Immersive Analytics: Exploring Future Visualization and Interaction Technologies for Data Analytics

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ABSTRACT

We propose to conduct a workshop on the topic of *Immersive Analytics*: a new multidisciplinary initiative to explore future interaction technologies for data analytics. Immersive Analytics aims to bring together researchers in Information Visualization, Visual Analytics, Virtual and Augmented Reality, HCI, and Natural User Interfaces. `http://www.aviz.fr/~bbach/immersive2017/`

Index Terms: K.6.1 [Management of Computing and Information Systems]: Project and People Management—Life Cycle; K.7.m [The Computing Profession]: Miscellaneous—Ethics

1 IMMERSIVE ANALYTICS

Due to the recent advances in immersive technologies (VR, AR, MR, large displays, tangible surfaces, etc.), we see new opportunities to using these technologies to analyze, explore, and present data. Several research areas are concerned with the development of methods to support the analysis of data, including information visualization, data science, and visual analytics. Visual analytics, introduced a decade ago as "the science of analytical reasoning facilitated by interactive visual interfaces" [3], has now become a key technology for dealing with big data [8], and there is massive potential for its use in further emerging application areas like health informatics, business intelligence, transport and logistics, scientific applications including astronomy and physics, environmental monitoring, and personal information management.

The definition for visual analytics given above is agnostic to the actual interface devices employed by visual analytics systems. Nevertheless, the affordances of the display and input devices used for analyzing data strongly affect the user experiences of such systems as well as their degree of engagement and productivity. Ultimately, therefore, it affects the adoption and ubiquity of sophisticated data analysis tools. For practical visual analysis tools used in the industries and areas of data science described above, the platform for interaction is almost always a standard desktop computer: a single display with keyboard and mouse.

While visualization researchers sometimes publish studies exploring data visualization applications in 3D or using natural user interfaces (NUIs), this has never been a core topic. By contrast, 3D user interface researchers have tended to focus more on lower-level technologies rather than practical applications. Therefore, we lack a systematic approach to developing visual analytics tools that go beyond the desktop, leveraging novel input and output techniques. We call for a new facet of data analytics research that seeks to unify these efforts to identify the most enabling aspects of these emerging NUI and augmented reality (AR) technologies for real-world analysis of data. We call this new research thrust *"Immersive Analytics,"* a topic that will explore the applicability and development of emerging user-interface technologies for creating more engaging experiences and seamless workflows for data analysis applications.

Figure 1: Possible use-cases to be explored by immersive analytics: data analysis in AR and immersive environments.

We believe that this workshop is a perfect fit for collocation with the 2017 IEEE VIS conference with its focus on different emerging display, interaction and natural user-interface technologies. Last year, the InfoVis conference had a track called "Immersive Analytics" featuring five full paper publications and showing the growing interest for immersive scenarios and technologies within the visualization community. Our workshop is a continuation of a previous workshop held at the conference for interactive spaces and surfaces (ISS), in November 2016. That respective whole-day workshop featured 13 short papers and 3 discussion groups.[1] This call differs from the more general and ISS themes (HCI, technology, interaction) by focussing on collaboration between Information Visualization, Visual Analytics, novel display, interaction, and Virtual and Augmented Reality researchers. Another workshop this call is related to is the Death-of-the-desktop workshop,[2] held in collocation with VIS in 2014. Our call is much more focused on the technical feasability of beyond-the-desktop scenarios and intends to be a forum for researchers to present work-in-progress, demos, position papers, and original research.

This basic definition of Immersive Analytics has already been explored in some depth at meetings at NII Shonan, Japan and a seminar at Dagstuhl, Germany. The goal of these meetings was to establish the field by authoring an introductory book and "manifesto." This book is now in production.

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[1] http://immersiveanalytics.net
[2] http://beyond.wallviz.dk/

2 Topics Covered in the Workshop

The overarching goal of immersive analytics research is to understand if and how new interface and display technologies can help improve humans' understanding and interaction with information and data through, e.g., more realistic input and output technologies, multi-sensorial environments, and the ability of these setups to facilitate distant collaborations, to name just a few. The kinds of devices and environments considered in this approach include but are not limited to AR and VR displays, large high-resolution 2- and 3-D displays [11], haptic and audio feedback, and more natural interaction including touch, gesture, and speech. These potentially require very different visualization and interaction models and techniques to those used in standard visual analytics. Some of the important research questions and core topics in this workshop, and which our ISS workshop started exploring, are:

Changing Technologies and Scenarios: What are the lessons that we can learn from previous research into the use of 3D visualization for information visualization? Do the new technologies invalidate the current wisdom that it is better to use 2D visualization for abstract data since the designer of the visualization has complete freedom to map data to an occlusion-free 2D display? How do we perceive, interact [2, 10, 16], collaborate, annotate, communicate with visualizations in the forthcoming decades?

