On the Death of Visualization[1]

Can It Survive Without Customers?

Bill Lorensen

Introduction

After attending the IEEE Visualization 2003 Conference in Seattle, I captured some of my observations and opinions of the state and future of our field. I have been thinking about some of these issues for the past five years. To some extent these thoughts are a reflection of my work experience at an industrial research lab, but I think they deserve exposure to a broader audience. My opinions are personal but I have been listening to some of my peers express similar thoughts and concerns.

What gives me the right to make these criticisms and comments? I don't pretend to know all the technology of our broad, multi-disciplinary field. Over the past 35 years my career has focused in two areas: scientific/biomedical visualization and software engineering. I developed skills in the later so that I could be more productive in the former. Even though I have not published new algorithms for a few years, I keep active in our community and still foster and enjoy the personal relationships I've made over the years. Since I have reached a point in my career when I don't need more fame and fortune, I can be objective in my assessments. Also, I consider myself as part of the founding generation of Visualization (there are many of us). Ancestrally, recently tenured faculty are the children and the current students are the grandchildren. In some respects, I think my comments might be more accepted by this new generation as they leave their current graduate school nests. I expect to get the most criticism from my peers and the second generation. But, as a grandparent, it is important to transfer wisdom to subsequent generations. The decision to accept and act on the advise of the elders is optional.

It is healthy for an organization or community to take an introspective view and look for ways to improve itself. The title of this note is meant to provoke discussion and debate, not to attack people or damage careers.

Visualization, as a field of computer science, was established in response to a need from the scientific and biomedical communities. These communities were facing an explosion of simulation and sensor information that required new algorithms and interfaces to help researchers effectively explore the mass of data and gain insight into phenomenon represented by the data. These customers of visualization technology felt that computer graphics[2], the original venue for innovation in visualization, focused on techniques and applications that would not meet their scientific requirements. To some extent, computer graphics was responding to the needs of its new customer base, entertainment.

---

[1] In this note, Visualization means the IEEE Visualization Conference. I think this is fair because conferences and publications are a reflection of the field.

[2] In this note, computer graphics means the ACM Siggraph Conference.

The overriding theme of my comments is simple: our community has lost its customers. Here are a few observations that I justify in subsequent paragraphs:

- Visualization, alone, is not a solution.
- Visualization is a critical part of many applications.
- Visualization, the Community, lacks application domain knowledge.
- Visualization has become a commodity.
- Visualization is not having an impact in applications.

The Birth of Visualization

In any look to the future, it is valuable to look at the past. Visualization began because customers in big science, biomedical and aerospace were drowning in data. With the reality of Moore's Law driving computation, new sensors and astounding advances in engineering, there was a call to arms to provide technology to process data and turn it into information. The processing of structured volumetric data preceded these demands, mainly driven by medical imaging computed tomography and to a lesser degree magnetic resonance imaging. The technical venues for "visualization" were mainly medical conferences (like RSNA[3]) and ACM Siggraph. In 1987, Harvey Cline and I published the Marching Cubes paper at Siggraph. Arie Kaufman presented the notion of voxelization in the same session as Marching Cubes. In 1988, Bob Drebin and his colleagues at Pixar, published the seminal volume rendering paper at Siggraph. At the time of publication, the expected application of these techniques was limited to medical applications. Now, we look back and see that these techniques have had a profound impact on Visualization and to this day, much of Visualization revolves around isosurfaces and volume rendering. Another big piece of Visualization, flow visualization, revolves around line interval convolution (LIC). LIC was first introduced by Brian Cabral at Siggraph 93. The interest at Siggraph in visualization topics rapidly declined. Siggraph's focus was moving towards creating reality and found a hungry customer in the entertainment industry. This included Hollywood and video games.

The Heyday of Visualization

In 1988, Nick England, then at Transcept, had a Birds-of-a-Feather (BOF) at Siggraph '88 that brought together people interested in the new area of volume visualization. Nick's company built the TAAC processor that was capable of fast video processing. The folks at Pixar (Drebin, Carpenter and Hanrahan) also had a device, the Pixar Image Computer), that they programmed to produce exquisite volume renderings. Actually, as far as I recall, neither device was built specifically to process volumes[4]. Also, Marc Levoy published seminal volume rendering work as a PhD student at UNC Chapel Hill. In 1989, Nick's BOF turned into the first Volume Visualization Workshop, held at UNC at Chapel Hill. A year later, Arie Kaufman, Larry Rosenblum and Greg Nielson (with others I'm sure) convinced IEEE to sponsor the first Visualization Conference.

The Visualization Conference established itself quickly as the place to publish solid techniques and applications in Visualization. The Tutorial/Keynote/Panel/Papers session that had been so successful at Siggraph was augmented with a Capstone and adjoining workshops and symposia: Information Visualization, Volume Visualization and Parallel Rendering. This established a weeklong program of stimulating and informative sessions. I recall lots of diversity in the audience and the program.

---

[3] The Radiological Society of North America

[4] As an aside, the development of Marching Cubes was motivated by a GE Division, SCSD, that was creating a fast (25k tris/second) graphics engine called the Graphicon.

