ICAT 2001
December 5-7, Tokyo, Japan

VR_4U_2C: A Multiuser Multiperspective Panoramic Browser Using QuickTime VR and Java Featuring Multimonitor and Stereographic Display

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Abstract

One of the first principles of immersive visual display is to fill the user's field of view with imagery, often of a single environment, sometimes an actual place remotely viewed in space and/or time. The means to project such imagery depends upon both the display devices and the software environment supporting image delivery to the display devices. We have developed a multiuser multiperspective panoramic browser using Apple's QuickTime VR technology and the Java programming language, together with the support of the QuickTime for Java application programming interfaces (API). This unique QTVR browser allows coordinated display of multiple views of a virtual environment, limited primarily by the size and number of monitors or projectors assembled around individual or groups of users in various viewing locations. Named "VR_4U_2C" ("virtual reality for you to see"), the browser, developed by the first author for both Macintosh and Windows operating systems, is one of many integrated clients in the University of Aizu Spatial Media Group's Multimodal Groupware suite— which includes the Internet Chair, 2.5D Dynamic Map, PSFC Proxy, Hero Telerobot, Helical Keyboard, Soundscape-Stabilized (Swivel-Seat) Spiral-Spring, and iAppli "ιcon" graphic interface for mobile telephone— and interoperates seamlessly with them. VR_4U_2C can be used interactively to explore and examine detailed multi-dimensional, virtual environments (photorealistic or otherwise) using a computer and conventional input devices— including mouse, trackball, track pad, and keyboard. In addition, it provides a unique solution to the problem of interactive stereoscopic display of QTVR imagery.

VR_4U_2C has several novel features, including stand-alone and client/server modes, and multiple synchronized windows and monitors with the same or different viewing angles. Synchronization via a Java-implemented client/server (C/S) framework enables multi-window and -monitor configurations of QTVR browsers, even when the windows and monitors are discontinuous, suggesting the idea of "panoramic panoramas," panoramic viewers that piecewise partially or totally surround a user. The further ability to intelligently and seamlessly switch panoramic scenes enables several novel QTVR features, including stereographic viewing. Users can utilize VR_4U_2C for viewing a stereo panoramic scene using special eyewear and several well-known viewing techniques such as parallel, cross-eyed and over/under viewing techniques. In addition, a stereo panoramic scene can be projected through polarized filters using two projectors onto a silver screen. Then users can view this stereo effect through passive polarized eyewear.

Keywords: multiuser, multiperspective, multidisplay, panoramic scene, stereographic QTVR, image-based rendering (IBR).

1. Introduction

This paper describes a novel Java-based browser that enables multiple users to enjoy panoramic views of one or more environments via Apple's QuickTime VR technology. Whether the visual environment to be displayed is computer generated or photographically captured, the browser, named "VR_4U_2C" ("virtual reality for you to see"), can immerse a viewer or viewers in that environment using a wide variety of spatial configurations of visual display devices. Fig. 1 depicts a deployment that might be called a "video-wall" configuration. The viewer in this figure (rendered in wire-frame) is surrounded by a natural scene (prehaps captured using a camera fitted with a fish-eye lens), and that video wall is recognized only by the monitor frames. What is unique about the VR_4U_2C browser is that it provides several features beyond those provided by ordinary video-wall displays. First, one viewer's interactive control over viewer perspective can be synchronized across mutliple sites for other viewers. Each viewing site can have its own unique spatial configuration of display devices, some of which providing immersive stereographic imagery. So, in contrast to the more conventional idea for a video wall depicted in Fig. 1, the flexibility of VR_4U_2C suggests the idea of "panoramic panoramas" that piecewise partially or totally surround a user. Multiple synchronization of windows and monitors with the same or different viewing angles is accomplished seamlessly for each user via a Java-implemented client/server (C/S) framework, even when the windows and monitors are discontiguous. This paper focusses upon only a few potential display-device configurations, in order to explain implementation details and functions of the browser, begining with an introduction to basic concepts in spatialized hypermedia, including panoramic and stereographic display.