Hybrid 2D/3D: Traditionally 3D visualizations have been used in the physical sciences, engineering, and design while 2D visualizations have been used to display statistical and abstract data in information visualizations. Increasingly there is a need to combine both sorts of visualization in holistic visualizations. For instance, in the life sciences different aspects of a cell are displayed using 2- and 3D images, 2D network data and the various -omics. Can these new technologies support more holistic visualizations of such data incorporating 3D spatial information as well as abstract data [15]?

Affordances for Immersion: What are the "tricks" and affordances such as high-resolution displays, sound, touch, novel hardware and responsive interaction that change the user perception from an allocentric view of the data to a more egocentric and immersive view of the data?

Collaboration: Much research has been devoted to computer-assisted collaboration both synchronous and asynchronous, local and remote. In contrast, only few research [7] and formal user studies [6] have investigated collaborative visualisation of abstract data in immersive environments. The new devices and environments potentially support new models for collaboration as shown in Figure 1. Collaborative Immersive Analytics can be supported, for example, by CAVE-style environments, the use of Virtual Reality HMDs, or Mixed Reality HMDs. This heterogeneity of technology involves a lot of variation on the type of collaboration and raise important research questions. How do these different environments scale with increasing number of participants? What paradigms are potentially enabled by these new interaction modalities? Can new technology bring distant collaborators closer together?

Physical and Tangible Visualization: Being part of the real world for a long time[3], physicalizations and dynamic visualizations have become interactive through electronics, tactility, and fabrication mechanisms [14]. How do data physicalizations integrate into immersive scenarios and with other immersive technologies [4]?

Interaction Techniques: Which interaction and interface design advances are needed to foster a heightened sense of immersion? The interaction techniques incorporated in existing desktop-based visualization tools introduce interface elements such as menus and widgets that act as mediators between users and the visual representation. However, due to recent advances in immersive technologies, we envision the need for new interaction techniques and designs that support direct user involvement with visualization elements rather than communication through an intermediary. This ranges from the use of novel technologies to create these interactions, to augmenting existing UI designs to foster more engaging user experiences with traditional hardware.

Real-World VA and Applications: What are the most fertile application areas for visualization? For example, these could be in life-sciences, climate science [13], disaster and emergency management, astronomy [9], personal visualization [1], archaeology, Air Traffic Control and Management [5], and many more. What questions do technologies like AR raise for visualization? Traditional information visualization supports open-ended exploration based on Shneiderman's information mantra: overview first, zoom and filter, then details on demand. In our view a different model is required for analytical applications grounded in the physical world. In this case objects in the physical environment provide the immediate and primary focus and so the natural model is to provide detailed information about these objects and only provide contextual information on demand.

3 Nature of the Workshop

The aims of the workshop are as follows:

1. To bring together experts from the Human-Computer Interaction, Augmented Reality, Virtual Reality, Information Visualization, Scientific Visualization, and Visual Analytics communities; as well as industry representatives, and domain experts from application areas that require analysis of complex data.
2. To investigate the potential and the challenges of immersive analytics in research and industry.
3. To investigate how existing interaction models and techniques can be adapted to new environments, and where new approaches are necessary. Based on this to formulate guidelines for the use of such interaction models and techniques in immersive analytics.
4. Initial design of open-source tools and platforms for supporting immersive analytics research and practice.
5. To investigate how to evaluate these new concepts, including interaction efficiency.
6. To explore the design space for immersive analytics for effective collaborative data analysis in various forms, e.g. distributed or local, synchronous or asynchronous.

4 Formats and Contributions

We aim to make this workshop as inclusive as possible. Below the formats we would like the workshop to be based on.

- A **standard submission** would be 2-4 pages TVCG format, including figures and references. We explicitly encourage demos and we would discuss with the workshop organizers or art-show organizers how to best integrate interactive demos and experiences into our workshop and the conference.
- **Demos and "Immersive Experiences"** with visualizations would feature a simpler publication format, likely a single page of the purpose of the demo, demoed technology, and relevance for visualization application and research.

