



# The Future of Interactive Data Analysis and Visualization

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## Abstract

*The interactive data analysis and visualization (VIS) community has prospered for over thirty years. Generation after generation, the community has evolved its understanding of research problems and, along the way, contributed various techniques, applications, and research methods. While some of the developed techniques have stood the test of time, we will consider what else needs to be remembered or even revitalized from the good old days in this panel. Further, VIS is currently facing exciting times, with great changes and trends within and outside the community. Thus, in this panel, we want to analyze current research trends and discuss our most exciting ideas and directions. Looking ahead, it can already be anticipated that the future of VIS is subject to change. In this panel, we want to map out future research directions for our community. Along these three lines, the guiding theme of our interactive panel will be three types of (provoking) statements: (i) In the good old days, I liked when we did ... (ii) Currently, a most exciting trend is ... & (iii) In the future, we will be doing ... Come and join us to reflect on past and present trends, daring a look ahead to an exciting future for the interactive data analysis and visualization community!*

## 1. Introduction

With the steady advancement of interactive data analysis and visualization, the VIS community has seen, is seeing, and will see considerable change. After over thirty years of outstanding research contributions to the field, the field has blossomed into a very diverse community.

With this panel, our aim is to hear the voice mainly of the generation that will shape VIS research in the next twenty years. Thus, our goal was to invite experienced mid-career researchers to join our panel to discuss their reflections on great VIS achievements, current trends, and future changes. With these three leading questions in mind, we were able to cast a great cohort of five researchers, diverse in their contributions to the VIS community and individual backgrounds. One aspect all of the panelists share is having interesting standpoints on the past, the present, and the future; and they are happy to share these with the audience!

To start our preparation, we invited each of our panelists to an individual discussion, gathering their opinions and feedback on past and current trends and exciting avenues for the future. Our discussions were quite open and entailed many topics. However, we were able to converge on three exciting topics that would form the basis of structuring our panel.

Hence, through the discussions, we distilled three main themes (see Section 4), which will mainly form the agenda of the panel:

- *Introduction by Organizers* (5 mins)
- *Introductory Statements of Panelists* (10 mins)

Statements will be structured to reference our leading questions,

along the lines of “Based on these past and current trends..., I see the future of VIS being X...”

- *Discussion of Themes 1-3, including Questions and Provocations from the Audience* (20 mins each, 2x5 mins transitions)
- *Closing by Organizers* (5 mins)

This document presents the panelists (including their short statements) and the organizers. Afterward, we briefly describe the three main themes that we distilled from our first discussions. Lastly, we describe the proposed panel mechanics and future outreach.

## 2. Panelists

We are happy to announce the five mid-career researchers who will be at the podium, serving as panelists. These researchers represent a broad spectrum of expertise and interest in the realm of VIS research and applications. The panelists are happy to share their individual perspectives with interesting statements about the past, the present, and the future. Warm welcome, dear Johanna, Timo, Alvitte, Michael, and Marc!

### Panelist: Johanna Schmidt

**Short Bio** Johanna Schmidt is the head of the *Visual Analytics* group and coordinator of the associated research area at *VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH* in Vienna, Austria. VRVis is a non-university research organization focusing on applied and company-related research projects.



Johanna and her team work on interactive visual systems that can support tasks like data quality assessment, decision-making, and predictive modeling for Industry 4.0 use cases. Johanna has been part of the IPC of past EuroVis and VIS conferences and will serve as a General Chair for VIS 2025. She is also a lecturer at the TU Wien, the University of Applied Sciences Salzburg, and the University of Applied Sciences Krems.

**Statement** Working closely with domain experts and through my teaching experience, I could see changing requests and needs regarding visualizations from end users over the past years. Nowadays, applications and tools for creating even complex data visualizations and dashboards are ubiquitously available (e.g., various visualization libraries for Python, R, and JavaScript and applications like Tableau and Power BI for users without programming skills). Users and students increasingly request support and guidelines for creating *good* visualizations. These requests are connected to an increased demand for data literacy studies and a better understanding of how users read and interpret information. Another challenge, mainly observed by company partners, concerns their increased need for tools supporting the necessary data-handling steps before creating a proper visualization. Here, as a visualization community, we have to decide whether we consider this a valuable research direction in the future.

