AGAVE : Access Grid Augmented Virtual Environment

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Introduction
The goal of AGAVE (pronounced agavay) is to augment the Access Grid to allow collaborators to immersively share three dimensional content, such as scientific and engineering data, in conjunction with their 2D Access Grid content. AGAVE accomplishes this with a low-cost passive stereographics projection system and accompanying networked PC. Audiences will view the immersive content using inexpensive 3D movie glasses. If desired an additional 3D tracking system and pointing device can be incorporated to support 3D interaction. AGAVE can be deployed as a separate display screen placed on one side of the Access Grid display screens so that both standard 2D content can be viewed simultaneously with 3D content.

The AGAVE Hardware Configuration
The display system will consist of a pull-down polarization-preserving silver screen, two LCD projectors with linear or circular polarizers in front of each lens, a dual processor Linux driven PC with a high-end graphics card capable of dual display output, such as the Evans and Sutherland (E&S) Tornado 3000. To mediate the stereo, viewers will don low-cost polarized movie glasses. Disposable glasses can be purchased in bulk at a cost of approximately $0.50 a pair or individuals may purchase their own personal glasses for approximately $12 a pair. Circularly polarized filters and viewing glasses will cost slightly more.

When 3D is not in use, the projectors and the silver screen can be used as a standard powerpoint projection system hence providing additional utility to the display system.

In choosing the graphics card for AGAVE the primary constraints were: 1. Linux support on dual screens; 2. OpenGL acceleration under Linux for dual screens; 3. performance; and 4. cost. Linux support is required because our CAVERNsoft software, used to drive AGAVE, relies on Performer, which only works under Linux and Irix. The E&S Tornado 3000 satisfies these requirements. The Matrox G450 is another possibility, but up until recently, the Linux support did not provide OpenGL acceleration on dual screens. We are currently in the process of evaluating this card. The Intense3D Wildcat would have been the ideal candidate if it were not for the fact that there is currently no Linux support for it.

To support 3D tracking and interaction, Ascension Technology's Flock of Birds (Extended Range Transmitter version), and EVL's Wanda can be used. Wanda is a wand with an imbedded tracker, joystick and three buttons. It is the standard interaction device used in CAVEs. The Flock is typically driven by a Windows9X or Linux PC. An alternative to the Flock is Ascension's pcBIRD. Whereas the Flock is a self-contained unit that communicates with the PC via RS232, the pcBIRD consists of a circuit board that plugs into 3 full-sized ISA bus slots in a PC.

Projector Placement
Three projector configurations are possible. The first, and easiest, stacks two projectors on top of each other. This solution requires projectors that have integral shift lenses that are needed to converge the images on each projector into the same area of the projection screen. This solution is more costly (>$7500 per projector.) The Sharp XG-E3500U is an example of projector with this capability. EVL has already confirmed that this solution works.

The second and less costly solution uses standard powerpoint-style projectors with factory fixed keystone offsets (~$5000/projector). In this solution one projector is mounted on the ceiling, approximately flush with the top of the projection screen, while the other is mounted approximately flush with the bottom of the screen. Figure 1 shows the display cones for two Proxima DX-1 DLP projectors mounted in this manner. The intersection of the cones for each projector is where the screen will be placed. The projectors are placed approximately 5' apart (i.e. desktop to ceiling) to produce an image size of approximately 5' x 4' at a 10' projection distance.

The third solution sacrifices display resolution for cost by attempting to stack low-cost DLP projectors. Because of the factory fixed keystone, the projection cones of the two projectors will not intersect perfectly. To compensate for this the viewports for each eye's image needs to be reduced and shifted vertically as shown in Figure 2. Unfortunately this means that a portion of the display screen's resolution will be wasted. EVL has confirmed that this solution works.

Immersive Collaboration over AGAVE

The CAVE library can easily be configured to work in dual-display mode under both Windows and Linux. To support collaboration in AGAVE, CAVERNsoft can be used. A separate CAVERNsoft server can be deployed at a known site. AGAVE participants will all launch their applications and connect directly to the known site. CAVERNsoft is a widely deployed cross-platform C++ toolkit to allow programmers to quickly develop collaborative, immersive virtual reality applications. Included with CAVERNsoft is an application called coanim (collaborative animator) that will allow collaborators to load up 3D data sets and begin collaboration immediately. Collaborators will see each other as avatars and may point at, rotate and scale the object being viewed. They may also cycle through a sequence of data sets to generate a 3D animation flip book. As Coanim is based on the CAVE library and SGI's Performer product, users on the Access Grid can interact in 3D with fully immersed participants in the CAVE and ImmersaDesk. Audio streaming will be supported by the existing Access Grid architecture.

Broadcasting AGAVE Visualizations

AGAVE visualizations can also be shared with Access Grid nodes that do not have AGAVE systems. Images generated by AGAVE can be shared with standard Access Grid viewers by feeding one of the AGAVE display signals into one of the video inputs of an existing Access Grid node. A scan converter (such as the Extron VSC 200) will be needed to convert the AGAVE display signal to an NTSC signal. EVL is currently evaluating this option.

