Immersive Visualization Bootcamps: sharing expertise, building community

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Figure 1: Participants in the Immersive Visualization Bootcamp held at the University of Wyoming's School of Energy Resources.

ABSTRACT

A major issue concerning high-end visualization technologies is that they are frequently not embraced by the researchers for whom such systems were expected to benefit. Considerable resources are often brought to bear to stand-up a large new visualization display, but often without adequate training to help those who are now expected to make the system useful for their local science community. Officials who commit to secure a new system generally do so because they have seen demonstrations of the best software revealing its potential. But what they don't see is the hours of training and experience that were needed to make the system work well, and the additional time demand to engage with the science community. To help new members of the high-end visualization community establish themselves and become more rapidly effective, we organized and hosted a pair of condensed seminars (bootcamps) that simultaneously introduce participants with best-of-class software and introduce them to both experienced and other new members of the community. The software applications are presented not as demos, but as tools, with explanations and opportunities for learning how to genuinely use them. The community continues beyond the bootcamps with shared experiences and documentation via a web-hub.

Index Terms: I.3.7 [COMPUTER GRAPHICS]: Three-Dimensional Graphics and Realism—Virtual Reality; I.6.3 [SIMULATION AND MODELING]: Applications—Immersive Visualization;

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1 INTRODUCTION

Governmental funding agencies have continued to fund large-scale visualization technologies, including multi-panel tiled walls and walk-in immersive systems (i.e. CAVE$^{\text{TM}}$-style systems). Legitimate arguments are made that such systems can enhance the scientific process [4] [3] while improving workflow in the areas of well-path exploration [8], microbiology [13] [18], atmospheric flow [2], and geo-sciences [11] [7]. However, persistent use of most high-end systems has yet to be attained.

Adoption of high-end visualization systems is impeded by several factors. One factor is location, and there is generally little that can be done about that for truely large scale facilities. What can be done is make these systems sufficiently enticing and easy to use by providing portable, laboratory-sized systems and good software that integrates into the scientific workflow that there is enough "energy" to boost the researcher over the hurdle of location.

Illustrious software is out there. Finding the good software though can be difficult. In the past there were communities of like-minded visualization developers who frequently shared techniques and applications, which raised the level for all participants [1] [9]. There have also been gatherings where software examples and use-cases have been presented to like-minded researchers. For example the CAVE Research Network User Society (CAVERNUS) hosted a series of meetings on using the CAVE Library. Workshops were also held at the IEEE Visualization conference in 2008 [17], and the IEEE Virtual Reality conference in 2012.

Seeing an opportunity to inspire a renaissance of like-minded visualization technologies to come together to learn and share, we organized a series of "Immersive Visualization Bootcamps".

2 LOGISTICS

These bootcamps were targeted primarily toward immersive visualization facilitators — leaders at facilities that recently, or planning to come online, but lack software and experience in the realm of high-end and immersive visualization. Similarly, attendees may have come from an established center that suffered an exodus of expertise and are looking to reboot. The final group of attendees came from on-going facilities with both software and expertise that simply wanted to expand their capabilities and user populations.

With time support from Idaho National Laboratory, Indiana University and Kitware Inc., we decided to open the bootcamps to anyone, and charge a minimal fee to cover the hard costs of the sessions. Additionally, speakers funded their own travel in order to participate in the events, further keeping our costs low. Participation of companies that gave presentations — Kitware Inc. and Mechdyne Corp. — were likewise provided as in-kind contributions.

The two facilities to host bootcamps were the Indiana University Advanced Visualization Lab's IUPUI/Indianapolis center, and the University of Wyoming's School of Energy Resources whose CAVE literally came online weeks before hosting. Host locations were selected based on three criteria: free for our use, able to run most of the software on the agenda, and geographically spread out. Each criteria was part of the scheme to make the bootcamps affordable. By choosing disparate geographic locations, attendees could choose to attend the nearer event, possibly within driving distance. Obviously holding the events at venues offering the facilities at no charge was a cost benefit, but additionally, recognizing that being a host would be advantageous to their facilities, each host also generously provided funds for dinners and other social gatherings.

3 Software

The extensive experience in immersive visualization software by the organizers provided the opportunity to select a wide variety of applications that have been deployed and are in-use by working domain scientists. The variety ranged from applications developed on multiple virtual reality toolkits, many open-source, but not exclusively, some as VR from the ground-up, others with VR grafted onto visualization tools. Software talks for the two bootcamps largely overlapped, but in cases where licenses were required or there was a conflict between the operating system and the software, substitutions were made.