#### Panelist: Timo Ropinski

**Short Bio** Timo Ropinski is a Professor for Computer Science at Ulm University, where he leads the Visual Computing Research Group. He and his team work on the intersection of data visualization, computer graphics, and machine learning, whereby their research targets the generation, processing, and analysis of digital images and 3D data. As such, they have also made significant advancements in visualizing complex data sets and developing innovative visualization techniques, whereby interactivity often plays a crucial role. Ropinski is on the editorial board of IEEE TVCG, is heading the EG VCBM steering committee, and has been full paper co-chair for various conferences, such as EuroVis and IEEE PacificVis.



**Statement** In the past two decades, we could witness a transformation of the visualization research landscape. Initiated by Thomas and Cook's 2005 Illuminating the Path research agenda, a trend towards more system-based visualization research could be observed. This trend was also supported by the importance and wide applicability of these systems, as well as the fact that many algorithmic visualization research challenges could be considered solved. While these systems are naturally targeted towards human users, the visualization research community could and should consider what the requirements will be, when more and more intelligent and autonomous agents start interacting with data. This drastic change, will not only affect the design of interactive visualization systems, but will also impact active learning approaches, and might require us to rethink long-accepted standards for visual encoding.

#### Panelist: Alvitta Ottley

**Short Bio** Alvitta Ottley is an Assistant Professor in the Department of Computer Science & Engineering at Washington University in St. Louis. She also holds a courtesy appointment in the Psychological and Brain Sciences Department. Her research, which has won several best paper and honorable mention awards, uses interdisciplinary approaches to solve problems such as how best to display information for effective decision-making and design human-in-the-loop visual analytics interfaces that are more attuned to people's thinking. Dr. Ottley received an NSF CRII Award in 2018 for using visualization to support medical decision-making and an NSF CAREER Award in 2022 for designing context-aware visual analytics systems. She is also the recipient of a 2022 EuroVis Young Researcher Award. For more information, see <https://www.alvitta.com/>.



**Statement** I urge the VIS community to come together and work to identify and address our grand challenges. These challenges include but are not limited to (1) Developing new visualization techniques for large, high-dimensional and/or complex datasets, perhaps by incorporating AI. The amount of data that is being generated continues to grow exponentially, and many of our solutions do not scale. For example, how can we enable a material scientist trying to understand and navigate high-dimensional parameter space to create new materials that exhibit desirable characteristics? (2) Creating new human-AI collaboration paradigms. As machines become more intelligent and potentially embedded into our visual analytics tools, it is becoming increasingly important to communicate with them effectively. Visualizations (or direct manipulation of visual elements) can be powerful tools for communicating with machines. (3) Making visualizations more accessible to a wider audience. Experts and government officials often use them to communicate with a wide audience. It is important to make visualizations more accessible to people with different levels of expertise and visual, data, and reading literacy. (4) Addressing the ethical implications of VIS. As VIS becomes more widely used, it is important to consider the ethical implications of its use. For example, bad actors now use visualizations to manipulate people's opinions or disseminate misinformation. These are just a few examples of the many grand challenges the VIS community could address. By working together, we can make a real difference in how society interacts with and understand data.

#### Panelist: Michael Sedlmair

**Short Bio** Michael Sedlmair is a professor at the University of Stuttgart and leads the research group for Visualization and Virtual/Augmented Reality there. He received his Ph.D. degree in Computer Science from the University of Munich, Germany, in 2010. Further stops included the Jacobs University Bremen, University of



Vienna, University of British Columbia in Vancouver, and the BMW Group Research and Technology, Munich. His research interests focus on visual and interactive machine learning, perceptual modeling for visualization, immersive analytics and situated visualization, novel interaction technologies, as well as the methodological and theoretical foundations underlying them.

