Redefining a Contribution for Immersive Visualization Research

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Abstract
Immersive computing modalities such as AR, VR, and speech-based input are regaining prominence as research threads in the visualization field due to the advancement in technology and availability of cheap consumer hardware. This renewed interest is similar to what we observed a decade ago when multitouch technology was gaining mainstream adoption. In this work, we reflect on lessons learned from designing for multitouch, with the goal of highlighting problems that may also emerge in AR/VR research. Specifically, we emphasize the need for the field to rearticulate what is expected from research efforts in the area of visualization on immersive technologies.

Author Keywords
Immersive technology; AR; VR; speech; multitouch

ACM Classification Keywords
H.5.m [Information interfaces and presentation]: Miscellaneous

Introduction
Computing modalities such as augmented reality, virtual reality, touch, and speech-based input have gained potential for mainstream adoption due to the introduction of advanced technology in low-cost hardware. The visualization research community has taken a keen interest in en-

visioning novel ways of using these modalities to support the process of sensemaking with data. Although the modalities themselves are not new [2, 6, 7], interest in them has renewed because there is a greater likelihood of research contributions reaching end users now than before.

Each modality unlocks a plethora of novel use cases and opportunities for further exploration. Past research has clearly demonstrated the potential of these modalities in collaborative data analysis [3] and for envisioning novel interaction techniques [8]. The opportunities are, however, accompanied by an equally distinctive set of design challenges. These include representational challenges (e.g. 2D vs. 3D visualizations for AR/VR), interaction challenges (e.g. selecting objects in 3D interaction environments [1]), and task ambiguity challenges (e.g. interpreting voice-based questions about data [8]).

Several research endeavors are currently underway that examine these challenges across different modalities. However, one problem that often stifles such endeavors is the novelty fallacy: the argument that an idea is superior exclusively because it is new. As a result, an idea that does not demonstrate novelty is not considered a significant contribution.

This rush for novelty hinders progress by making it difficult for researchers to address the fundamental problems that currently affect our adoption of the new modalities. In this work, we discuss this theme further. Drawing on the analogy between multitouch and the new immersive modalities, we highlight issues from the past that may emerge again. Finally, we discuss the potential ways in which the research community can address these issues.

A lesson from the past

The emergence of mainstream affordable AR/VR technology has surely piqued the interest of the visualization field. Yet, such a boost is not unique. In the past, we witnessed similar enthusiasm when multitouch technology entered mainstream usage with the introduction of Apple's iPhone and iPad. Multitouch equally fascinated the research community as it opened doors to new platforms and design challenges.

However, while the multitouch revolution was real and far-reaching, our community may not have fully unlocked the potential of visualization on this technology. In the years since, only about twenty research articles have been published in leading conferences, such as CHI[1], VIS[2], UIST[3], DIS[4], and ISS[5], that address this research thread.

This relative lack of significant research can be interpreted in several ways. One argument could be that we simply overestimated the benefits of multitouch for visualization. Alternatively, one could conclude that multitouch may just not be an ideal platform for visualization. The same argument can then be extended to other, newer technologies such as AR/VR, and speech-based interfaces.

However, we believe that such an interpretation would be premature and inaccurate. Instead, we speculate that the lack of research is due to a different problem that currently burdens research explorations in new domains — the inconsistency between the contribution the visualization community expects and the contribution that is needed.

[1] Computer-Human Interaction www.sigchi.org
[2] Visualization www.ieeevis.org
[3] User Interface Software and Technology Symposium uist.acm.org
[4] Designing Interactive Systems www.dis2016.org
[5] Interactive Surfaces and Spaces iss.acm.org

Deconstructing contribution

Munzner highlights five categories in which the contribution of visualization research can be classified — Technique, Design Study, Systems, Evaluation, and Model [5]. While the categorization is fairly comprehensive, it omits any reference to visualization research for new devices, platforms, and technologies. Such research is typically classified under the Techniques and Design Study categories, neither of which effectively represent the effort required in bringing visualization to these new platforms. Instead, the categories indirectly mandate that research endeavors result in a novel representation technique or interaction behavior.