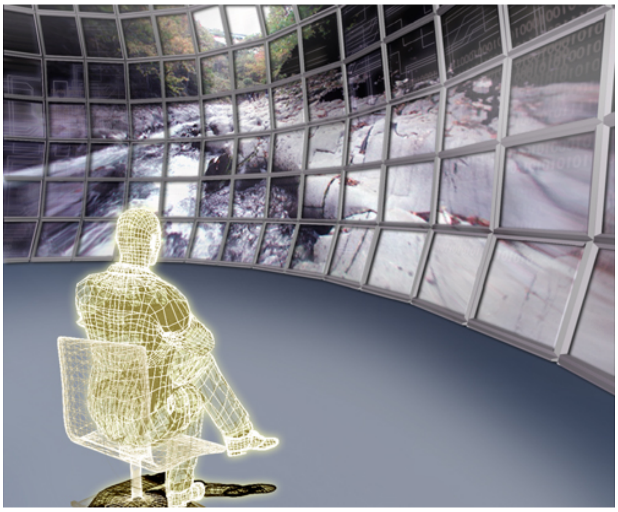

Fig. 1: Graphic depiction of a curved "video-wall" configuration of visual display devices showing immersive QTVR imagery to a viewer. (Graphic produced by "Eyes, Japan.")

1.1 Degrees of Freedom and Hypermedia

There are several dimensions of spatial motion that can be experienced in the "real world," including translational degrees-of-freedom (sway, heave, and surge), and rotational degrees-of-freedom (roll, pitch, and yaw). The dimensions can also describe sound source localization (azimuth, elevation, and range/distance).

1.2 Hypermedia and Stereo Panoramas

Hypermedia combines a hypertext system and media elements (or multimedia, including sound, graphics and images, audio, video, animation), and makes use of a variety of interactive tools to tie them together in a meaningful way. Some people also refer this term to virtual reality, artificial reality, cyberspace, and so on.

The word "panorama" was introduced in 1792 in London to describe a large cylindrical room entirely covered by a 360° painting [Nai97] [Nai91] [BK01]. However nowadays, in addition to static panoramas, we can also create and display complete 360° scenes over time as "moving panoramas." Computer-based moving panoramas— such as Apple's QuickTime VR[1] [Kit98], Helmut Dersch's PTViewer[2] , and iPIX Viewer[3] — can be produced by tiling multiple rectangular images or by combining images captured by a fisheye lens. Such systems allow a viewer to look around (angular movement— i.e., panning and tilting), but not to move around (translational movement— i.e., dollying and tracking). The zoom angle can determine how much of the source image is in the playback window. Zooming changes the field of view (FoV), the visual angle subtended in the display.

The reason that people have stereoscopic vision is because we have two eyes. The lenses of these two eyes project two slightly different images onto the retinas, which are then transformed, by the brain, into a spatial representation [Nai97]. An ordinary panorama represents only a single point of view, but a stereo panorama requires more than two points of view. In this case, we use multiple panorama movies of the same scene taken from slightly different point of view (separated by an interocular distance). Then using one of many viewing technologies, the stereoscopic movies are combined in our mind producing a third dimension of depth, as illustrated by Fig. 2.

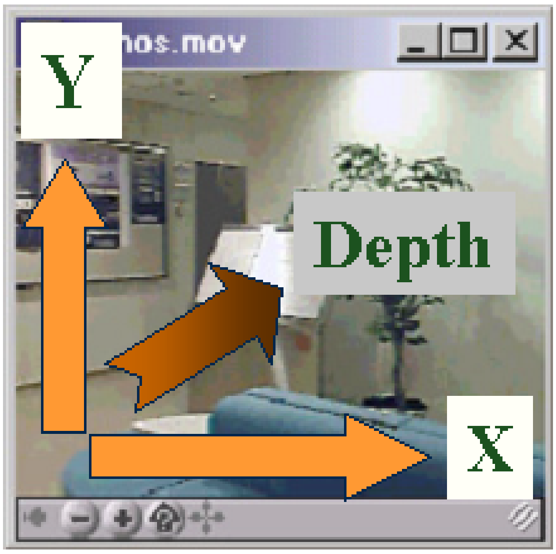

Fig. 2: Depth: 3^{rd} Dimension of Stereo Images

[1] www.apple.com/quicktime/qtvr
[2] www.fh-furtwangen.de/~dersch/PTVJ/doc.html
[3] www.ipix.com

2. Aim and Objectives

This research involved development of a multiuser multi-perspective panoramic browser using Apple's QuickTime VR (QTVR) technology and the Java programming language [BC01].

