LARGE TILED DISPLAY WALLS AND APPLICATIONS IN METEOROLOGY, OCEANOGRAPHY, AND HYDROLOGY

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1. INTRODUCTION

Tiled display walls provide a large-format environment for presenting high-resolution visualizations by coupling together the output from a collection of projectors. Multiple projectors allow display of images much larger than possible on standard computer display screens[1]. The use of these walls enables researchers to step back and get an overall picture of a dataset or move in and study fine details without changing the visible image. For example, very high resolution satellite data sets can be displayed using thousands of pixels in each direction. In addition, the large display screen can be blocked and used to simultaneously display images from multiple sources.

The National Center for Supercomputing Applications (NCSA) is exploring the use of large tiled display walls (currently 4096 pixels wide and 3840 pixels high) for viewing and studying very large images such as those from GOES or MISR satellite instruments. Currently this includes 1 km visible GOES images at approximately 14,000 x 12,000 pixels per image and single pass, 250 m MISR images at approximately 80,000 by 9,000 pixels. The wall is located in a room where these images can be viewed in a classroom setting or by a small to moderate sized group studying them. Viewers can zoom and pan through the image much like that possible using imaging software with single computer screen display.

Alternatively, the wall can be used to display a set of images or animations such as those typically available in a synoptic lab. For example, the new synoptic laboratory in the Department of Atmospheric Sciences at the University of Illinois Urbana/Champaign is using 15 separate LCD screens mounted on a wall to display 15 synoptic or weather maps simultaneously[2]. A large display wall can also be used for this purpose.

Other sets of images that can be displayed include those from multiple simulations from an ensemble modeling study or of different fields from one simulation. Lock-step animation of these images with standard video display controls along with collocation capabilities across all images enhance viewing and understanding. For example, the results from simulations carried out using the community Weather Research and Forecasting Code (WRF)[3] will be displayed on the NCSA wall in November at Supercomputing 2001[4]. The TeraGrid[5] will be used to carry out hundreds of simulations launched by visitors to the NCSA booth. These simulations will be used to help study how two merging storms influenced tornado development as observed on April 19th, 1996 in Illinois[6]. The idealized simulations will involve the initialization of two storms within a numerical model with the location, intensity, and appearance of the second storm determined by the visitor. Visitor input will be handled through a web browser and XCAT software will be used to launch the simulations on one of several TeraGrid computers. Results will be collected, visualized, and analyzed for incorporation into a data mining learning environment (D2K)[7]. The latter will be used to aid the visitor in their choice of parameters and will also be updated after every simulation. The results will be simultaneously displayed on the tiled wall along with those initiated by others. Fig. 1 illustrates this use of the wall while Fig. 2 contains an example of a single image.

2. THE NCSA TILED DISPLAY WALL

A tiled display wall was recently designed and installed by the NCSA's Scientific Visualization group. Currently, it is a 20-tile scalable display wall that provides a display surface of 4096 x 3840 pixels. A 20-node PC Linux cluster is used to drive the wall. The current cluster machines are dual-processor 550 MHz HP Kayaks with GeForce2 graphics accelerator

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[1] The July August 2000 Issue of IEEE Computer Graphics and Applications (http://computer.org) has a number of articles on large display walls including an introduction on building projection-based tiled display systems.

[2] See preprint 9.9 in this volume entitled *Reviving the Synoptic Lab with Unique Digital Display Systems*

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[3] http://www.wrf-model.org

[4] http://www.sc2001.org

[5] See preprint J3.5 in this volume entitled *A Report on Plans for a Teragrid*.

