SciVis, InfoVis – bridging the community divide?!

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1 Introduction

Scientific Visualization (*SciVis*) and *Information Visualization* (*InfoVis*) are well-established and often used terms in the research field of visualization. But instead of intuitively illustrating two research fields – with disjunctive goals, challenges, and approaches, which they are not –, this terminology of SciVis vs. InfoVis rather represents a manifested community divide: there are *SciVis researchers* and there are *InfoVis researchers* (and there are only a few who appear on both sides), there are *SciVis conferences/journals* and there are *InfoVis conferences/journals*, etc.

In this panel, we boil up a discussion about the pros and cons of this community divide, we identify the good reasons for staying apart from each other (yes, there seem to be some of these...) as well as the good reasons for getting together a bit more. We also delineate to what extent this divide is due to historic, social, and organizational reasons (as compared to significant and inherent differences between the fields of InfoVis and SciVis).

It is important for us to outline opportunities for benefitting from each other (information visualization of scientific data as well as SciVis goodies for InfoVis). Considering future research challenges for both SciVis and InfoVis, e.g., in the context of *visual analytics*, we call for the educated "Think big!" and propose to consider visualization research as one joint field, hosting disjunctive parts, but also offering opportunities for promising and challenging joint activities, not at the least in the context of joint applications.

2 Position Statements

In the following, the panelists and the moderator contribute their points of view on the panel subject.

2.1 Breadth vs. Depth, and the Usefulness of Interdisciplinarity (Daniel Weiskopf)

As discussed earlier (e.g. in the IEEE Visualization Panel 2004 on InfoVis and SciVis [5]), InfoVis and SciVis are historically distinct fields, with largely different groups of researchers. Content-wise InfoVis and SciVis can be distinguished according to the data with which they deal. SciVis is typically applied to data with an intrinsic spatial layout (e.g., a flow simulation in 3D space), whereas InfoVis deals with data that has no pre-defined spatialization (e.g., graphs of web links). Similarly, SciVis data tends to be continuous, whereas InfoVis data tends to be discrete in nature.

The different problem settings and required background knowledge are good reasons to keep SciVis and InfoVis separate. In general, there is a trend in all areas of research toward more specialization because more advanced research questions require more in-depth knowledge and methodologies. This generic observation is also true for both SciVis and InfoVis, which have matured as research fields. Researchers need to have a thorough background in their respective areas, which is hard to achieve for the greatly differing types of methodologies typically employed in InfoVis and SciVis. Similarly, the issue of expertise affects the organizational form: the chairs, program committees, and reviewers of conferences or workshops should be experts, which is easier to achieve for narrower topic areas. Likewise, a specialized conference tends to be more appealing to an expert audience.

On the other hand, InfoVis and SciVis share many goals and basic principles, e.g., visual perception and interaction models. Therefore, a strong interaction between both fields can be productive; and, this interaction is already happening as illustrated by researchers that actively publish in both communities. It should be pointed out that visualization, in general, has started as an interdisciplinary endeavor, and it still is. Therefore, it is more than natural to maintain "interdisciplinary" links between InfoVis and SciVis. However, the advantages of interdisciplinary research may be even more pronounced for collaborations with outside fields. For example, feature extraction in 3D unsteady flow might benefit most from joint work with CFD engineers [10]; or color design issues and visual attention for interactive multi-variate data visualization might be investigated together with perceptual psychologists. Therefore, the "Think big!" should especially address the outreach to outside fields.

The current model of the separation in InfoVis and SciVis and the co-location of the IEEE Infovis Symposium and the IEEE Visualization Conference can be considered a good solution for the time being: it allows for separate organizational forms for InfoVis and SciVis and, at the same time, it facilitates interdisciplinary communication and discussion between both communities. Furthermore, additional co-located workshops provide enough flexibility to accommodate new trends (e.g. VAST and visual analytics) or venues for specialized interdisciplinary research topics.

2.2 In the InfoVis Search for Scientific Insight (Kwan-Liu Ma)

SciVis and InfoVis have each developed into distinct fields of study. I started my career as a SciVis researcher but I find myself now being actively engaged in both fields. Why? In the early days, for example, my work, and the one of many others, placed a strong focus on high-performance rendering of 3D physical phenomena or structures. However, if we look at the complete tasks of data understanding in the scientific discovery process, we can find many examples showing the need of information visualization. There are some inherent InfoVis aspects of the scientific data analysis problem which were not looked at. We need to either develop new InfoVis techniques or make creative use of known techniques for addressing these aspects.