The main objectives of the research are:

- To clearly identify and understand methods for capturing panoramic scenes, producing QTVR movies.
- To develop a Java program that can be used to interactively explore QTVR movies with other users in realtime through network.
- To integrate QTVR movies seamlessly with other clients in the Multimodal Groupware suite [KCNH01], including the Internet Chair [Coh00] [KCA00], 2.5D Dynamic Map [MSC01], PSFC Proxy [AMY+98], Hero Telerobot [HOS97] [HST+99] [YCHY01], Helical Keyboard [KC01] [NC01b], Soundscape-Stabilized (Swivel-Seat) Spiral-Spring [CS00], and iAppli "ιcon" application for mobile phones [NC01a].
- To elaborate more interesting features for viewing QTVR movies on computer and other equipment such as TV screens, head-mounted displays (HMDs), etc.

3. Related Systems

3.1 Panoramas

Many advanced panoramic viewers have been developed recently, including the well-known Elumens VisionDome,[4] which can deliver a full-color, high-resolution, raster-based, interactive, 3D display, with a 360° by 180° panorama projection on the interior of a hemispherical dome. A dozen or more people can simultaneously participate and collaborate without having to use restrictive head-mounted displays or goggles. The tilted hemispherical screen is positioned so as to fill the field-of-view of the participants, creating a sense of immersion in the same way that a large-screen cinema draws its audience into a scene. The observer loses most of the cues regarding display surface position, such as screen edges, and perceives 3D objects beyond the surface of the screen. The dome itself allows freedom of head motion, so that the observer can change direction of view, and yet still have vision fully encompassed by the image.

3.2 Stereograms

The Simsalabim Cyberscope is an optical hood that can be mounted on monitors of various size. Stereo pictures are drawn sideways. The left-eye image is drawn on the left half of the screen up to the left. The right-eye image is drawn on the right half of the screen with up to the right.

[4] www.elumens.com

4. Implementation Details

4.1 Panoramic Capture

We photographically capture panoramic scenes using the Nikon[5] CoolPix 990 digital camera, its 8 mm Fisheye Converter FC-E8, Kaidan[6] KiWi 990 rotating (180° detented) tripod head, and any standard tripod, and then combine multiple fisheye images into integral panoramic scenes in post-production using Adobe Photoshop, QuickTime VR Authoring Studio,[7] DeFish,[8] Panorama Tools,[9] Ptgui,[10] SoundSaVR,[11] QTVR MakeCubicPPC,[12] and VR Worx[13] stitching and authoring software.

4.2 Stereo Panoramic Capture

The equipment used for capturing and preparing stereo panoramic scenes includes all that for ordinary panoramic capture plus a Jasper[14] 8" stereo slide bar. Referring to Fig. 3, firstly, place a camera at the center of slide bar and take a picture, capturing a hemisphere. Then without moving the slide bar, rotate the camera 180° and take another picture. These two images are stitched together using some combination of authoring and stitching software into a panoramic scene, which can later be designated as the left-eyed movie.

To make the right-eyed side of a panoramic scene, take another picture after moving the camera an interocular distance (nominally 65 mm, or about 7 cm) towards the right of slide bar. After that, rotate the slide bar 45° and take another picture. Rotate it again and take the third picture. Repeat this until all necessary pictures (eight all together) have been captured. Afterwards, convert eight fisheye images to rectangular images, and then stitch or combine these rectangular images into a panoramic image, which can be designated as the right-eyed movie. Finally, this pair of panoramic scenes (JPEG format) can be converted to QTVR movies, using QTVR MakeCubicPPC or VR Worx.

