

Case Study: The “Office of Real Soon Now” for Visualization

Samuel P. Uselton
Lawrence Livermore National Laboratory

Abstract

As part of a larger effort exploring alternative display systems, Lawrence Livermore National Laboratory has installed systems in two offices that extend and update the previously described “Office of Real Soon Now” project to improve the value for visualization tasks. These new systems use higher resolution projectors driven by workstations that run Unix-based applications via Linux and support hardware-accelerated 3D graphics, even across the boundary between displays.

CR Categories and Subject Descriptors: B.4.2 [Input/Output and Data Communications] Input / Output Devices – *Image display*; I.3.6 [Computer Graphics]: Methodology and Techniques - Interaction Techniques.

Additional Keywords: display, projection, panoramic image display.

1. Introduction

A variation on the “Office of Real Soon Now” project has been designed and deployed at Lawrence Livermore National Laboratory (LLNL). The ASCII VIEWS (VIEWS) program [4], the element of the ASCII program developing tools for data management and visualization, is investigating a variety of display technologies, motivated in part by the large size, high resolution, and complexity of data sets that ASCII users frequently explore and analyze. While large, tiled displays have been well received at LLNL, availability and ease-of-use problems have motivated exploration of alternatives, from high resolution LCDs to projectors in offices [6]. The Office of Real Soon Now project [1, 8, 2] at the University of North Carolina at Chapel Hill (UNC) has built “low fidelity” versions of the “Office of the Future” [5, 3] that can be installed in users’ offices now.

The goals of the LLNL display system are to exceed previous UNC versions in resolution, to run Unix-based applications, and to support interactive visualization of simulation data better than can be done via current workstations and monitors. At UNC, the Office of Real Soon Now installations use only a small number of relatively inexpensive projectors, generally two or three, that limit resolution and

features. These projectors are connected to Microsoft Windows PCs or Apple computers that are used for daily activities, such as reading email, writing papers, and debugging programs.

Even though the UNC faculty involved are predominantly computer graphics researchers, these display systems are used mainly for text-oriented applications [2]. Designing, developing, and deploying an office-based system at LLNL provides opportunities to adapt the system to our specific uses and to evaluate such systems for a range of tasks beyond those typically found at UNC.

2. Alternatives Considered: Design and Implementation

The initial plan for the LLNL display systems had four projectors placed in a 2-by-2 array in order to get the highest possible resolution using reasonably priced projectors. Because an office display system should run on a single, user-class workstation, we had difficulty finding a host supporting hardware-accelerated 3D graphics across four outputs. In the spring of 2001, Sun Microsystems demonstrated a system that supported four graphics cards used as a single display, with hardware-accelerated Java3D graphics instructions. The system required an Ultra 60 workstation, which is substantially more expensive than the typical Ultra 10 office workstation, but it seemed a viable possibility.

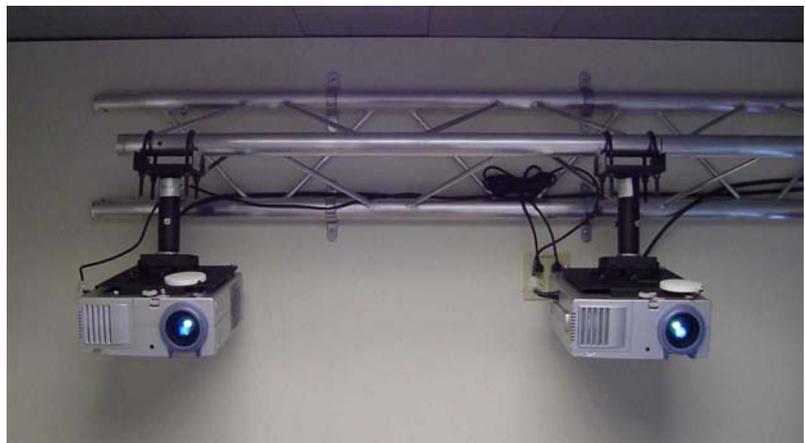


Figure 1. Two projectors suspended from an Opti truss by Chief Manufacturing mounting hardware.