In volume rendering, a critical task is to classify the different materials in a volume according to the purpose of visualization. Usually, classification is done by defining, through an interactive graphics editor, a transfer function mapping voxel values to color and opacity. The conventional 1D transfer function is of limited effectiveness in performing the actual classification. To obtain better classification results, higher-dimensional transfer functions that take into account more properties of the data, such as gradient, neighboring texture, and position, are needed. Similar challenges are found in the feature extraction tasks for 4D volume data from physics simulations, from which a data set typically consists of from hundreds to thousands of time steps. A single transfer function would not be able to accommodate the often varying dynamic range of data values over time. Furthermore, some of the features are defined by multiple scalar and vector quantities, suggesting that the feature extraction must be done in a high-dimensional space. The complexity of the conventional user interface, however, rises with the dimensionality of transfer functions. Higher dimensional transfer functions are too confusing, if not impossible, for the user to define directly. In this case, we can make use of information visualization techniques, many of which have been designed for understanding high-dimensional data.

If we generalize this transfer function problem and consider that the user's task is essentially a search for insightful visualization within a space defined by a set of data properties, visualization representing the user's search pattern can allow the user to easily switch back and forth between different points in the search space. How to represent this search space is more an InfoVis problem, which appears in many scientific applications. The solution that we derive must be integrated with both the SciVis and quantitative analysis steps through linked or superimposed views of the data.

The complete data understanding process involves multiple steps including quantitative analyses at different scales, visualization of the analysis results in both the data space and some derived space, and examining uncertainty inherently in the data or introduced in the process of visualization. In fact, visualization, if appropriately designed, can also be used to effectively direct the overall data analysis process. These needs demand new information visualization capabilities. Furthermore, modern large-scale scientific investigations are collaborative in nature. Next generation visualization technologies must help users keep track of their visualization experience, use it to generate new visualizations, and share it with others. An ideal visualization system should be therefore capable of displaying not only different aspects of the data but also information about how a picture is made and related to other pictures, as well as the knowledge derived from the pictures [3]. This is again an information visualization problem.

Over the past 15 years, we have made a lot of progress in advancing the state of the art in scientific visualization [4]. To develop a complete visualization solution for large-scale scientific investigation, however, I anticipate to see even greater exchange between researchers in SciVis and InfoVis. This annual meeting provides the best venue to facilitate such very much needed exchange.

2.3 Different Data and Different People (Jarke J. van Wijk)

In my view, there are two major differences between InfoVis and SciVis. Firstly, the kind of data studied differs. Generalizing, InfoVis is concerned with abstract and discrete data, such as multivariate data, trees and graphs, whereas SciVis deals with spatial and continuous data, such as volume and flow data. Secondly, the supporting disciplines and the background of the members of the communities are different. A member from the InfoVis community has typically a background in human computer interaction, psychology, statistics, or data mining, while an SciVis researcher will often have a background in for instance computer graphics, geometric modeling, numerical computing, and parallel processing. Is there a problem? I do not think so. Both communities are active, flourishing, and produce many interesting results.

Nevertheless, real innovation comes from out-of-the-box thinking and crossing boundaries, and I think there is much potential here. As a member of the SciVis community who later joined the InfoVis community also, I will focus on what SciVis can contribute to InfoVis, using the two differences mentioned as a guide.

One central problem in visualization is the scale of data sets. If really large data sets have to be handled, they have to be transformed. One approach is to convert discrete, abstract data into continuous, spatial data. A prime example is the use of landscape metaphors where discrete objects (articles, news messages, etc.) are positioned in 2D or 3D space, and next density distributions are generated and shown. Using such conversions, the InfoVis community can take advantage of exisiting SciVis methods and techniques.

Secondly, all disciplines mentioned that are used in SciVis can also be applied for InfoVis. As an example, I have a background in computer graphics and geometric modeling, and I used this to provide extra cues for the visualization of hierarchical data. This has led to for instance the cushion treemaps [9]. I believe that realism can be used as a means to visualize abstract data more effectively, and graphics people know how to do this. As another example, I have shown how differential geometry can be used to attack zooming and panning issues [8].

In short, I think there are many interesting opportunities for SciVis methods and SciVis researchers to contribute to InfoVis. And obviously, also the opposite case can be made.

2.4 InfoVis is from Venus, SciVis from Mars (Robert Kosara)

How different are the InfoVis and SciVis communities? Let me count the ways:

Technical soundness. While SciVis papers are usually very technical and go into great depth of how a particular method is implemented and why, InfoVis papers tend to be light on implementation details, and consider implementation a minor problem. This is of course problematic on the InfoVis side, where dataset sizes are growing, and we have little existing work that can deal with that. SciVis, on the other hand, easily gets lost in implementation issues that sometimes only work on a particular (brand of) graphics card, and whose novelty and useful life are therefore limited.