4.3 QTVR Movie Callbacks

Callbacks are used to allow QuickTime-triggered invocation of developer-supplied subroutines, QuickTime calling back into Java through the movie controller, movie, and QuickTime VR APIs [MS99]. These callbacks are used in VR_4U_2C to perform tasks when certain conditions arise within QuickTime itself. `MovieDrawingComplete` callback is used to notify a supervising program whenever QuickTime has drawn to the screen. Once a movie draws on

[5] www.nikon.com
[6] www.kaidan.com
[7] www.apple.com/quicktime/qtvr/authoringstudio
[8] www.iqtvra.org/DeFish
[9] www.fh-furtwangen.de/~dersch
[10] www.ptgui.com
[11] www.smgvr.com
[12] developer.apple.com/quicktime/quicktimeintro/tools
[13] www.vrtoolbox.com
[14] www.stereoscopy.com/jasper

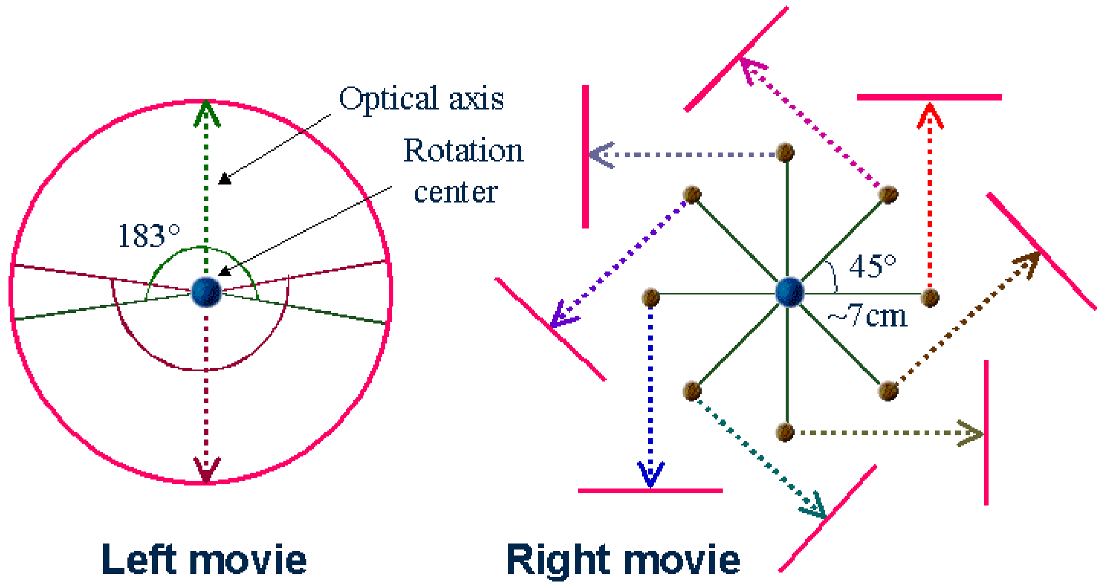

Fig. 3: Capturing Stereo Panorama Movies

the screen, an instance of the subclass (`MovieDrawing`) implementing this callback will be called automatically, and will compute wide view (W) and mullion wide view (M) for calculating pan angle (PA) of other windows, as shown in Fig. 4.

Moreover, there are two more QTVR callbacks provided in QuickTime VR: `QTVRInterceptor` for panning, tilting and zooming processes, and `QTVREnteringNode` for entering node processes. The subclass implementing the `QTVRInterceptor` callback contains a number of useful methods, as outlined in Table 1.

Method	Event
`getPanAngle()` `setPanAngle()`	To get/set current pan angle
`getTiltAngle()` `setTiltAngle()`	To get/set current tilt angle
`getFieldOfView()` `setFieldOfView()`	To get/set current field of view
`ptToPanAngle()`	To get pan angle at certain point (in pixels) on movie window
`goToNodeID()`	To move to another node in multinode movie

Table 1: Relevant Callback Methods

4.4 Multithreaded Implementation

The benefits of multithreading are better interactive responsiveness and real-time behavior. [HC01, p. 10] Upon opening a movie, VR_4U_2C will create a thread for its own operation, and other threads for displaying each window/frame, as shown in Fig. 5. Every process in the opened movies can be run in parallel on the same machine.

4.5 Groupware Architecture

Fig. 6 illustrates the relationship between VR_4U_2C and other clients in our Spatial Media Group's Multimodal Groupware suite.