[6] http://redrock.ncsa.uiuc.edu/~jewett/Apr19/

[7] D2K: Data To Knowledge is a next generation workspace architecture for the creation of data analysis applications in any domain area. It is a visual programming environment that allows users to easily connect software modules together in a unique data flow environment to form an application. http://archive.ncsa.uiuc.edu/ALG/d2k/

cards. Communications between them is handled over Myrinet. The machines are connected to 20 NEC VT540 projectors arranged in a matrix 5 high and 4 across. The output of the NECs is rear-projected towards a single screen, creating a large-format, high-resolution image space. The wall will be scaled to 40 tiles later this year with a resolution of 8192 x 3840 (or 8 tiles wide by 5 tiles tall). Costs for the wall are controlled by using commodity projectors and low-cost PCs. A picture of the machines and projectors is shown in Fig. 3.
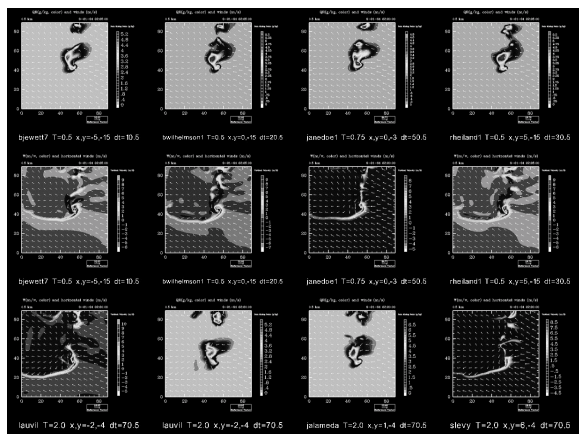

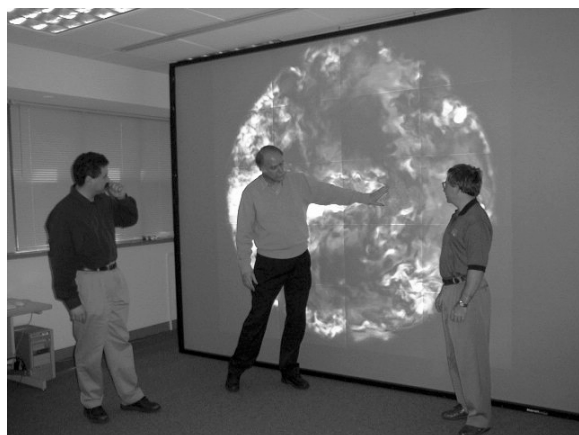Fig. 1: Windows of different fields shown on the display wall.

Fig. 2: An example image displayed on the NCSA tiled display wall. Paul Woodward, developer of one of the first display walls – called the PowerWall[8] – in the mid 90's, is pointing at an image of a 3D simulation of a red giant star.

In order to enable others to more easily set up walls, the NCSA Alliance[9] has launched the DisplayWall-in-

a-Box[10] effort. This is a collaborative effort with contributions from Argonne National Laboratory, University of Utah, University of Illinois at Urbana-Champaign, University of Minnesota, Princeton University, Stanford University, and the National Center for Supercomputing Applications. Guidelines will be provided for building a tiled display wall including information on choosing Linux machines and graphics accelerators, for evaluating projectors, and for selecting screens. The DisplayWall-in-a-Box software toolkit will include utilities and applications for single and multiple image display, movie playback, and image roaming as well as complete visualization tools that can direct output to a tiled wall. The software for the Alliance DisplayWall-in-a-Box will be compatible with the Alliance Cluster-in-a-Box[11] software. This software will greatly simplifies the task of installing and running a parallel Linux cluster that is compatible with the Alliance's large-scale production clusters and will provide a foundation on which other software packages—including grid toolkits and scalable display wall software—can be built.

Fig. 3: The projectors behind the display wall mounted on a custom frame for adjusting the images so that they are continuous with minimum overlap.

Software available to display images and animations on the wall currently includes

1) WireGL[12] is a package from the Computer Graphics group at Stanford University. It allows many OpenGL graphics applications to output to a tiled display without modification. The functionality of WireGL (a single application) is available also through Chromium[13], a new modular system for

[8] http://www.lcse.umn.edu/research/powerwall/powerwall.html
[9] http://www.ncsa.uiuc.edu/About/Alliance/

[10] http://www.ncsa.uiuc.edu/TechFocus/Deployment/DBox/index.html
[11] http://www.ncsa.uiuc.edu/TechFocus/Deployment/CiB/
[12] http://www.graphics.stanford.edu/software/wiregl/
[13] http://graphics.stanford.edu/~humper/chromium_documentation/

interactive rendering on clusters of workstations.