Theory. While building new things is certainly a big part of our life as computer scientists, we also need to understand the theoretical basics of our field. Most model papers have so far been published at InfoVis [6], or by truly interdisciplinary people at Vis [7]. But in order to become a proper field of research, we need a foundational theory of visualization, and a much deeper understanding of the things we do [2].

Process. Understanding the processes of design and implementation of visualizations is extremely important, especially for a discipline as young as visualization. InfoVis has a history of publishing artistic papers as well as design studies, both of which put a lot of emphasis on how the results were achieved, not just on the outcome. This is very valuable especially to beginners and outsiders, and needs to be emphasized a lot more.

Abstraction. While scientific visualization deals with things that are real, or that could be seen if they were, InfoVis usually does not. What does a bank account look like? How do you depict the results of a survey so that you can understand them and draw conclusions? The question of coming up with a visual representation from nothing in InfoVis demands a different approach than the quasi-photographic view of SciVis.

Interdisciplinary work. Visualization is inherently interdisciplinary. People who mostly come from a computer science background try to produce images that are perceived easily, and that communicate data effectively to the user. We draw on perceptual psychology, cognition, illustration, visual communication, etc. Yet this is hardly acknowledged especially in SciVis, while InfoVis researchers started conducting user studies and basing their work on literature in other fields long ago. The number of artists and other non-computer scientists is also much larger than in scientific visualization, which tends to scare them off with the level of technical knowledge that is required for entry.

Women. Look around you, how many women do you see? If there are quite a few, you stumbled into InfoVis or an InfoVis session at Vis. If there are mostly men, you're at Vis. Does this bother you? It certainly should, we need a lot more variety and color in our field, and InfoVis is doing a lot better here.

Some of the points in the above list are connected, and most of them present strengths as well as weaknesses. We can certainly act as if InfoVis and SciVis were the same, and hope that by doing so the differences will simply disappear – but that is not going to help. In fact, we can profit much more from realizing and understanding the differences, and trying to leverage them. Who says an InfoVis paper can't be extremely technical, or a SciVis technique can't be documented from start to end and thoroughly evaluated?

Like it or not, the historical division between InfoVis and SciVis is here to stay. But this should be taken as an advantage, as something that can drive innovation, rather than an obstacle.

2.5 Communities, Divides and Bridges (Helwig Hauser)

It is not in the nature of panel discussions to significantly change the course of history. If at all, panels can stimulate a broader discussion amongst scientists about relevant issues. But this, at least, is very important. And the community divide between SciVis and InfoVis definitely is a relevant issue, and even though already previously, e.g., at Vis 2003 [5], panelists discussed this issue, it is still necessary to explicitly discuss what possibly divides or integrates SciVis and InfoVis. Thinking about it and discussing the issue, we can try to delineate what we just think from what actually is true. This, hopefully, then leads to a more informed (and a less emotional) point of view.

When being open to new points of view, when being ready to expand the horizon of our usual considerations, we can identify a lot of useful input from outside worlds [1]. Many InfoVis solutions proof very useful when it comes to the visualization of multivariate, scientific data (see, for example, Fig. 1 for a InfoVis-SciVis-mixed analysis of scientific data). Increasingly, also results from the SciVis world, such as the general-purpose use of GPUs, for example, or the use of semitransparency for visualization, inspire the InfoVis world. Also, we have to face the fact that research topics change and evolve over time, both also in the fields of SciVis and InfoVis, and we are departing from known grounds and enter new ones [1]. SciVis data, for example, becomes more versatile, i.e., multi-dimensional (e.g., time-dependent and 3D), multivariate, multi-modal, multi-typed (e.g., also including discrete, categorical, nominal data, etc.), aso. InfoVis, on the other hand, faces new challenges when dealing with really large data, when going 3D, or when being confronted with dense data distributions which tightly relate to the scenario of continuous data as in SciVis.

Another point of view is the one of practitioners. For many of those who actually need visualization, it really makes no point of whether something is SciVis or InfoVis – visualization solutions are needed – and if they stem from different fields, that's just fine, but not really relevant (in the first place). In many application cases, we anyhow see that the visualization part only makes up a limited part of the complete solution – other aspects like data acquisition and management, documentation and reporting, ergonomics of the GUI, automation, etc., make up important parts, as well. From this point of view, for example, it not really makes a whole lot of sense to finely distinguish between SciVis and InfoVis. A similar point of view, for example, also is the one of funding organizations – it might pay off to sell our technology as Vis (not as SciVis or InfoVis). The same also holds for application people. Do the life sciences need SciVis or InfoVis? They probably need both.