As one of many integrated clients, VR_4U_2C connects to a common server to exchange parameters with other clients synchronously. Conforming to our groupware protocol by implementing the `CVEClientIF` interface (abstract superclass) provides `get` methods. `Set` methods are in `CVEClient` class, an instance of which is linked to our application. Upon receiving values using `getOrientation()` method, VR_4U_2C will assign pitch to tilt angle value, and yaw to pan angle value. However, the program will only save the roll value. Afterward, if the user changes tilt angle or pan angle, these three values will be multicast through the server using `setOrientation()` method. Furthermore, VR_4U_2C uses the `getExtraParam()` method to get "zoom" value from the server, assigning it to the field-of-view data-field. Symetrically, if this variable is updated, it will be sent to the server using `setExtraParam()` method.

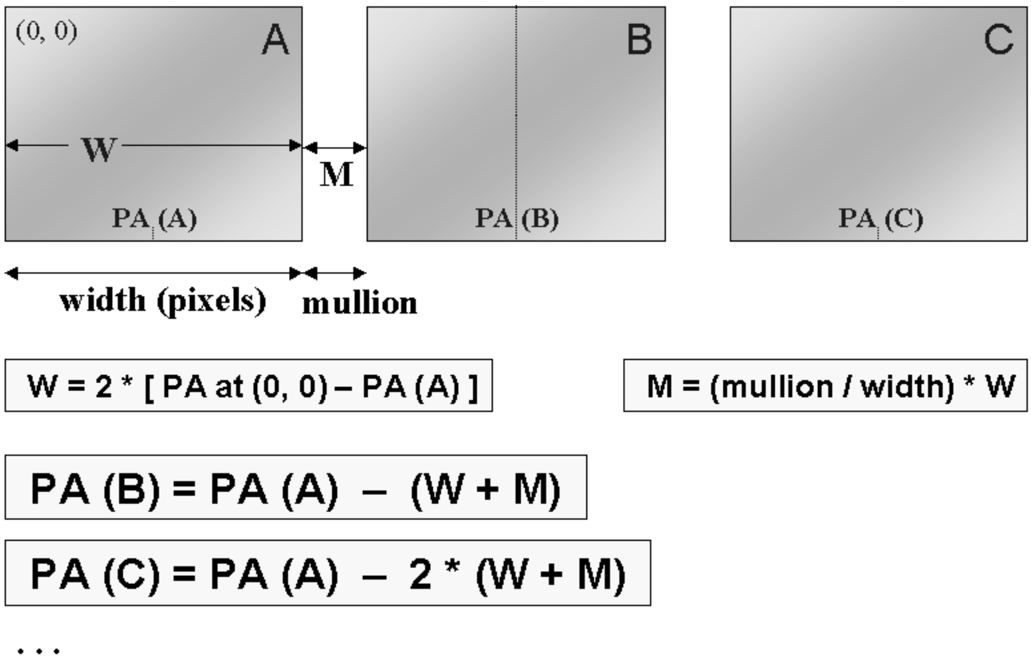

Fig. 4: Calculation for Wide View, Mullion Wide View, and Pan Angle

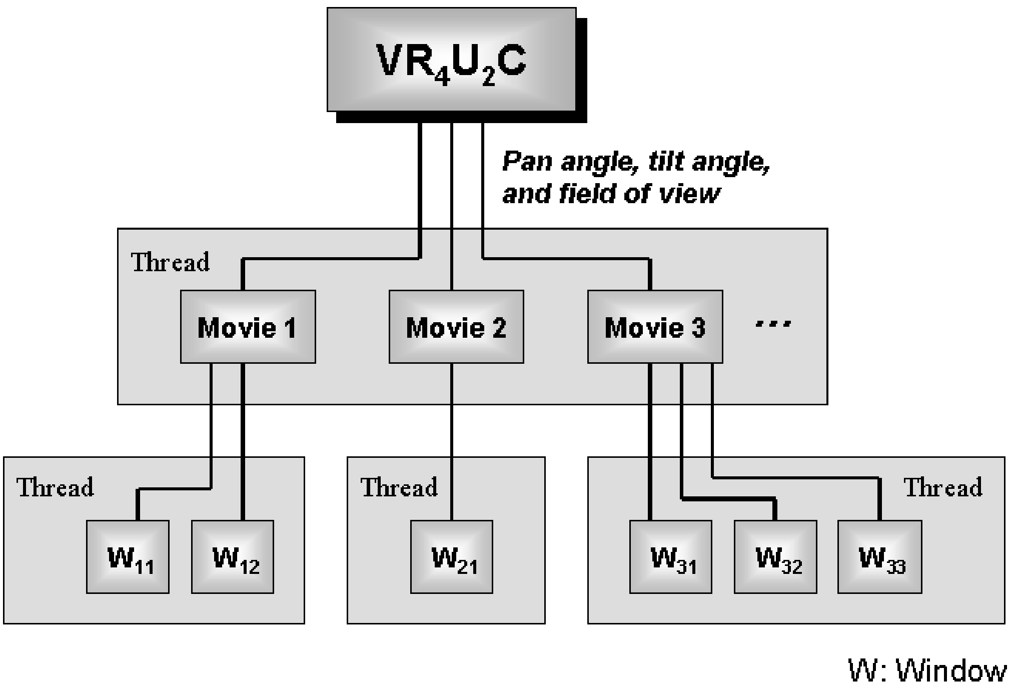

Fig. 5: Example of Multithreaded Execution

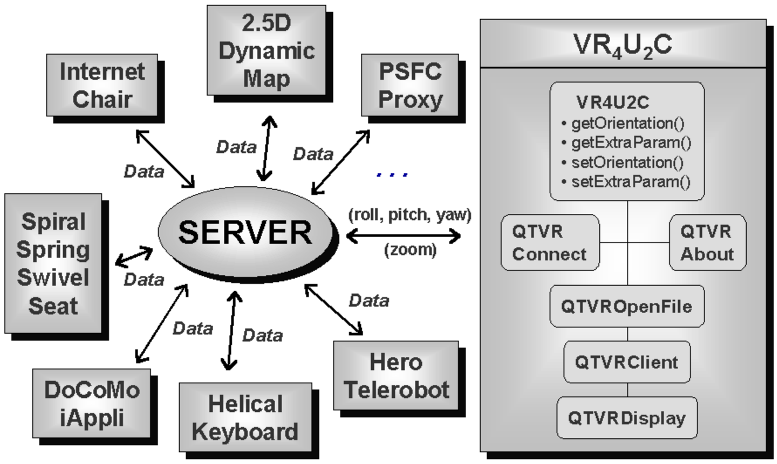

Fig. 6: System Structure

Method	Event
`getOrientation()` `setOrientation()`	To get/set roll, pitch and yaw values from/ through server
`getExtraParam()` `setExtraParam()`	To get/set extra parameter values from/ through server, such as "zoom" value

Table 2: Shared Methods from Server

5. System Features

5.1 Multiple Synchronized Windows/Monitors

With this feature, users can use VR_4U_2C to open and play a QTVR panorama movie across multiple frames/windows with the same or different viewing angles. They can also deloy a multidisplay system for viewing multiple screen-sized windows on separate monitors. However, for best appearance, they should use monitors with same screen size, frequency, resolution, color characteristics, etc. If desired, they could view many aspects of movie scenes on many monitors arranged around them, which might be called "panoramic panoramas."