Standard submissions will receive a 10 minute presentation slot, while demos will be accessible through breaks and during the closing. Standard submissions can make a wide variety of contributions to immersive analytics including:

Descriptions of novel techniques.

[3] http://dataphys.org/list/

Systems supporting specific scenarios or workflows and variety of of visualizations and interaction techniques.

Toolkits providing solutions or better integration for specific aspects in developing analysis systems for immersive environments.

Studies and evaluations of all types both for gathering feedback on techniques and other aspects in immersive environments, such as context, tasks, devices challenges and interaction modalities, etc.

Surveys of existing techniques, implementations, devices, modalities, for immersive visualization.

Theories and models that are either new or adaptations of existing models to the immersive context.

Positions and reflections to create a critical discourse on novel visualization and interaction technologies (e.g., [12]).

Table 4 shows a possible schedule. We assume between 30-50 attendees for the workshop. As we would like to feature demos, we would need an extra set of power outlets in the room.

Schedule	
8:30	Introduction and overview of the workshop structure
9:00	Invited keynote talk
10:10	*coffee*
10:30	Submitted paper talks
12:10	*Lunch*
14:00	Topic brainstorming and group formation
14:30	Group discussions
15:40	*coffee*
16:15	Group reports
17:00	Community building, demos
17:50	Closing remarks

5 Outcomes

We plan to prepare a special journal issue (IEEE Computer Graphics and Applications would be appropriate) both compiling expanded versions of the accepted workshop papers and inviting new papers evolved from the discussions at the workshop. We aim to write a Visualization Viewpoints article that explains the importance of Immersive Analytics along with the summary of workshop outcomes. We would argue that Immersive analytics could address the needs that are not addressed by any single research community.

Another goal of the workshop is to "test the waters" to see if there is sufficient interest to develop a continuing symposium on Immersive Analytics. This will be a focus of the "Community Building" activities scheduled for the afternoon session. Our workshop would be a forum for:

- Invited talks from one or two important figures in the relevant communities.
- Work-in-Progress and novel research presentations (with submitted and reviewed short papers).
- Brainstorming activities and new project formation around the themes of the workshop.
- Community building and panel discussions about how to progress the topic of Immersive Analytics.

6 Organizers

The organizers have been part of the VIS community for many years. Beyond the areas of information visualization and visual analytics, together the organizers span experiences in the most relevant areas: augmented, virtual, and mixed reality, human-computer interaction, and input techniques and devices.

Benjamin Bach will start as an Assistant Professor at the University of Edinburgh. He was a coorganizer of the ACM ISS Workshop and a participant of the Dagstuhl seminiar on Immersive Analytics. His research interests include visualization of and interaction with spatio-temporal data, and 3D information visualization.

Maxime Cordeil is a Research Fellow at Monash University, and studies several aspects of immersive visualisation. He was a participant at the Immersive Analytics Dagstuhl seminar, and a coorganizer of a sister workshop on Immersive Analytics at IEEE BDVA.

Tim Dwyer is a long standing member of the IEEE VIS Community and co-directs the Immersive Analytics initiative at Monash University. He coorganized the seminars at Shonan and Dagstuhl as well as the 2016 ISS workshop on Immersive Analytics. He is a co-editor of the forth-coming book on Immersive Analytics.

Bongshin Lee is a Senior Researcher at Microsoft Research. Her research explores innovative ways for people to create visualizations, interact with their data, and share data-driven stories. She coorganized the ISS workshop and participated in the Dagstuhl on Immersive Analytics.

Bahador Saket is currently a Ph.D. student at Georgia Institute of Technology. He has been part of the VIS community since 2014 and his current research focus is on designing novel interaction techniques for visual data exploration.

Alex Endert is an Assistant Professor at Georgia Tech. He leads the Visual Analytics Lab, where him and his students explore novel user interaction techniques that combine machine learning with visual analytics.

Christopher Collins is a Canada Research Chair leading a lab investigating interaction design for visualization at the University of Ontario Institute of Technology. He participated in the 2016 Shonan Seminar on Immersive Analytics as well as co-organizing the ISS Workshop on Immersive Analytics.

Sheelagh Carpendale is a Canada Research Chair in Information Visualization and NSERC/AITF/SMART Technologies Industrial Research Chair in Interactive Technologies at the University of Calgary, where she leads the Innovations in Visualization (InnoVis) research group. She was a coorganizer of the ISS workshop.

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