the art technique to evaluate HCI aspects. However, the number of visualization techniques for eye-tracking data is very little. Mainly heatmaps and scan-path visualization are used. One aim of our work is to enlarge this number with new presentation techniques based on the visual analytics paradigm.

Visualization today often uses OpenGL, DirectX, PreFuse or other rendering libraries. The usage of these techniques leads to a very technical perspective of visualization structures (parallels in HCI are the usage of GUI-designer tools). The cognitive understanding of visualization or GUIs does not only work with mental line-, pixel- or button-recognition functions. We use syntactical and semantic pattern recognition to find important GUI elements and to understand connections between presented graphical elements. Beside the study of cognitive recognition patterns, our work also leads to graphical ontologies, which we will use for the adaptation of visualization to users' needs or preferences[6]. Also, semantic models of visualization could lead to new rendering techniques which focus more on a cognitive inspired approach than on technically defined visualization elements.

A cognitive simulation allows studying users' cognitive processes during their work with visualization. Eye-tracking is used to train the cognitive simulation; semantic models provide a "mental" database.

We think that our interdisciplinary approach will lead to a better understanding of cognitive processes of perception and understanding of geometric forms and thus to optimized graphical representations. Although we are mainly working in the domain of visualization, results of our approach can be applied to questions of usability in HCI. Working in the domain of visualization implies using HCI techniques (e.g. massively integrated in visual analytics software). A main inspiration for our simulation concepts comes from usability tools like CogTool[7] which simulates interaction processes with GUIs. In our opinion, HCI and visualization should not be seen as two split domains. They inspire each other; have common questions, especially from the point of view of cognition.

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Envisaging the Goal: The Design of Visualization Based on Cognitive Task Analysis

Rosa Romero, Sara Tena, David Díez, Paloma Díaz, and Ignacio Aedo

DEI Lab - Computer Science Department
Universidad Carlos III de Madrid, Spain
{rromero, stena, ddiez, pdp}@inf.uc3m.es, aedo@ia.uc3m.es

1 Motivation

Visualization is defined as "the use of interactive visual representations of data to amplify cognition" [1]. This definition characterizes the last purpose of visualization: the elaboration of a mental picture that eases the achievement of specific goals. But, which kind of knowledge is required to reach such goals? And, more important, can we understand cognition to the point of being able to design artifacts that speed it up? The term 'cognition' implies that it is not enough to simply observe what people do but also it is important to know the goal they are pursuing and to find out how they think, what they know, and how they structure information [2]. Therefore, visualization is concerned with high-level cognitive tasks. Moreover, since not every piece of information is relevant to a specific task [3], it is needed to realize which information is more relevant in order to provide effective visualizations that allow users to complete their goals. A real scenario of this situation is the operation of electrical smart grids, where the main goals pursued are monitoring and controlling the state of the grid in order to maintain stable its electrical state. If unnecessary information is provided to the operators (for instance, energy prices or individual power consumption) they can get lost in irrelevant data and reduce their response efficiency, which is one of the parameters used to measure the quality of the service.

2 Proposal

The success of visualization requires the support and representation of all the cognitive elements underlying the awareness, comprehension, and judgments of the concepts that are represented by a visualization technique. Thus, the main challenge in designing visualization should be not only the inspection of the tasks carried out by the user but also the inquiry and definition of the mental process performed by a user to fulfill such tasks. In this way, the application of HCI approaches may be a suitable way of minimizing the barrier between the cognitive model of the user and the application of visual representation of data to support user's tasks. In particular, this paper proposes Cognitive Task Analysis (CTA) as a methodological approach to address the design of visualization. This approach is defined as a set of methods for identifying cognitive skills, or mental demands, needed by the psychological processes underlying the completion of a task [2]. Therefore, CTA would allow us to collect knowledge about the most significant cognitive tasks related to the achievement of specific goals, identifying those cognitive tasks that require a detailed study for the design process [5]. As a proof of concept of this approach, we have applied CTA methods to create advanced operation environments for electrical smart grids. Our design process was divided into two main activities:

1. Preliminary analysis of both the operation tasks in a smart-grid control room and the structured information required to carry out them. The analysis was tackled by using elicitation methods such as document review, observation, and unstructured interviews. This preliminary analysis allowed us to identify those tasks that required a high level of cognition. Such tasks are conducted by the knowledge that an operator maintains and applies to make decisions.
2. A detailed analysis of such high-level cognition tasks from a cognitive point of view. This analysis was focused on: (1) what operators think about when they are operating; (2) what they pay attention to; (3) what strategies they apply to either make decisions or detect problems; (4) what kind of information they use; (5) which personal information and background characterized operators.