Cost Estimate

- PC - $5000-10000
- Polarization-preserving silver screen – 70"x70" - $320
- 2 DLP projectors - $10000 for low cost solution, $15K-20K for higher cost solution.
- 100 pairs of glasses - $50
- Polarizing filters and projector mounts – $1000 (this is only an estimate- the cost will depend on the complexity of the mounting system.
- Extron VSC 200 - $3995
- Wanda 3D Joystick - $2560
- Ascension Flock of Birds with extended range transmitter and 3 sensors – $12580
- Ascension pcBird with extended range transmitter and 3 sensors - $11920

References

Intense3D Wildcat 4210 : http://www.intense3d.com/4210/4210data.html
Matrox G450 : http://www.matrox.com/mga/products/mill_g450/home.cfm
Evans and Sutherland (E&S) Tornado 3000 : http://www.es.com/wg/tornado.html
CAVE Library : http://www.vrco.com
CAVERNsoft : http://www.evl.uic.edu/cavern/cavernG2
Coanim : http://www.evl.uic.edu/cavern/cavernG2/modules/coanim/coanim.html
SGI Performer : http://www.sgi.com/software/performer/

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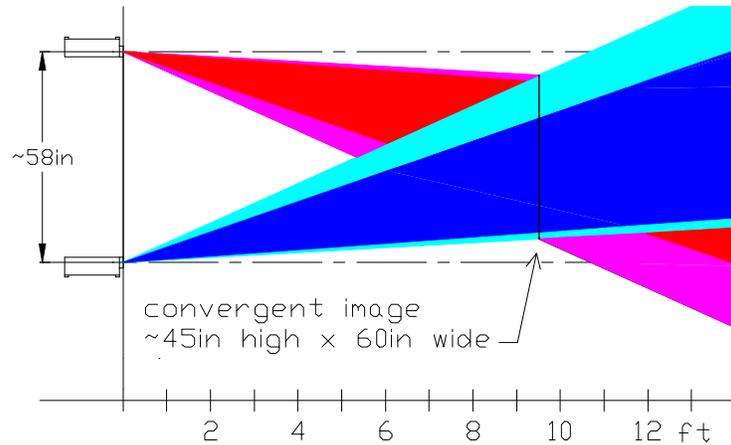
DLP : http://www.dlp.com/dlp/default.asp
Extron VSC100 : http://www.extron.com/product/product.asp?id=vsc100
Wanda 3D Joystick : http://home.att.net/~glenmurray/
Ascension Technology - Flock of Birds : http://www.ascension-tech.com/products/flockofbirds/
Ascension Technology – pcBIRD : http://www.ascension-tech.com/products/pcbird/

Figure 1 : Projection Cones for Two Low Cost LCD Projectors at approximately 10' away from the screen and separated by approximately 5'.
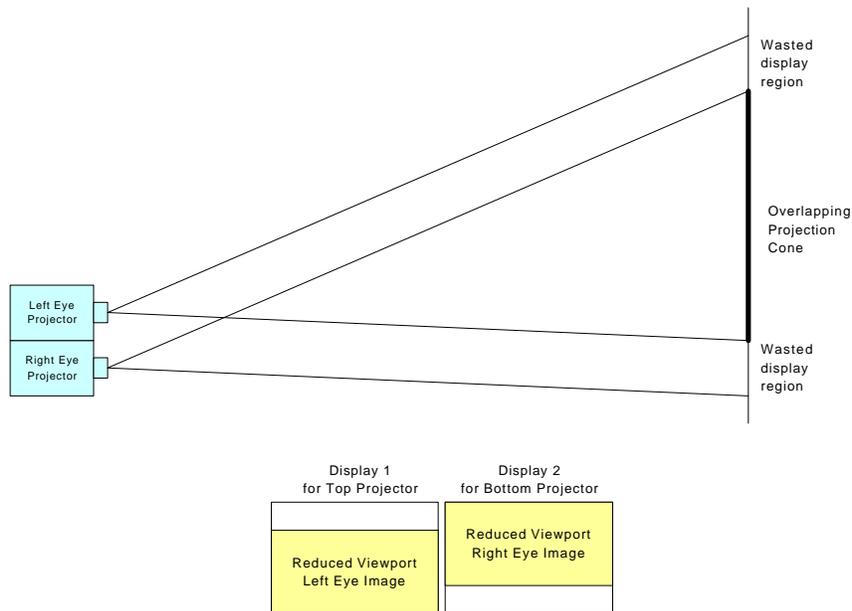
Figure 2 : Stacked projector solution using low-cost LCD projectors with factory fixed keystone offsets. Because of the keystoning the display cones of the two projectors do not overlap completely. This is accounted for by reducing the viewport for each eye's image accordingly.

Leigh, J., Dawe, G., Talandis, J., He, E., Venkataraman, S., Ge, J., Sandin, D., DeFanti, T., AGAVE : AccessGrid Augmented Virtual Environment, Access Grid Retreat, January 2001, Argonne National Laboratory, Argonne, Illinois.