We also had difficulty designing an implementation plan for the projector geometry. For the best image quality, the projectors need to be arranged as far apart as the centers of

Table 1		
Projectors	Computer Workstations	Mounting Hardware
2 JVC projectors, model DLA-DS1 1280 x 1024 pixel resolution 13.2 pounds 1300 lumens \$9,000 list price Digital keystone correction	Dell Precision 530 2 processors 1 gigabyte RAM RedHat Linux version 7.1 VisionTek graphics board with Nvidia GeForce2 MX graphics 1 standard VGA output 1 standard DVI-I output TwinView mode	Opti Trilite truss 212-T6 Chief Manufacturing RPA 3010, ADJ 6009, ACC 557 projector-mounting hardware $\frac{3}{4}$ " GatorFoam screen, 4 x 8

their images. Reducing the spacing between projectors without reducing the image size means that the projectors are not projecting orthogonal to the screen. The result is a "keystone" distortion of the image in which the farther edge of the image is larger, distorting the rectangle into a trapezoid. Image keystone also exacerbates alignment difficulties, since the adjacent edges of two images may no longer be parallel. Another geometric difficulty is that the four pyramids of light from the projectors make it difficult to find a place for users to sit without casting shadows onto the screen. Despite these problems, we continued with our implementation plan.

Then, three companies announced 1280 x 1024 pixel resolution projectors that were substantially smaller, lighter, quieter, cooler, brighter, and less expensive than any previously available. Two such projectors have about 80% of the pixels of the four commodity projectors previously selected; the new system would provide a combined resolution of 2560 x 1024 pixels. These projectors can also be driven from an ordinary PC graphics card with two video outputs including 3D support. To preserve the largest possible pixel count and to avoid complexities in blending images, we chose to abut the images rather than overlap them.

3. Systems as Implemented

We installed systems in two separate offices in order to provide better feedback. The components used in each office are listed in Table 1. The projectors were hung upside down (allowing the off-center projection to reduce keystone

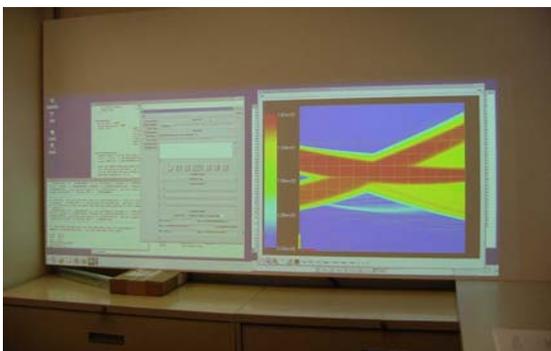


Figure 2. A GatorFoam screen with images from two projectors (before trimming and mounting).

problems) from an Opti Trilite truss by projector-mounting hardware from Chief Manufacturing (see Figure 1). The twelve-inch, triangular truss was used to allow enough

clearance for the projectors. The truss was bolted to the wall a little more than seven feet above the floor. One sheet of GatorFoam, 4 feet by 8 feet, was used as the projection screen in each office, as shown in Figure 2.

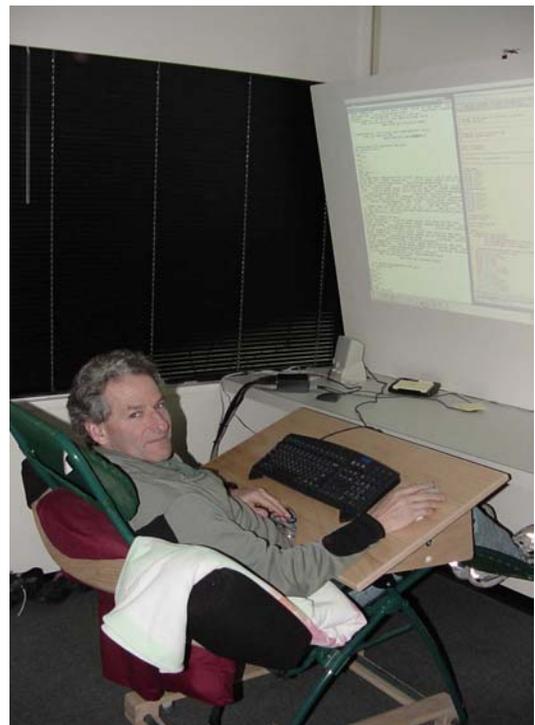


Figure 3. Gary Kerbel's work environment.