**Statement** Once upon a time, there was a world without treemaps, parallel coordinate plots, and marching cubes. In the early days of visualization research, all these “new” techniques had to be discovered first. These ideas were not perfect but exciting and inspiring, and little formal evaluation was needed to convince others of their novelty and value. Today, we have generated an enormous design space for visualization which we now need to understand and organize through systems, applications, design studies, empirical evaluations, and systematic literature reviews. Doing so allows us to gradually build up the much-needed theoretical and practical foundation that ties visualization research together—a process that has started but is far from complete. VIS is not the first research field that has matured; we can learn from other areas. Toward this future, I advocate for open-mindedness toward a wide variety of contribution types, different ways of thinking, and teaming up with other research communities (HCI, AR/VR, ML, etc.) toward solving the fundamental quest of human-data interaction.

#### Panelist: Marc Streit

**Short Bio** Marc Streit is a Full Professor at the Johannes Kepler University Linz in Austria where he leads the JKU Visual Data Science Lab (<https://jku-vds-lab.at/>). He finished his PhD at the Graz University of Technology in 2011. His scientific areas of interest include visual analytics, biological data visualization, and explainable AI. He won multiple best paper and honorable mention awards at major conferences in the field. Marc is also co-founder and CEO of datavisyn, a spin-off company that develops data visualization solutions for biomedical R&D. For more information, see <http://marc-streit.com>.



**Statement** Explainable AI contributions have taken our conferences and journals by storm. Everything seems to be flagged as explainable AI – sometimes even a plot visualizing the results of a simple clustering algorithm. However, I believe that the use of AI for the purpose of visualization will be much more relevant for the future of our research field. Large language models, such as GPT and Bard, are the elephant in the room. As one of the first major VIS conferences after the release of these groundbreaking technologies, we need to face the revolution and discuss the impact on our community.

### 3. Organizers and Moderators

In the following, we present the two initiators of the panel (Jürgen Bernard and Mennatallah El-Assady), who are organizing the event and moderating the session during the EuroVis conference.

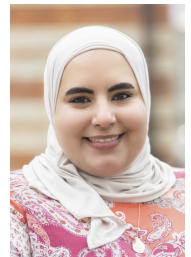
#### Organizer and Moderator: Jürgen Bernard

**Short Bio** Jürgen Bernard is an Assistant Professor of Computer Science at the University of Zurich (UZH), Switzerland, and associated with the Digital Society Initiative (DSI), Zurich. He is leading the Interactive Visual Data Analysis Group. His primary research includes the characterization, design, and evaluation of visual-interactive data analysis interfaces to combine the strengths of both humans and algorithms in interactive machine learning and data science applications. For his contributions in visualization research, Jürgen was recently awarded with the EuroVis Young Researcher Award (2021) and the Eurographics Young Researcher Award (2022). For more information, see <https://juergen-bernard.de>.



#### Organizer and Moderator: Mennatallah El-Assady

**Short Bio** Mennatallah El-Assady is a research fellow at the AI Center of ETH Zurich, Switzerland. Prior to that, she was a research associate and doctoral student in the group for Data Analysis and Visualization at the University of Konstanz, Germany, and in the Visualization for Information Analysis lab at Ontario Tech University, Canada. She works at the intersection of data analysis, visualization, computational linguistics, and explainable artificial intelligence. For more information, please visit: <https://el-assady.com/>.



### 4. Main Themes

Based on our pre-panel discussion with all of the panelists, we derived the following three main themes.

#### 4.1. Goodbye VIS technique and algorithm contributions?!

InfoVis, SciVis, and VA have all seen great techniques and algorithms in the past. Partially, the results were so convincing and useful that papers got accepted with only marginal evaluations involved. However, the wild west of novel techniques and algorithm contributions seems to be over.

Today, VIS contributions ought to be complex, sophisticated, and big, as parts of powerful systems or deployed in applications as a combination of existing techniques. While in the past, techniques and algorithms were implemented and developed to solve a general problem for broad user groups and across applications, our panelists identify that today sophisticated systems and application contributions are rather limited to very specific user groups. Not necessarily do these applications generalize, nor are they conducted based on qualitative empirical methodologies. Instead of an empirical underpinning, high engineering effort is often needed for these systems and applications to be attractive to the VIS community, even if end users seem to prefer simple solutions. This seems

to differentiate VIS research from HCI research, where contributions can be much simpler and sometimes even more effective.