Finally, there is yet another issue, which shows up when we take a step backwards and consider the panel topic from a slightly larger distance: in addition to SciVis and InfoVis, there is a lot more which also is visualization, or at least tightly relates to it. Knowledge visualization, for example, which much more focusses on presentation than on exploration and analysis, and cartographic/geographic visualization, which – in principle – has important aspects in common with InfoVis (but with a strong and central relation to geographical, i.e., spatial references), make up just two related fields (amongst others more), which also should be considered. Accordingly, it is well possible that in future, we not only talk about SciVis and InfoVis, but about *x*Vis, with *x* being a lot more, or, dropping the *x*, just about Vis.

3 Short Biographies

Daniel Weiskopf is an assistant professor of computing science and a co-director of the Graphics, Usability, and Visualization Lab (GrUVi) at Simon Fraser University. His research interests include scientific visualization, GPU methods, real-time computer graphics, mixed realities, as well as special and general relativity. He received a diploma degree (MSc) in physics and a PhD in physics, both from the University of Tübingen, Germany, and he did his Habilitation in computer science at the Univ. of Stuttgart, Germany.

Kwan-Liu Ma is a professor of computer science at the University of California at Davis. He has a PhD in computer science from the University of Utah. Before joining UC Davis in 1999, he was with ICASE/NASA LaRC as a research scientist. His research spans the fields of visualization, user interface design, and high-performance computing. Presently, he has projects in terascale visualization, intelligent visualization interfaces, security visualization, and large graph visualization. More information about his work can be found at http://www.cs.ucdavis.edu/~ma/.

Jarke J. van Wijk obtained a MSc degree in Industrial Design Engineering in 1982 and a PhD degree in computer science in 1986 from Delft University of Technology, both with honors. He has worked at a software company and at the Netherlands Energy Research Foundation ECN before he joined the Technische Univer-