While the components of the systems are identical, installation details varied for each office. In the first installation, the truss and projectors were mounted on an interior wall and the projection screen was propped up on the desk against the opposite wall. During the installation, the user, Gary Kerbel, gave feedback that he strongly preferred the images to be as bright as possible. The image size was reduced from 96 by 36 inches to 80 by 30 inches, since the same energy in a smaller area produces a brighter image. (Note: Each projector image has a standard 4 by 3 aspect ratio, even though this means that pixels are not square.)

Gary works while seated in a unique chair that gives him a partially reclining posture. This unusual seating requires that he have a fairly high display, so the top of the screen is much farther from him than the bottom, particularly if the screen is absolutely vertical. He sits fairly close to the screen, which

increases the importance of the screen angle. UNC recommends tilting the screen to make it more perpendicular to the projectors; in their experience, using keystone correction affects image quality. However, in this situation the user preferred to tilt the screen in the opposite direction, making it more perpendicular to his view, and therefore more oblique to the projection direction. The keystone correction provided by the projectors is used at its maximum setting. To complete the picture, he usually works with the lights off and the blinds partially deployed so that image contrast is improved (see Figure 3).



Figure 4. Milo Dorr's work environment.

Our second volunteer, Milo Dorr, has a more rectangular office, with windows on two sides. His truss is mounted above the windows on an exterior wall, as seen in Figure 4. Milo sits conventionally and asked to have the large display as low and as vertical as possible. He also said he would prefer brighter images, so we adjusted the image size to be small. He tried working with the lights out but finds he has less eye fatigue at days end if he has more ambient light, so he typically works with half of his lights on. After initial experimentation, the screens in both offices were trimmed to 3 feet by 7 feet, given rounded corners, and mounted to the wall using velcro.

4. User Experience

After a few weeks of use, each user was informally interviewed to get preliminary assessments of these display systems. Both users liked the increase in the amount of information that can be displayed at once. They both commented on how the large format was especially valuable for use by small groups. Wireless keyboards and pointers had been added and were not only convenient for the users but also facilitated sharing control during collaboration sessions. There were little or no problems associated with shadows

blocking the front-facing projectors. The projector heat and fan noise was noticeable, but not objectionable. Both users would like the images to be brighter, higher contrast, and higher resolution. Both users noted color differences between the two projectors and often placed window boundaries along the color discontinuity to minimize this distraction.

Gary, whose projectors were mounted on an interior wall, commented on vibrations resulting from things like doors closing down the hall. He also said that it was difficult to get the two images to stay precisely aligned, but that he found the usual one-sixteenth of an inch mismatch acceptable. We installed panels called "flags" in Gary's office to address a brighter area in the center, where light from the projectors "leaking around the images" overlapped each other's image. The flags reduced the size and softened the edges but did not totally eliminate this brighter area. Gary said he had used the display primarily for text-oriented work, although he did display some images as part of the process of getting visualization software he uses to run under this version of Linux. This usage was not enough to provide much feedback, but he expects to be doing much more work with visualization and images soon. In spite of some of the problems, Gary is very enthusiastic about using the system.

Milo's overall assessment was more cautious than Gary's. He has used the system for visualization, but primarily 2D, and with relatively low interaction demands. He likes the large format but is uncertain how much difference it makes in his analysis of visualizations. Milo observed intermittent increases and decreases of brightness of a projector's image, which he finds distracting. These changes happen on either projector, are relatively uniform across one projector's image, and can stay brighter for time periods from fractions of a second to several seconds. About three weeks after the interviews, Gary began experiencing the same intermittent intensity variation.

Later conversations indicated that these systems are preferable to their predecessors for visualization uses. It is difficult to assess whether the size of the images or the increase in resolution is more important. The larger field of view means that more context is present when zooming to examine fine details. The visualization use producing the strongest reaction to the increase in pixel count is the ability to examine two large images displayed side-by-side.