Users can set a mullion width value for placing multiple windows contiguously, or modeling the frames of the monitors as mullion-like borders. However, this value must be given in resolution size units (pixels), so that it can be used for wide view, mullion wide view, and pan angle calculation. Fig. 7 shows how multiple synchronized windows of a panorama can be arrayed. The horizontal gap between them is the mullion width.

5.2 Stereo Panorama Viewer

Stereographic viewing uses the multiple synchronized windows feature, but requires some modification on node ID and the movie itself. To view the stereo QTVR movies, users can choose one of three viewing techniques: Parallel, Cross-eyed, or Over/under viewing techniques. If the Parallel option is chosen, an opened movie pair will be displayed side-by-side with the movie for the left eye on the left, and the one for the right eye on the right. If the Cross-eye option is chosen, an opened movie pair will be displayed side-by-side as well, but with the movie for the left eye on the right, and the one for the right eye on the left. Finally if users want to use a special viewer called "Leavision,"[15] they can select the Over/under option, so the stereo movie will be displayed vertically, with the movie for the right eye above that for the left.

To see a movie stereoscopically, the left eye must view the movie taken by the left camera, and the right eye must view the right movie. Using parallel and cross-eyed viewing techniques, they can be viewed without any form of viewing aid (free-viewing) [McA93], but the fusion takes a little practice because it involves paralleling or crossing one's eyes slightly. However eye strain can be reduced by using a stereo viewer with a lens for each eye and special mounts like ScreenScope[16] (Fig. 8) for viewing the movies. Alternatively, binocular HMDs can present stereographic pairs to individuals.