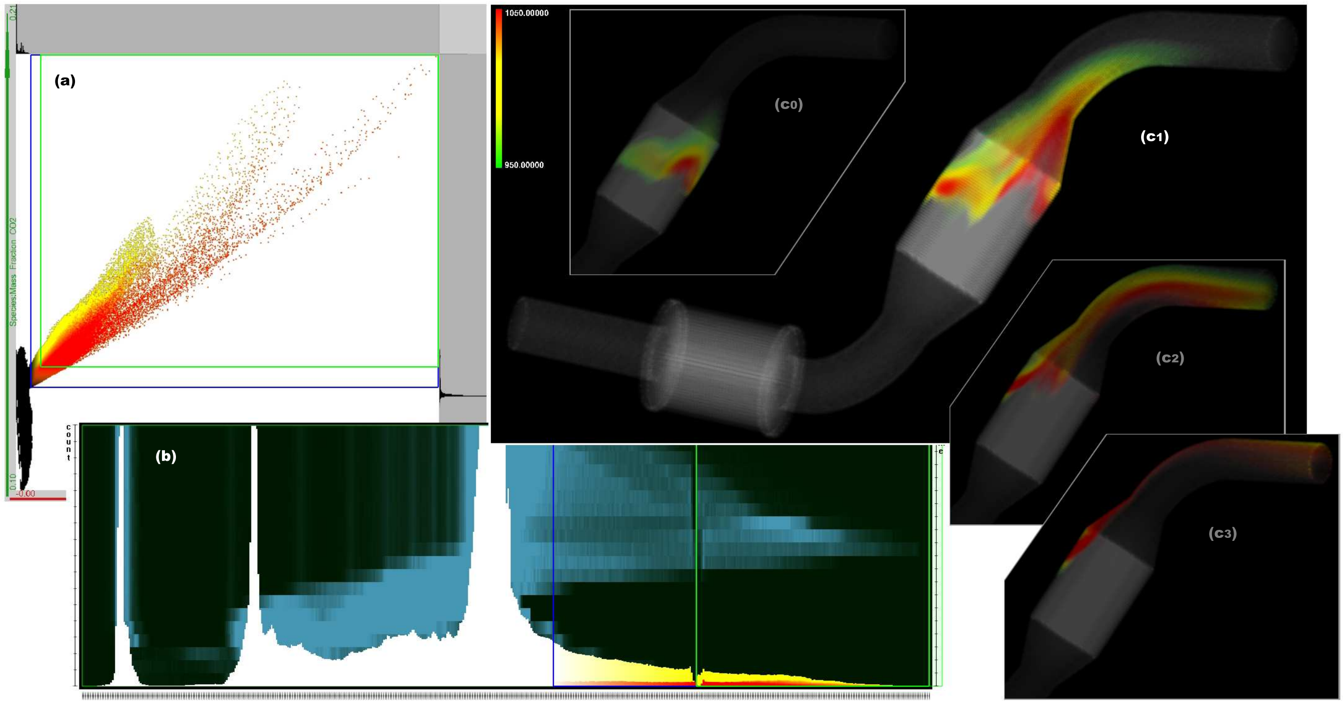

Figure 1: Visualization of the oxidation during the regeneration of a Diesel particulate filter (SciVis & InfoVis integrated). In the scatterplot (a) the CO-CO_2 distribution of the data is visualized (larger amounts of CO/CO_2 have been selected through brushing) and in the histogram (b) the temperature distribution is shown (highest values brushed). A 3D focus+context visualization (c1) shows the data according to the selections in (a) & (b), i.e., highlighting the oxidation front (at time $t = 35s$, temperatures color-coded). Dimmed views (c0), (c2), and (c3) show the data at time steps $t = 30s$, $t = 40s$, and $t = 45s$ after the start of the regeneration, respectively.

siteit Eindhoven in 1998, where he became a full professor in Visualization in 2001. He is a member of IEEE, ACM SIGGRAPH, and Eurographics. He has been paper cochair for IEEE Visualization in 2003 and 2004, and is paper cochair for IEEE InfoVis in 2006. His main research interests are information visualization and flow visualization, both with a focus on the development of new visual representations.

Robert Kosara is an Assistant Professor of Computer Science at the University of North Carolina at Charlotte (UNCC). He received his M.Sc. and Ph.D. degrees in Computer Science from Vienna University of Technology in Austria. His interest in information visualization is based to a large part on the specific problems he has to solve in this field, and the way it forces him to work in a truly interdisciplinary way.

Helwig Hauser graduated in 1995 from Vienna Univ. of Techn., Austria. In 1998, he received the degree of a Dr.techn. (PhD), also from TU Wien. From 1994 until mid-2000, Helwig Hauser worked as a Univ.-Ass. (assistant professor) at the Inst. of Computer Graphics at TU Wien. Since 2000, he works for the VRVis Research Center in Vienna, Austria, as a key researcher in the field of visualization. In 2003, Helwig Hauser became the scientific director of VRVis (`http://www.VRVis.at/`). His main interests include volume, flow, and information visualization, and the combination thereof. Helwig Hauser is member of IEEE and EUROGRAPHICS.

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REFERENCES

[1] Helwig Hauser. Towards new grounds in visualization. *ACM SIGGRAPH Computer Graphics*, 39(2):5–8, 2005. VisFiles column.

[2] T. J. Jankun-Kelly, Robert Kosara, Gordon Kindlmann, Chris North, Colin Ware, and E. Wes Bethel. Is there science in visualization? In *IEEE Visualization (Panel Proceedings)*. IEEE CS Press, 2006.

[3] Kwan-Liu Ma. Visualizing visualizations: User interfaces for management and exploration of scientific visualization. *IEEE Computer Graphics & Applications*, 20(5):16–19, 2000.

[4] Kwan-Liu Ma, Eric Lum, Hongfeng Yu, Hiroshi Akiba, Min-Yu Huang, Yue Wang, and Greg Schussman. Scientific discovery through advanced visualization. In *Proceedings of the DOE SciDAC 2005 Conference*, pages 491–500, June 2005.

[5] Theresa-Marie Rhyne, Melanie Tory, Tamara Munzner, Matthew Ward, Chris Johnson, and David H. Laidlaw. Information and scientific visualization: Separate but equal or happy together at last? In *IEEE Visualization (Panel Proceedings)*, pages 611–614. IEEE CS Press, 2003.

[6] Melanie Tory and Torsten Möller. Rethinking visualization: A high-level taxonomy. In *Proceedings Information Visualization*, pages 151–158. IEEE CS Press, 2004.

[7] Jarke J. van Wijk. The value of visualization. In *Proceedings IEEE Visualization*, pages 79–86. IEEE CS Press, 2005.

[8] Jarke J. van Wijk and Wim A. A. Nuij. Smooth and efficient zooming and panning. In *Proceedings IEEE Information Visualization*, pages 15–22. IEEE CS Press, 2003.

[9] Jarke J. van Wijk and Huub van de Wetering. Cushion treemaps. In *Proceedings IEEE Visualization*, pages 73–78. IEEE CS Press, 1999.

[10] Daniel Weiskopf and Gordon Erlebacher. Overview of flow visualization. In Charles D. Hansen and Christopher R. Johnson, editors, *The Visualization Handbook*, pages 261–278. Elsevier, Amsterdam, 2005.