Toirt Samhlaigh • Gaelic for Volume Visualization, Toirt Samhlaigh is an open-source visualization tool that renders volumes by applying transfer functions to the data using a GPU view-aligned texture rendering approach [12]. Two aspiring methods of specifying transfer functions are provided within Toirt — a Gaussian shape manipulator and a data plotted against the gradient selector. These transfer function editors make Toirt a valuable volume visualization tool even for the desktop. Toirt Samhlaigh was written with the Vrui open-source VR library [10] through which it offers a number of interactive immersive tools.

LidarViewer • A visualization solution for the rendering of point-cloud datasets. LiDAR data scanners are the most common source of point-cloud data, and generally produce datasets consisting of billions of point values. Thus LidarViewer provides a hierarchical data structure that can transfer data into and out of memory as the region of interest shifts [11]. Also built using the Vrui open-source VR library, it can take measurements both from internal Vrui measurement tools as well as special algorithms that can calculate a mathematical expression for a selected subset of the points.

VMD • The VMD (Visual Molecular Dynamics) application is a widely used molecular structure visualization tool [19]. It is typically used as a desktop tool, but has included "exotic" interfaces for haptics devices and virtual reality displays for nearly 15 years. Chemists have long found a need for improved perception while interacting with molecular displays, including stereoscopic rendering and 6-DOF inputs such as the original SpaceBall. For multiple-screen virtual reality though, the immersive feature is still more of an add-on to the core application. The interactions available are simple but effective means of enhancing the perception of the structure. The FreeVR virtual reality library is the primary means by which multi-screen head-tracked display is accomplished [16].

ML2VR • Looking to enhance the user base of their 6-sided CAVE style display (the DiVE), the Duke University Visualization Technology Group looked to what tools were being used by the engineering faculty in their research and classes. The Matlab program from Mathworks was the overwhelming rejoinder. The result is the ML2VR tool that translates between the Matlab desktop interface and a virtual reality display [21]. As the rendering system of Matlab is a closed program, the adopted solution was to use an OpenGL intercept method of capturing the graphics produced by Matlab desktop and sending it to the ML2VR rendering and interaction application in the CAVE. Because Matlab is in fact a programming language, the ML2VR package includes a feedback API that takes advantage of the Matlab socket interface to receive and handle interaction inputs sent from the user in the CAVE. The ML2VR immersive application is written for both FreeVR and the Syzygy [14] VR libraries.

ParaView VR • ParaView is a popular open-source GUI tool for scientific visualization built on the VTK visualization API. It has established itself as one of the primary visualization tools for many scientific domains. As a general-purpose visualization tool, it serves as a good testbed for quickly doing an analysis of data, and can continue to be used to enhance the visualization, and even produce animations as the output. Taking advantage of ParaView's multi-screen rendering along with the plugin system, a virtual reality interface is now part of the standard source code release. While ParaView VR does not link to a VR rendering library, for 6-DOF position tracking data it makes use of either (or both) the VRPN input library [20] or the Vrui system's input device daemon.

ArtifactVis • Visualizing data from an archaeological dig involves bringing together disparate and often discrete items of data. For example, the coordinates of artifact locations in a dig, photographs of the dig site, and point cloud data from LiDAR or photographically reconstructed sources. ArtifactVis is a plugin for the CalVR virtual reality interface system [15]. The style of the CalVR system is to bring together multiple worlds and objects into a single world space. This style makes it ideal for archaeological data, but it can also serve as a renderer for other polygonal model data sets, molecular structures, etc. The ArtifactVis plugin as well as the CalVR system are multi-platform, and available as open-source programs.

InstantReality + Virtools • Object and location models are not often thought of as a typical source of scientific visualization data, but there are frequently circumstances where a scientist may process an initial dataset and save the result as polygonal geometry. For example, a geologist may have a polygonal model of some field location where they perform research. Furthermore, there are other areas of research or academic presentations well suited to the polygonal model. InstantReality and Virtools were the two world exploring tools covered in the Indianapolis bootcamp. The InstantReality tool [6] is specifically designed around X3D [5], which offers both polygonal representations, but also interactions through a scripting interface. It is a cross-platform tool that is freely downloadable, but closed-source. Virtools is a complete virtual world tool that offers programmed interactions as well as integrated features such as collision detection and physics. Virtools is also closed-source, and freely offers a desktop player, but requires a license to run in VR systems, and only runs on Microsoft Windows systems.

