HCI&IM Working Meeting

Frontiers of Visualization – May 2, 2014

Steering Committee:

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Attendees:

Jim Ahrens (Los Alamos)
Peter Bajcsy (NIST)
Jeff Baumes (Kitware)
Ryan Boller (NASA)
Katy Borner (Indiana U)
Rachael Brady (Duke U)
Maria Esteva (TACC)
Kelly Gaither (TACC)
Todd Hughes (Next Century)
Chris Johnson (University of Utah)
JoAnn Kuchera-Morin (UCSB)
Richard Marciano (UMD formerly UNC)
Kenneth Moreland (Sandia National Lab)
Eric Newburger (US Census)
Hanspeter Pfister (Harvard)
Nathalie Riche (Microsoft Research)
Bernice Rogowitz (Visual Perspectives)
Francesca Samsel (U of Texas at Austin)
Jon Schwabish (Urban Institute formerly CBO)
Ben Shneiderman (University of MD)
Claudio Silva (NYU)
John Stasko (GA Tech)
Amitabh Varshney (University of MD)

Synopsis:

The Human Computer Interaction & Information Management (HCI&IM) Coordinating Group (CG) hosted a "Frontiers of Visualization" meeting on Friday, May 2, 2014, at the National Science Foundation (NSF) in Arlington, VA. The purpose of this meeting was to bring together networking and information technology professionals to discuss their current and planned use(s) of visualization technologies, the challenges they face, and new directions for research that may be beneficial to their work. Attendees also participated in breakout discussions surrounding topics in relation to visualization in decision making, cognition, and the future of visualization research. The goal of this meeting was to gain an understanding about current visualization standards and practices, the work in the field, and identify additional research needs. The information in this document was gathered from these talks.

Breakout Group 1

Topic: Write an abstract for an ideal visualization research proposal.

a. *Imagine you are the recipient of a $10M research grant: What would you research?*

Visualization research has been intertwined with solving larger, more specific problems defined by a need or an area of great concern. Group 1 took on the task of writing a description of an ideal visualization research proposal, taking the approach of looking at grand challenges the general public can identify with. This emerged as a challenge for an interdisciplinary group as this approach would allow researchers to self-organize and learn from each other. These diverse research teams could aid in discovering research needs that would be applicable across all grand challenge problems.

The proposed grand challenge should respond to the following areas of concern:

1. Data collection, data parsing, and data management – We need to gain a better understanding of where visualization fits.
2. Fundamental scientific research – how is visualization integral in this space where the bulk of the analysis is conducted?
3. Communicating the results – Visualization aids communication and in many cases, bridges the gaps of understanding; therefore, it must be tailored for its audience to convey meaning.

While responding to the areas of concern noted above, the following requirements/capabilities should also be included in the proposal:

- Better integration of visualization and data analytics
- A framework that automatically takes a description of a visualization and addresses/tests for the following:
    - Correctness
    - Quantifying error and measuring uncertainty
    - Validates and verifies answers
    - Testing effective visualization types including perception, zooming, and level of detail
    - Understanding Scale comparison
    - Understanding Dashboards versus other tools in that genre
    - Interaction modalities
- Facilitation plans for interdisciplinary teams working and talking together and thinking collectively about formal methodologies to receive and understand data.
    - Group Structure – How will the team be structured to optimize throughput?
    - Generate tools real people can use on real data while recognizing we need people to understand hybrid coding and different representations of data.
    - These groups will respond to questions such as, "*What are the general purpose metrics across all areas and commonalities among the domains?"* We need to understand, in the process of responding to grand challenge

problems, all of the coordinating pieces and what worked that could be a piece of solving another grand challenge problem across domains.

- Address visual literacy problems across cultures:
    - Knowing what constitutes a good visualization
    - Storytelling, how is this used?
    - How do people learn from visualizations?
- Sustainability for and open source access to tools developed under this work

Breakout Group 2

Topic: What are some current obstacles and opportunities in visualization?

a) *Describe some of the compelling issues facing visualization and decision making*
b) *What are some of the most overlooked issues in visualization?*

1. Crafting legitimate interdisciplinary teams in support of visualization research.

Interdisciplinary teams introduce innovative methods. The group structure or the science of team science is essential to the research however creation of such a team is a hurdle in certain communities. Considering the rewards system of science in a visionary way sets the stage to promote and encourage this interdisciplinary involvement.