For the future, we identify two possible perspectives expressed by our panelists. First, VIS research could make better use of existing frameworks like Power BI, and focus on custom visuals to support a targeted user group, instead of maintaining expensive in-house frameworks of individual VIS labs. The focus could be more on the innovation aspect of (applied) VIS research rather than on systems, VIS machinery, and multiple re-creations of the wheel/technology stack. Second, after strong technical contributions in the past, predominant system engineering and applications in the present, the future may bring more empirical contributions. The line of approach could be to use what exists, study it with/on people, and make meaningful adaptations and extensions, e.g., towards personalization or persona support. It is likely that the artifacts to study are generalizable techniques of the past rather than specific applications of the present.

#### 4.2. Rapid AI advancement as risk, challenge, & opportunity.

AI is taking the world by storm. We have all witnessed the rise and effectiveness of different AI models. Recently, large language models and generative AI models have been impacting all areas of life and opening up much potential for future research.

The impact of ChatGPT and similar technologies directly on VIS research are still comparatively small, compared, e.g., to the computational linguistics and NLP research communities. But what is about to come? And will the change be negative?

The panelists agree that, from current AI trends, future topics will emerge, including how AI will impact our community more directly, what AI research can contribute to generating visualizations, and what the risks and challenges are to VIS of the fast-paced advances of the AI field. In addition, there will be many opportunities for VIS-relevant AI research, such as new human-AI collaboration paradigms to allow for effective communication or whether AI Agents will be the users of future VIS systems (i.e., ever more intelligent and autonomous agents will start interacting with data through and with visualization).

#### 4.3. Is the human in the loop?

In the past, VIS research has seen paradigm changes in the way how the human is put into the loop; for design processes supported through design studies, as well as for human-in-the-loop applications controlled and individualized by humans.

Today, can people really use VIS tools? Can end users, students, or other audiences really benefit from VIS contributions? How far developed is visualization literacy in the general public, and what was the contribution of VIS to this process? What is the situation on data literacy like, and who is responsible for tremendous upstream data wrangling problems still taking up to 80% of time in the process? Did we successfully enable users to help themselves when a visualization design problem or a data science problem is at hand?

The panelists identify that VIS research has potential for further improvement in many of these regards. For data wrangling, VIS could stronger contribute to the identification of the *right data* for a given task; data portions that are of value, interesting, and relevant. A central call to arms is deriving VIS best practices and guidelines to enable users to create meaningful visualization designs. From an ethical perspective, different user groups with different data literacy will require different visualization solutions and would benefit from stronger methodological support. In general, the future may point towards the general public, away from the prevailing analytics-only perspective; with (even) more focus on the optimization of existing interactive analysis techniques and visualization algorithms.

### 5. Panel Mechanics and Dynamics

This panel is not supposed to let panelists open up with long standpoints at the start. Instead, we are planning for a short introduction and for maximizing discourse. In the core part of the panel, a series of questions will be raised to be answered and discussed by the panelists. Types of questions will be a healthy mix of live questions from the audience, Mennatallah and Jürgen as moderators, and a pre-selected set of questions acquired through an upstream *Call for Questions*. This Call for Questions will be sent out to the VIS community two weeks before EuroVis, asking the community for questions/statements/positions regarding the three leading questions about the past, the presence, and the future of VIS. These questions will be presented to the audience with prepared slides, including the researcher who has raised the question. Questions from the audience during the panel can be submitted through a question submission system; these questions can be up/down voted by the audience with a Voting System in real-time. We look forward to experiencing an exciting, insightful panel with constructive, provocative, visionary, and diverse flavors. Come and join us to reflect on past and present trends, daring a look ahead to an exciting future for the interactive data analysis and visualization community!

### 6. Conclusion and Summary

With this panel, we hope to collect current trends in the visualization community while reflecting on the past and looking ahead to forming future research agendas.

The discourse that will be initiated by the panelists, moderators, and audience will hopefully generate momentum for further activities. In particular, we aim to create a collection of future challenges and opportunities, shaping our collective research agendas, as well as sparking new projects and alliances.

Furthermore, this panel could become a starting point for follow-up events with different groups of researchers in the community. We hope to start a multi-year dialogue within the community about current best practices, research gaps, and future directions.

Come join our discussion at the conference, reach out to us with ideas, and maybe propose your own reflection panel on the future of interactive data analysis and visualization.