At this point, with the purpose of addressing the visualizations, we made adaptations into CTA design process. This adaptation was based on filtering out and prioritizing CTA results in order to avoid the existing 'soft knowledge' [4]: such knowledge is less quantifiable and cannot be represented so easily. Examples of soft knowledge may include internalized experience and automated skills, internalized domain knowledge, and cultural knowledge embedded in practice. In this way, such adaptation would help keeping visualization mapping consistent with the goals, tasks, and actions of the users.

The application of CTA methods has allowed us to systematize the inquiry process prior to the definition of suitable visualizations. Thanks to this methodology we identified and organized the information that would be considered as an input to the visualization design process. Nevertheless, CTA methods were not specifically conceived to support such a design process and variations must therefore be applied. Our adaptation, based on prioritizing data and filtering 'soft knowledge', has helped us in designing visualizations for smart grid control room. However, this approach could be merely considered as a proof of concept. Further work may be oriented to deepen in the knowledge of CTA methods and their application to address the design of interactive visual systems. Exploring issues such as the relationship between 'soft knowledge' and effective visualization, techniques to inquiry cognition, and effective mechanism to filter knowledge should be carried out.

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Visualization of complex information in complex work situations

Bengt Sandblad and Anders Jansson

Uppsala University, Dept of Information Technology, Human-Computer Interaction
Bengt.Sandblad@it.uu.se

Abstract. The presentation will discuss visualization of complex information in connection with human work in complex dynamic work situations.

Keywords: Human-Computer Interaction, Visualization, Human Complex work

1 Introduction

In our research, we are focused on studying IT-systems for highly skilled professionals in complex and dynamic work. To support operators/users in such work situations, we must visualize complex information sets and patterns and develop efficient interaction systems. The demands on the operators/users are often very high concerning performance, quality, efficiency, timeliness and safety. We have found that not one single approach, theory or methodology can provide tools for design and development of efficient, usable, safe and resilient support systems in such environments. In this workshop, mainly Human-Computer Interaction and Visualization are discussed, but there are also other scientific areas that must be considered.

Human-computer interaction, HCI, (ACM SIGCHI) is “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”.

Visualization is (ACM SIGGRAPH) “the formation of mental visual images, the act or process of interpreting in visual terms or of putting into visual form”. Other attempts to define visualization speak e.g. about “a method for seeing the unseen” or “based on (non-visual) data, produces an image, and results in a readable and recognizable output”.

Image analysis (Wikipedia) is “the extraction of meaningful information from images; mainly from digital images by means of digital image processing techniques”.

Interaction design (Wikipedia) “defines the structure and content of communication between two or more interactive "beings" to understand each other. Interaction Designers strive to create meaningful relationships between people and the products and services that they use, from computers to mobile devices to appliances and beyond”.

2 Complex and dynamic information in complex dynamic work

Complex work situation can be found in many different domains. Examples are:

A. Health Care. Here e.g. physicians and nurses must be supported by systems that show relevant complex sets of information in a form adapted to their work processes. They must also be able to interact in an intuitive way so that they can be focused on the patients and their problems. Examples of applications are electronic patient record systems, intensive care unit systems and systems for specifications of (hundreds of) medical procedures that must be followed according to rules and regulations.

B. Train traffic control. Here traffic controllers shall continuously observe very complex and dynamic processes, identify disturbances and conflicts, decide on as optimal actions as possible based on complex and conflicting goals and at the same time communicate with many others involved in the process. The absolute focus on safety must not be disturbed.

When we study, describe and analyze complex work situations, and when we design and deploy information systems in such environments, we use many different theories from different areas. Examples are perception and cognition, mental models, situation awareness, human decision making, automation, resilience engineering, user centered development etc. Research and experiences support the hypothesis that a human operator can overview, interpret and in real time use almost unlimited information if it is relevant to the situation and coded according to human capabilities.