For projection method (Fig. 9), users can configure a dual display system sending the video signals for the left and right movies to separate projectors. These two projectors project through two out-of-phase polarized filters onto the same place on a silver (not white) screen with retroreflective properties that preserve polarization. Then users can enjoy the stereo effect with passive polarized eyewear.

[15] `www.stereoscopy.com/faq/waack-ch-5.html`
[16] `www.berezin.com/3d/screenscope.htm`

Fig. 7: Three Synchronized Windows

6. Restrictions and Future Research

When playing back a QTVR movie, we cannot make the displayed image rotated to the left or right. Therefore this is an obvious limitation: no roll. Moreover the stereo stitching is not entirely seamless; there are subtle but distinct “hick-coughs” when switching between the multiple panorama movies used for one side of a stero pair.

One of our motivating goals has been the idea of giving pictures depth, like that exploited by the “Esper” in the movie “Blade Runner,” which could extract almost limitless information from a single “hyper-still,” allowing users to look around corners and behind walls, seeing previously occluded objects. Such photographic omniscience (if not omnipotence) recalls the successive magnifications used in Michaelangelo Antonioni’s “Blowup.” “Deep panos” captures the idea of aligned multinode movies, which interpolate between the 2D of cylindrical/spherical geometry of QTVR and the 3D geometry of CAD. We can call this “multinode movies with smart zooming feature,” in which the system nudges the azimuth, elevation and zoom to align with panos captured from displaced viewpoints.

Other features for future research include:

- vertical viewing mode (which uses transoms instead of mullions to stack windows or monitors vertically),
- multifocal fisheye function (to allow inspection of portions of a panoramic scene at higher magnification),
- dynamic window (contraction/dilation) sizing,
- subliminal scenes (rapidly switching panoramic movies),
- object movies,
- spatial sound (delivered via authoring tools like SoundSaVR[17] or directly at runtime), and
- integration with other clients.

Fig. 8: Viewing Stereo Movies on Screen using Screen-Scope

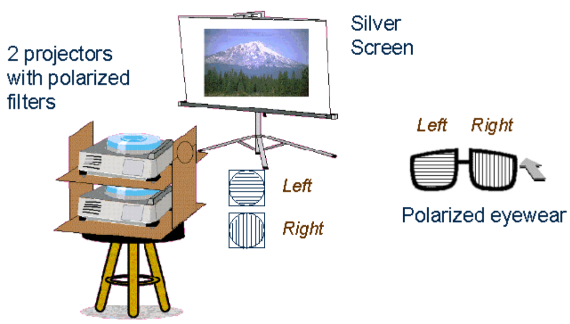

Fig. 9: Screen Viewing using Polarized Projection Filters and Eyewear

[17] www.smgvr.com

7. Conclusion

The VR_4U_2C multi-monitor and -display QTVR browser, integrated with our heterogeneous groupware client suite, enables multimodal activity. Although stereo panoramic viewers have been developed, as well as multimonitor applications, to the best of our knowledge, ours is the first instance of non-anaglyphic stereographic QTVR.

References

[AMY+98] Katsumi Amano, Fumio Matsushita, Hirofumi Yanagawa, Michael Cohen, Jens Herder, William Martens, Yoshiharu Koba, and Mikio Tohyama. A Virtual Reality Sound System Using Room-Related Transfer Functions Delivered Through a Multispeaker Array: the PSFC at the University of Aizu Multimedia Center. *TVRSJ: **T**rans. **V**irtual **R**eality **S**ociety of **J**apan*, 3(1):1–12, March 1998. ISSN 1344-011X; www.u-aizu.ac.jp/~mcohen/welcome/publications/PSFC.ps.

[BC01] Noor Alamshah Bolhassan and Michael Cohen. A Multiuser Multiperspective Panoramic Browser Using QuickTime VR and Java. In *Proc. HC2001: 4th Int. Conf. on **H**uman and **C**omputer*, pages 12–17, Aizu-Wakamatsu, Japan, September 2001.