Conduit • Conduit is another tool for working with polygonal data from Mechdyne Corporation. The Conduit suite is designed to take advantage of existing desktop applications, adding an immersive interface without changing the internal source code (which usually isn't available). Conduit works as an OpenGL interceptor, like ML2VR. Unlike ML2VR, Conduit strives to work with a wide variety of applications rather than focusing on a single product. In theory, Conduit can tap into any OpenGL program. However, in practice, most applications require customized tuning to work with Conduit. During the bootcamp, Conduit was demonstrated for the Google Earth application.

Another difference with ML2VR is that Conduit does not provide controls back to the host package, so flying through Google Earth is done by a user at the desktop interface, and only the portions of Earth in the scope of the desktop view can be seen in the immersive display.

getReal3D for Unity • The getReal3D for Unity application from Mechdyne works with polygonal data. In contrast to Conduit, getReal3D for Unity uses the Unity-3D plugin technology to control window creation and perspective rendering from within Unity-3D.

By taking advantage of Unity-3D's modular plugin interface, getReal3D allows the immersed user to interact with the application. Two-way interactions (view and user input) are much more satisfying and immersive.

4 Presentations

Software presentations were given live, with side-by-side displays of slides with the application running interactively in the CAVE display. Even while the talks were on-going, attendees were invited to get out of their seats and explore the software first-hand.

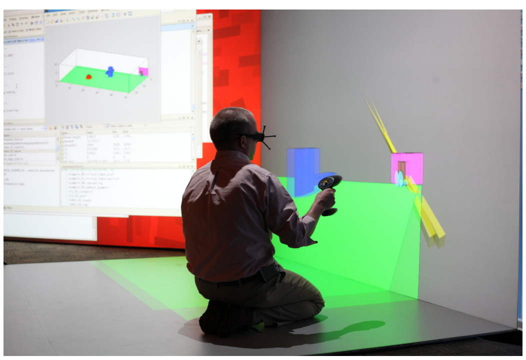

Figure 10: Participants were encouraged to get out of their chairs and experience applications first hand.

There were also presentations that touched on other important factors of immersive visualization software development and usage. In particular, talks on interaction design for immersive visualization, the workflow of immersive visualization at the Idaho National Laboratory, building low-cost immersive displays, and on the configuration of VR tools on different immersive systems.

5 Results

The results were exceedingly positive. We planned to limit attendance to 16 at both sites, but actually ended up allowing one or two extra people to register at each site (two people missed the Indianapolis event due to a snow storm). The demographic mix of attendees was also well distributed, though clearly heavily weighted toward universities. Not counting presenters or hosts, 24 of the participants were from universities, with 4 from DOE laboratories, and another 4 from companies. There was even a slight international flavor with 3 participants from Canada and 1 from Germany. Within the U.S., regional diversity was pretty good, ranging from California to Rhode Island. However, only 1 participant traveled from the Southeast, and none from the Southwest. Most participants took advantage of the regional nature of the sites, though timing prevailed over distance for others.

In addition to the formal presentations, each bootcamp offered food for two lunches and two dinners at which people could then continue the conversation and mingle with other participants. Each bootcamp schedule also offered an opportunity to visit nearby labs, conference rooms and lecture halls with a wider variety of high-end displays, and there were times set aside just for people to request a reprise of an application for them to explore first-hand. All these activities served as catalyst for many lively discussions.

Of course, years will have to pass before we can measure any long-term effects, where we might report new adoption by scientists, or journal articles that were the direct result of the use of an immersive vis tool first encountered at a bootcamp. But we did conduct an informal survey of the participants after a few months had passed to learn of what immediate effects the bootcamp may have had.

Of the 24 institutions that participated in the bootcamps, responses were received from 10. Of primary concern was how did the bootcamp affect software usage and hardware purchases. As for the latter, not surprisingly, hardware plans were basically unchanged. As the bootcamps were targeted at people who had recently purchased or ordered a new system, that is to be expected. However, A few mentioned that they might also now look into assembling a low-cost immersive solution. On the software side, about half installed or planned to install LidarViewer, with a few looking to install Toirt, ParaView and VMD. There was one mention each of installing Conduit and InstantReality.