Funding also needs to be made interdisciplinary to promote richer, more clever, and granular methods of supporting these teams and taking into consideration the knowledge base, kind of science, and current research methods. This interdisciplinary funding mechanism needs to embrace the blending of quantitative big data methods as well as qualitative ethnographic methods.

2. Big science and Scalability (Volume, Variety, Value, Validity, Velocity, and Veracity)

- *Interoperable Technologies and Software* - Due to the multifaceted nature of underlying data for decision making support, there is a need for adaptable tools, automated algorithms, and the ability to manually choose saliency to use all of the data as a community.
- *Representation of uncertainty and precision of data,* coupled with automation.
- *Provenance and Curation* - How do you know a certain result was achieved and how do you curate the data, processes and software?
- *Human components in the general National Agenda*: Visual Cognition, Visual Reasoning, Visual Literacy, Analytic Clarity, and Perceptual Psychology. The inclusion of these components will help reduce the potentially misleading nature of visualizations.
- *Dynamics of Collaboration in Data to Knowledge to Decision to Action*: How do we study collaboration in a visual context? How do we clarify responsibility for decisions made by groups (i.e. tracing the sources)?
- *Archiving* - What are the artifacts that should be archived? What kind of data, videos, etc.?

3. Theory of Visualization

- *How to form a Theory of Aggregation* – linking tasks to aggregation; (clustering, grouping, motif aggregation) currently there is no standardized strategy (ex. NASA earth data is organized by time, latitude/longitude, etc. however there is difficulty in finding where the tornados were.) Can these be generalized to fit other domains?

- *Data cleaning*: Constraint specification, outlier handling, gap & redundancy detection.
- *Perceptual Psychology* -Visual Cognition as support for visual reasoning
- *How to do*: Query formation, task specification, and hypothesis generation
- *Formal task definition & data definition* leading to the automated selection of visualizations that would support a decision
- *Support of visual reasoning* - How do users express what they want?
- *Human expression* (language) – Language that invokes the appropriate analytic techniques. The user needs to learn and be able to express what they need to be able to invoke the appropriate analytic techniques underneath

4. Improvements in evaluations leading to better approaches for adoption/dissemination of technologies.

5. Training for students, practitioners, and domain experts (education and fluency in the common core).

Breakout Group 3

Topic: Personalized data visualization – How do you do it?

To respond to the question of personalized data visualization and how it should or should not be done, Group 3 began asking several questions:

1. What is the most efficient way of going from a problem description to a personalized data visualization?
2. What type of person are we talking about?
3. What types of learners are you working with?
4. What are they trying to do?

Simply making a taxonomy may lead to exclusion. These questions beg for increased research in the area of perceptual cognition as there are things in the brain that play a part in "personalized" visualization that may be useful in the creation of methods of getting/giving a personalized data visualization.

Just as a taxonomy can lead to exclusion there is also the issue of customizing without bias, effectiveness and eventually evaluation. How do we take these known questions about perception, apply them in the potential formation of systems capable of creating a personalized data visualization? Perception, cognition, the application and theory are all components and how they come together determines the quality of a personalized data visualization. The lack of information in this area is a significant barrier to progress.

Breakout Teleconference Group

Topic: Define some measures in determining the usefulness of visualization.

The group agreed the research foundation for this is still being paved. There is a need for fundamental studies of visualization at the cognitive level and at a more practical level. Increased domain knowledge will have an impact on effectiveness in determining how closely the visualization aligns with the principles, practices, and theories of that domain.

Visualization for what **purpose**? The intention of the visualization, presentational versus decision making visualizations, is a determiner as there is a definite split between how the two should be developed.

Established **methodologies** for determining the usefulness of visualization to do classic studies at the cognitive level along with longitudinal case studies of the use of visualization. The process of establishing these methodologies is also a piece of enabling effectiveness evaluations.

Subjective versus objective measures – How do individuals perceive and decide whether the visualization is useful to them or is all the information needed to be visualized present? Is there anything missing addressing the issues of completeness and uncertainty?

Interdisciplinary teams – Visual Design and Analysis across Fields – Teams of people from domains including graphic design, cognitive/perception, visual algorithms/techniques, software infrastructure, and HCI to discuss how they approach visual design and analysis. These types of teams are a value to topics like visualization that are not domain specific.