2) <u>NCSA Pixel Blaster</u>[14] is a movie player application based on WireGL.

3) <u>Argonne Movie Player</u>[15] is an abstraction for a movie player, intended to operate on a tiled display, but easily extended for use in a variety of situations. The abstraction includes three components, a Loader which is responsible for getting an image into memory, a Renderer which is responsible for putting the image onto the screen, and a Movie which is responsible for handling the control and synchronization of the two.

4) <u>VTK Geometry Viewer</u>[16] is a viewer to display precomputed geometry on a tiled wall. VTKViewer supports a number of different geometry formats including VRML (*.vrml), 3D Studio (*.3ds), Wavefront OBJ (*.obj), and VTK Polydata files (*.vtk). The VTKViewer also supports some statistics information to aid in debugging and benchmarking the tiled wall display.

At NCSA, VTK (Visualization ToolKit) is a popular open source, freely available software system for 3D computer graphics, image processing, and visualization. It consists of a C++ class library and several interpreted interface layers including Tcl/Tk, Java, and Python. Professional support and products for VTK are provided by Kitware, Inc.[17] VTK supports a wide variety of visualization algorithms including scalar, vector, tensor, texture, and volumetric methods; and advanced modeling techniques such as implicit modeling, polygon reduction, mesh smoothing, cutting, contouring, and Delaunay triangulation. In addition, dozens of imaging algorithms have been directly integrated to allow the user to mix 2D imaging / 3D graphics algorithms and data. The design and implementation of the library has been strongly influenced by object-oriented principles.

Current software related projects at NCSA include the implementation of multiple windows for use in displaying multiple images and animations on the wall as mentioned earlier and the adaptation of the Virtual Director[18] interface for use in these windows. The windows are implemented using GL with some WireGL optimizations.

The Virtual Director is a virtual reality interface that enables gestural motion capture and voice control for navigation, editing, and recording in the CAVE[19] and on the ImmersaDesk (TM), and Infinity Wall (TM). It provides virtual choreography of multiple applications including <u>Cave5D</u>[20] (Vis5D modified for use in the CAVE) and also provides remote virtual collaboration capabilities, linking together virtual devices and people represented as customized avatars.

3. CONCLUSIONS

Display walls built with commodity components cost approximately $7,000 per tile including mounting equipment, projectors, and computers with ample memory and disk. They provide a way to look at large images or groups of images in a small classroom or group setting. The cost can be leveraged by use of some of the components for other purposes. For example, NCAR has recently demonstrated the ability to use some of the front projected display wall components of its new VisLab 2[21] in implementing an Access Grid node[22]. An Access Grid node consists of a large-format multimedia display, presentation and interaction software environments, interfaces to grid middleware; and interfaces to remote visualization environments. The node can be connected with other nodes over the national and international grid network. The nodes can be used for distributed group meetings, collaborative research, seminars, class lectures, and training.

4. ACKNOWLEDGEMENTS

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[14] http://www.ncsa.uiuc.edu/TechFocus/Deployment/DBox/Doc/PixelBlaster.html

[15] http://www.ncsa.uiuc.edu/TechFocus/Deployment/DBox/Doc/MoviePlayer.html

[16] http://www.ncsa.uiuc.edu/TechFocus/Deployment/DBox/Doc/GeomView.html

[17] http://www.kitware.com/

[18] http://virdir.ncsa.uiuc.edu/virdir/virdir.html

[19] http://www.evl.uic.edu/research/vrdev.html

[20] http://www.ccpo.odu.edu/~cave5d/homepage.html

[21] http://www.scd.ucar.edu/vets/Vislab/

[22] http://www.accessgrid.org