3 Discussion

The problems in designing, developing and deploying information systems in complex, dynamic work environments are not only related to visualization. It is also necessary to generate a basis for visualization and design by understanding, describing and analyzing the work domain.

During the workshop, we would like to discuss, among other things:

- Basic and general requirements for visualization of (more or less) complex information sets in dynamic work situations.
- How these requirements can be related to theories, methods and techniques for describing and analyzing complex work.
- When a research organization for studies of complex, dynamic work situations is founded, which competencies related to visualization should be included?
- When an educational curriculum for visualization of work related information systems is specified, what should it contain?

HCI and Visualization - Thoughts on the Relationship and Future Development of Two Disciplines

Johann Schrammel[1] and Manfred Tscheligi[1,2]

[1] CURE - Center for Usability Research & Engineering,
Modecenterstraße 17 / Objekt 2, 1110 Wien

[2] HCI-Unit, ICT&S Center, University of Salzburg
Sigmund-Haffner-Gasse 18, 5020 Salzburg

{schrammel, tscheligi}@cure.at

HCI and visualization are two closely related disciplines with several important overlapping topics. So far however they maintain distinct individual research traditions and agendas. We think these two traditions can be well characterized by differences with regard to their main focus, the applied methods and the main questions the regarding research tries to answer.

According to our perception v*isualization* traditionally is more concerned with rather static displays of available information, and focusing on ways to optimize the presentation of complex and multidimensional data set. The main emphasis in visualization typically lies on supporting the development of an understanding of data.

In contrast *human computer interaction* typically focuses much more on the dynamics and interaction between user and system, and the main goal is to support the user in achieving practical hands-on tasks.

Recently with the advent of so-called *visual analytics* researchers started to combine aspects of both worlds, especially enriching visualization with a more dynamic and interactive approach to data understanding. Visual analytics has been described as "the science of analytical reasoning facilitated by visual interactive interfaces" [Thomas & Cook 2005]. This interest in combining visualization and interaction approaches is driven by the increasing complexity and dimensionality of data which cannot be displayed in a single visualization but requires the active exploration and interaction of the user to reveal all its nuances.

In future we expect an even further integration of human computer interaction and visualization approaches to address the challenges of understanding ever more complex relations in ever increasing data pools. Furthermore we expect an increase of the integration and application of data mining and machine learning methods with visual analytics. Such approaches could be used to guide the users' attention to potentially interesting aspects of the available data, and allow integrating more information in the display as the processed data provides a concentration and compression of the multiple facets of available data.

In the context of the above describe developments we think the following research challenges are of key importance within HCI, visualization and visual analytics within the next years:

Integration of data mining and machine learning approaches with visualization, human computer interaction and visual analytics systems. We think that data mining and machine learning approaches could help to deal with the ever-increasing amount of data, and allows reducing the (visual) complexity of displayed data thereby making it easier to comprehend respectively allow to show additional features. For example, in prior work we used different methods to clustered tags within tag clouds according to their semantic relatedness, and could show that this could support fast perception and understanding of data structures [Schrammel et. al 2009].

Developing *new approaches for the visualization and understanding of large scale networked data*. The world is becoming ever more interconnected, and it has become impossible to understand phenomena in an isolated way. Therefore we think that analysis systems that support the understanding of networked data are of high importance for future research. New developments allowing to visualize the semantic structure of networks such as e.g. developed by NodeXL [Smith et. al 2009] or algorithms that allow optimize drawing and display of identified structures such as e.g. Euler diagrams [Rodgers 2004] have the potential to increase understanding of data based on improved data analysis, visualization and interaction concepts.

Exploring the possibilities of novel display hardware, and develop visualization systems that systematically capitalize the newly emerging possibilities for improving interaction and understanding. New hardware providing exiting possibilities (e.g. 3D-Screens, AR-Systems) is becoming available, and researchers only started to explore the possibilities for visualization and HCI.

Apply computer vision and vision theory to predict the usefulness of different visualizations, to allow to dynamically adapting visualization systems and parameters to the concrete circumstances of the visualization and the displayed data. Furthermore, learning from interactions of expert users with interactive visualization systems can capture knowledge which helps developing a deeper understanding of the involved perception processes and problem solving strategies, and to develop supporting mechanisms for novice users based on these findings.