The challenge in bringing visualization to new technologies is not only of envisioning novel methods of presenting data. Rather, the true challenge is in adapting the existing techniques, ones we are familiar with and presume to be fairly robust, to these new platforms. For example, how should data-dense techniques such as parallel coordinates or scatterplot-matrix be presented on handheld multitouch devices? Similarly, how can traditional 2D visualization techniques such as barcharts and linecharts be projected in a multiuser 3D Virtual Reality environment?

A research exercise that explores the answers to these questions will always run the disadvantage of seeming familiar to the reviewers. Even though the constraints of input and usage scenarios change drastically, because the underlying representation is not new, the research runs the risk of not being novel enough.

A similar disadvantage is also present for interaction, which is perhaps more important than representation to get right on new technologies. While decades of research has resulted in consistent solutions for most interaction scenarios on desktops, it is understood that these solutions do not translate to other platforms [4]. In practice, however, we observe that reviewers often measure the worthiness of a contribution based on how similar or dissimilar it seems to solutions designed earlier for desktops.

Getting the interaction right is a considerably difficult problem to solve. For instance, it is unclear how we can effectively interact with treemaps (e.g. Map of the Market [9]) on a mobile device - how rich can the feature set be and which interactions do we use? Similarly, how should we annotate the components of a visualization to meaningfully interact with it using voice? Solving these interaction challenges often requires several iterations, and even then we may not find ourselves any closer to identifying the correct implementation.

The underlying goal, however, is to make visualization work for users on a new platform or modality. We firmly believe that the solution is not to envision every single aspect of the interface and the interactions. Novelty will only excel at bringing a user to the new platform, not keeping her there.

Redefining Contribution

In light of the above discussion, we feel that there is a need to rearticulate what the goals and contributions of a research effort must be. This exercise would require researchers from different areas of expertise within our field to deliberate and converge to a collective understanding. In doing so, it would also be valuable to reflect on the practices followed within the design fraternity and the rich knowledgebase of principles for interface and interaction design that they have gathered.

For example, simplicity is often a goal that expert designers strive for. The goal postulates that the design should make simple, common tasks easy, and communicate clearly in the user's own language. This is relevant for visualization, whether one is designing a technique, an interaction, or an entire workflow. But simplicity can also be at odds with novelty as it requires one to deconstruct what may already exist instead of rethinking additional or complementary solutions.

It is important to consider this and other design principles when constructing a description of a contribution. Below, we present four guidelines that may be beneficial as starting points in the exercise of redefining the contribution.

1. **Novelty** - Do not make novelty of work the ultimate goal. In designing for the end-users of a new platform, we often overemphasize the need for novelty of the platform within the design of our systems. However, there is considerable value in research that solves a well-motivated problem using a combination of preexisting solutions.

2. **Value vs. overhead** - Measure the value of a solution against the added effort the user needs to put. Even when a solution solves a relevant problem, it may do so by introducing significant cognitive and physical overhead. In evaluating a contribution, it is important to weigh the value and overhead equally.

3. **Effort to publish** - Examine the solution for changes required to release it to end-users. It is useful to estimate how much the solution would differ if one were to release it publicly. This is not to acknowledge the engineering challenge that may be needed, but instead to understand the practicality of the solution, and whether the needs of the end-user are considered in the design of the solution.

4. **Demonstration limitations** - Accommodate for the fact that text or video may not be fully highlighting the complexity of the problem or the solution. With alternate input methods that constitute the larger piece of immersive technologies, it is difficult to judge the quality of the contribution through text, images, or videos. It is equally difficult to fully comprehend the true complexity of the problem being addressed or the process that was followed to solve it. This may require us to rethink how we release and share research findings, but is fairly important for us to consider as reviewers.

Conclusion

With the emergence of newer technologies, there are increasing opportunities for visualization research. The opportunities require us to envision novel visual representations and interactions techniques. However, to make meaningful contributions on the new technologies, there is also a need for us to revisit solutions that may have been found earlier, but may be non-trivial to adapt to the new domains. We discuss the challenges that are currently faced by research of that nature. Drawing analogy from multitouch, we discuss how these issues are relevant for newer technologies, and present guidelines to assist us in better defining what a contribution on these technologies should be.

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