Participants were also asked how the bootcamp can be improved. The general response was that the bootcamp provided a good mix of software presentations, lectures on use cases, and opportunities to mingle with speakers and other participants. The most-requested additional topic was for detailed information on how to configure VR libraries for particular VR setups. There was one request for an "Advanced Individual Training" camp.

6 Future

As more high-end visualization technology facilities come online, the demand for good software that enables them to be fruitful likewise rises. Unused and poorly used facilities devalue all similar facilities when VIP visitors come away underwhelmed by their potential utility. Thus the need for propagating viable and working solutions to the entire community benefits all.

Immersive Visualization bootcamps are one tool that helps serve the community. This bootcamp program has met the goals set out for it, and presently there are no future bootcamps scheduled. If the program is renewed, and new, viable sites are available, future bootcamps could cover a different mix of software, depending on what might be already available on the host site system and what can be feasibly installed given operating system and time constraints.

Should the program continue, it would be terrific to include more speakers — which would provide a broader variety of topics, and also provide a variation in speakers (one speaker spoke for about half of the time in the 2013 bootcamps). It would also be advantageous to have sponsorship from the funders of large visualization technology that perhaps could provide an opportunity for travel funds to bring in more speakers and attendees, etc.

7 Conclusion

In the end, bootcamps and other events that advance and promote the effective usage of the high-end visualization technologies are good for the entire community. In many respects, it's the building of community that gives the big payoff. In addition to directly providing useful information to participants, bootcamps also participate in community building, and in this case community building was directly encouraged during and after the event — emails were shared, and participants were invited to share experiences on the Wiki at iq-station.org (which has immersive visualization as one area of focus).

Communities are useful both to help individual sites make progress and succeed, and for sharing success stories, that the wider community can use as encouragement and potential actions to take.

So the community of high-end visualization facilities managers and support teams should continue the effort to bring good software to their users, and avoid relegating their systems to being mere dog & pony show facilities. It's little steps that can push things in a positive direction.

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Figure 2: Demonstrating Toirt Samhlaigh.

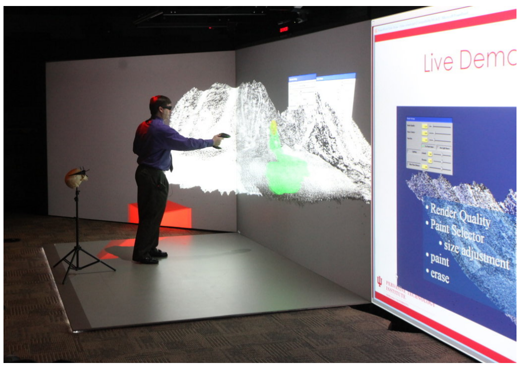

Figure 3: Demonstrating LidarViewer.

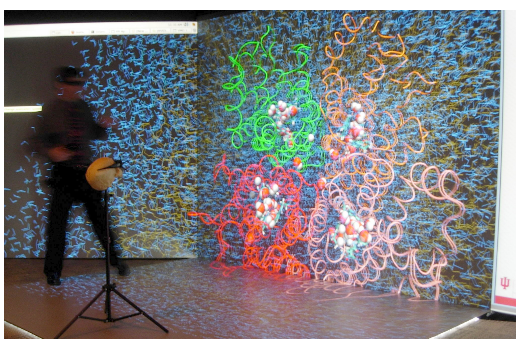

Figure 4: Demonstrating VMD with a quad-pore molecule.

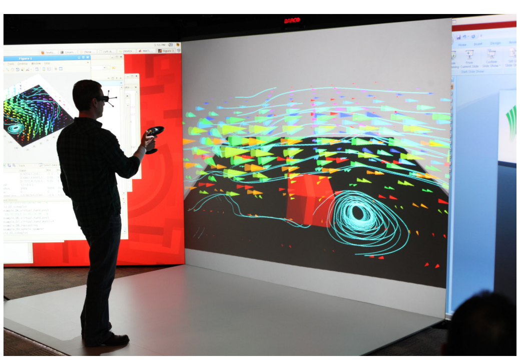

Figure 5: Participant testing ML2VR during the presentation.

Figure 6: Demonstrating ParaView with VR.

Figure 7: Flying through a world modeled with polygons.

Figure 8: Demonstrating Conduit with Google Earth.

Figure 9: Demonstrating getReal3D for Unity.