The Maturity of Visualization

Through the nineties, the Visualization Conference grew and the paper selection process became more and more selective. In the beginning, many Visualization papers were rejected Siggraph papers. This does not mean the papers were inferior to those of Siggraph, but that Siggraph felt that their audience was not interested in the topics. I confess that I submitted a few papers first to Siggraph and then to Visualization[5]. Volume rendering continued to be a hot topic, but it moved from the structured acquisition configurations of medical imaging to CFD and finite element applications. The Conference also started looking at techniques for navigating very large spatial and temporal datasets, mainly produced by the aerospace industry. Modeling, always a crucial component of visualization, also received a lot of attention. In particular, simplification and subdivision techniques became popular topics. Interestingly, these two topics continue to receive interest at Siggraph. As the introduction of new techniques slowed, the Conference started to focus on performance. In recent years, there have been few new techniques introduced. A notable exception is the visualization of MRI Diffusion Tensor Images (DTI).

The Death of Visualization

A few years back, I sensed that something was changing at the Conference. I can recall listening to papers and asking myself, "Is this a Vis paper?" Although the quality was still improving, I found that I was learning less at the Conference. There were fewer nuggets that I could take back. Part of this was because of the changes in my research focus. Our group at GE Research was seeing less and less corporate funding for visualization work. We had successfully written the Visualization Toolkit textbook and software and in many respects our customers didn't need us as much. Many techniques, either our own, or others, were available commercially or free. Our algorithms were being taught in school[6]. The impact of our work on the Company was declining. Our engineering counterparts in the GE businesses were building full solutions, with visualization as a small part. In fact, we had filled the technology pipeline and the businesses were happy to pick and choose what they needed. In a commercial setting, we had to do something new. We combined with our Computer Vision group and began to focus on image analysis and segmentation. All of our visualization work was transferred to other organizations within the Company. Our market had changed and our customers forced us into new areas. I had seen similar, so-called disruptive, changes in the past. In fact, I hypothesize that industrial research labs are leading indicators for technology forecasts, but that is a topic for future discussions.

I see Visualization following a similar course and if we don't adapt and change, the field (and Conference) will disappear. Our customers have disappeared. In some cases, they don't need us because they can purchase robust, well-engineered instances of our techniques. In other cases, we have not been responsive to their requirements, mainly because we don't understand their problems. Certainly, there are some customers still present at the Conference, namely the National Labs. But even there, it's the computer scientists, not the scientists that attend Visualization.

I provide one example that shows the disconnect between Visualization research and commercial offerings: Volume Rendering. Now I have to be careful here because I have a lot of friends that worked or work in this area. I'm not calling for an end to research in Volume Rendering, maybe just a redirection. My Company, GE, sells a radiology workstation called Advantage Windows. This system has, among many features, a volume rendering application. Vital Images sells Vitrea, a system that has, among many features, a volume rendering application. Both systems are built for radiologists, not scientists. I do not consider myself an

[5] My 1993 Vis paper, "Geometric Clipping Using Boolean Textures," was a rejected Siggraph paper. It won Best Paper Award at Vis that year.

[6] I have had many professors tell me that Marching Cubes is just an exercise in an undergraduate course.

expert at volume rendering and transfer function design, but I can load a dataset into the GE system, pick a reasonable transfer function from a select few and produce a beautiful, informative volume rendering in a few minutes. I can interact with the volume at 15 to 20 frames per second, produce animations and send the results to film or a printer. I can store selected renderings in the image database and even cut a CDROM that has all of the original slice data and my volume renderings. I know the Vitrea system can also do this. The systems read DICOM, a standard imaging format. In addition, if the CT data has been acquired at different slice spacings or gantry tilts, the rendering still works. The user can move quickly between this "Visualization" application and applications that do image display, measurement, segmentation and shape analysis. And these are not small datasets. Typical clinical CT exams are 512x512x500-1000 images. For cardiac studies, that number may be multiplied by the 16 acquired phases. These are commercial systems that have, as one piece, a volume rendering application. Granted they are not cheap, but why would a clinical radiology department use some research code. The underlying algorithms for these systems are based on techniques that members of our community created (probably years ago). The commercial companies have invested substantial engineering to adapt, refine and optimize those algorithms. How many of our community know about these commercial systems? I suspect there are examples in other areas of Visualization.

Visualization is dying. Like in many medical applications, early detection can lead to a cure if the proper steps are taken.

Towards a Cure

The Conference nurtured the field from its birth in computer graphics and the Conference can revive the field and itself. I have a few ideas but they do have a bias towards medical imaging:

- *Embrace our customers:* Find out the important problems they face. Ask them where they see innovation playing a role. **Keynotes and Capstones** are a great opportunity to expose our community to exciting application areas. We could solicit **more application papers** and insist that they be co-authored by domain specialists.

- *Form alliances with other fields:* Visualization is one piece of an application. It is often the most part of an application to the user. **Courses and panels** offer the opportunity to introduce new fields and show their similarities and differences to our field.

    - Our medical visualization community would benefit from close contact with medical image analysis. Computer Vision dominates that field. Computer Vision tends to be more mathematical than Visualization but lacks the expertise to transform results into compelling and informative presentations.

    - Structural Analysis is another field that could provide visualization challenges and benefit from our algorithms.

- *Define some grand challenges*. These may go beyond what our customers need in the near term. **Workshops** can refine ideas and establish plans of attack. I have a couple that excite me.

    - The Digital Human – produce a body double of individuals. This includes a complete radiological and medical history baseline. In addition to the data, provide simulations of the major organs and systems within the body. Include multi-scale information and simulations from the organ to the cell to the gene. There is already interest at DARPA (Virtual Soldier) and NIH.

- The Digital Medical Illustrator – produce patient-specific illustrations of anatomy that rival those of an expert medical illustrator.

Summary

Visualization is still an exciting discipline. But, without customers, the field and Conference will disappear. We owe it to the students and young faculty to revitalize the field