5. Conclusions & Recommendations

The projector-based display systems installed at LLNL use higher resolution projectors than any in office use at UNC. Our users sit closer to the screens, so the image subtends a larger view angle than the monitor it replaces. We have not been as meticulous in positioning the screens perpendicular to the center of projection; we chose to orient them for the users' best view and use the projector's features to correct the image distortion. Our new model, higher resolution projectors accomplish this correction better than expected. The projectors are bright enough for a darkened room, but the images lose some contrast when much ambient light is present. Color matching between projectors and color consistency across a single image could be better. A JVC

representative recently visited LLNL to examine our installations and collect information on the unusual demands being placed on the projectors.

Mounting our projectors on the wall means they are lower than UNC's original arrangement, so the angle to correct is not as large. The truss system was easy to install and works quite well to provide flexibility in spacing the projectors precisely for a chosen image size. Mounting it on a structural wall results in less vibration than when mounted on an interior wall. The mounting might be improved by damping the effects of vibrations on the projectors.

The conversion from Unix to Linux workstations was less disruptive than expected. The users' feedback is that these machines are faster and have more memory than the workstations replaced. Issues with the graphics cards include limited bandwidth of the analog signal from the DVI-I output and a substantial difference between that signal and the signal from the other output. At the time these systems were purchased, our choice in graphics boards was limited by the need for a Linux driver and by the need for multiple coordinated outputs. Nvidia's newest graphics chip at that time, the GeForce3, did not support the TwinView feature.

A noticeable color difference between the output channels may be due to the projectors, the graphics cards, or both. Both image brightness and projector heat should be checked during the summer. Longer usage will also give more information on maintenance and system stability. These projectors are substantially more expensive than monitors, but prices continue to drop rapidly while resolution and features improve. Reaction by the users seems sufficiently positive to continue the evaluation and include projectors in the list of possibilities for advanced office displays. Higher resolution projectors are preferable to attempting multiple rows of projectors in an office.

Even though the systems are not perfect, preliminary user reaction is generally positive. Additional experience, particularly with image-oriented applications, is needed. A more complete description of this project can be found in a technical report [7].

Acknowledgments

As with most projects, many people have contributed to these results. The ASCI VIEWS program funded this project. Several people from UNC were very helpful, particularly Herman Towles, Greg Welch, Henry Fuchs, and Gary Bishop. At LLNL, too many to name here provided a variety of assistance, but the most important contributors are Milo Dorr and Gary Kerbel, who agreed to try these systems and have been ideal early adopters.

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48. UCRL JC-147779.

References

- [1] Bishop, Gary, Office of Real Soon Now: <http://www.cs.unc.edu/~gb/office.htm>
- [2] Bishop, Gary, and Greg Welch, "Working in the Office of 'Real Soon Now,'" *IEEE Computer Graphics and Applications*, July/August 2000: 76-78.
- [3] Fuchs, Henry, The Office of the Future Project: <http://www.cs.unc.edu/~raskar/Office/>
- [4] Herman, P.D. "First-Generation ASCI Production Visualization Environment," *IEEE Computer Graphics & Applications*, vol 19, no 5, 1999, pp 66-71.
- [5] Raskar, Ramesh, Greg Welch, Matt Cutts, Adam Lake, Lev Stesin, and Henry Fuchs, "The Office of the Future: A Unified Approach to Image-Based Modeling and Spatially Immersive Displays," *Computer Graphics*. M. F. Cohen. Orlando, FL, USA (July 19 - 24, 1998), ACM Press, Addison-Wesley: 179-188.
- [6] Schikore, D.S., R.A. Fischer, R. Frank, R. Gaunt, J. Hobson, and B. Whitlock, "High-Resolution Multiprojector Display Walls," *IEEE Computer Graphics & Applications*, vol 20, no 4, 2000, pp 38-44.
- [7] Uselton, Samuel P., "The 'Office of Real Soon Now' Western Pilot: Projectors in Offices," Lawrence Livermore National Laboratory, UCRL-ID-147597, March 2002.
- [8] Welch, Greg, Office of Real Soon Now: <http://www.cs.unc.edu/~welch/oorsn.html>