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Perception or Pixels –Problems in Designing Visualization from the User's Point of View

Gerrit C. van der Veer, Laura Benvenuti, Teresa Consiglio, Els Rogier
Open University The Netherlands, Heerlen, The Netherlands
gvv@ou.nl, lbe@ou.nl, lbytco@ou.nl, sro@ou.nl

Abstract. User centered design would benefit from a dedicated environment, where the designer can focus on the application domain. Our current main domain is design for adult learning. We show how user centered interaction design often is confronted with limitations in the visual facilities of digital learning environment, hindering the support of learners in a way that fit the "human size". We also demonstrate ways to get around that.

Designers build bridges between worlds
They use their expertise on design and apply it on the domain they are designing for. The next section will elaborate on this for our case. Designers need tools and a design environment, in order to implement their design decisions. If these are not available, designers have to invest in additional types of expertise, or they have to cope with a suboptimal context. That is what the last section is about for our case, where visualizing our design ideas is the main challenge.

Design is a multidisciplinary expertise
It requires theoretical understanding, knowledge of techniques, experience with tools, and general design skills, in the domain of application. If the application is user-system interaction, the domain requires expertise from: Cognitive Psychology, Software Engineering, Industrial/Interaction Design and, depending on the context of use, Cultural Anthropology, Ethnography, or Organizational Design. In an ideal world designing is team work where the team owns all different types of expertise.

Our current case considers the domain of adult learning: we teach our students, and we ourselves practice the expertise of designing Internet based learning resources. This allows students, independent of location, context, or time, to find and use learning resources. These resources need to optimally fit unpredictable learning situations: learners might want to perform a multitude of different types of activities, e.g.:

- Get a definition;
- Get an explanation;
- Get theoretical background material related to a definition;
- Get a well prepared example;
- Construct their own example;
- Practice a skill;
- Attach a personal note to received or constructed material
- Highlight parts of material

- Attach a note to be shared with other learners;
- Attach a note intended to share with a teacher or expert;
- Discuss a topic with one or more others (synchronously or asynchronously).

Learners might need these activities to be supported, context dependent for different types of devices (smart phones, laptops, Wii, wall size screens, e-book-readers, …) communicating through many different modalities, e.g.:

- The system output to the learner through spoken or readable text (in some cases with voice over), still pictures (2D, 3D), video (sound could be synchronous and authentic to the video, or an expert's comment to the video, or a studio audience's reaction to the video, or a suggested learner's reaction, ….) etc.
- The learner's input to the system through voice, pointing in 2D or 3D, typing and mouse handling, body movements, …

Learners should be able to interact with these supporting systems in a way that fits the "human size". This includes supporting human ways of reading, scanning, pointing, and a system's way of reacting to learner behavior that is "naturally" perceivable, noticeable, and acceptable. And these aspects require a system behavior that should fit both: human perception, and culturally determined expectations and meaning (of colors, turn taking, location, reading direction, etc.).

Design requires a supporting environment

After design follows implementation, for which different types of expertise are needed to make the actual product or service. A design team should be aware of the characteristics, possibilities and restrictions that the design environment is presenting.

These characteristics have presented us with some problems for visual design of the electronic learning environment that was developed: the current commercially available products (e.g., Blackboard, Elluminate, and Adobe Connect) have guiding principals and concepts that are mismatching the endorsed didactic approach for the learning objectives of the course. In contrast, open source environments like Moodle offer more flexibility and allow to develop our own extensions and to profit from our colleagues and combine successful ideas. In practice, many educational institutes have yet to learn to trust and rely on open source solutions where an active community is replacing the commercial business model for managing risks.

This means we are confronted with limitations in the visual facilities of digital learning environment, hindering the support of learners in a way that fits the "human size" of this type of user. In many cases the system imposes, by design, restrictions to who is the boss of a screen's real estate: where can we put a question, a video, a button to press, or how can we specify our own animation. On the other hand, most designers of learning support are not eager to focus on pixels and to reinvent a wheel for which they do not have the expertise.

Commercially provided learning environments should be re-developed to allow designers to do their job in a proper way, possibly by freely applying Open Source based solutions. On the other hand, Open Source environments should (be developed to) acquire a state of acceptability for educational institutes that allows both designers and learners access to state of the art solutions.