[BK01] Ryad Benosman and Sing Bing Kang. *Panoramic Vision: Sensors, Theory, and Applications.* Springer, 2001. ISBN 0-387-95111-3.

[Coh00] Michael Cohen. A Design for Integrating the Internet Chair and a Telerobot. In *Proc. IS2000: Int. Conf. on Information Society in the 21st Century*, pages 276–280, Aizu-Wakamatsu, Japan, November 2000. IPSJ, IEICE, IEEE.

[CS00] Michael Cohen and Kenta Sasa. An interface for a soundscape-stabilized spiral-spring swivel-seat. In *Proc. WESTPRAC VII: 7th **West**ern **P**acific **R**egional **A**coustics **C**onf.*, pages 321–324, Kumamoto, Japan, October 2000. ISBN 4-9980886-1-0 and 4-9980886-3-7.

[HC01] Cay S. Horstmann and Gary Cornell. *Core Java 2, Volume I–Fundamentals.* Prentice Hall, 2001. ISBN 0-13-089468-0.

[HOS97] Jie Huang, Noboru Ohnishi, and Noboru Sugie. Building ears for robots: Sound localization and separation. *Artificial Life and Robotics (Springer-Verlag)*, 1(4):157–163, 1997.

[HST+99] J. Huang, T. Supaongprapa, I. Terakura, F. Wang, N. Ohnishi, and N. Sugie. A model based sound localization system and its application to robot navigation. *Robotics and Autonomous Systems (Elsevier Science)*, 27(4):199–209, 1999.

[KC01] Toshifumi Kanno and Michael Cohen. A Helical Keyboard Client. In *Proc. CIT: 2nd Int. Conf. on **C**omputer and **I**nformation **T**echnology*, pages 163–165, Shanghai, September 2001. ISSN 1007-6417.

[KCA00] Nobuo Koizumi, Michael Cohen, and Shigeaki Aoki. Japanese patent #3042731: Voice reproduction system, March 2000.

[KCNH01] Toshifumi Kanno, Michael Cohen, Yutaka Nagashima, and Tomohisa Hoshino. Mobile control of multimodal groupware in a distributed virtual environment. In *ICAT*, Tokyo, December 2001.

[Kit98] Susan A. Kitchens. *The QuickTime VR Book: Creating Immersive Imaging on Your Desktop.* Peachpit Press, 1998. ISBN 0-201-69684-3.

[McA93] David F. McAllister, editor. *Stereo Computer Graphics and Other True 3D Technologies.* Princeton University Press, 1993. ISBN 0-691-08741-5.

[MS99] Tom Maremass and William Stewart. *QuickTime for Java: a Developer Reference.* Morgan Kaufman: Academic Press, 1999. ISBN 0-12-305440-0.

[MSC01] Takashi Mikuriya, Masataka Shimizu, and Michael Cohen. A collaborative virtual environment featuring multimodal information controlled by a dynamic map. *3D Forum: J. of Three Dimensional Images*, 15(1):133–136, 3 2001. ISSN 1342-2189.

[Nai91] Michael Naimark. Elements of realspace imaging: A proposed taxonomy. In *Proc. SPIE/SPSE Electronic Imaging Conf.*, San Jose, CA, 1991. Vol. 1457.

[Nai97] Michael Naimark. A 3d moviemap and a 3d panorama. In *Proc. SPIE/SPSE Electronic Imaging Conf.*, San Jose, CA, 1997. Vol. 3012.

[NC01a] Yutaka Nagashima and Michael Cohen. Distributed virtual environment interface for a mobile phone. In *Proc. HC2001: 4th Int. Conf. on **H**uman and **C**omputer*, pages 43–46, Aizu-Wakamatsu, Japan, September 2001.

[NC01b] Kazuhisa Nakashima and Michael Cohen. Animated extensions to a helical keyboard client: Chord-chords, chord-kites, and intelligent spatialization. In *Proc. HC2001: 4th Int. Conf. on **H**uman and **C**omputer*, pages 39–41, Aizu-Wakamatsu, Japan, September 2001.

[YCHY01] Yasuhiro Yamazaki, Michael Cohen, Jie Huang, and Tomohide Yanagi. Augmented audio reality: compositing mobile telerobotic and virtual spatial audio. In *ICAT*, Tokyo, December 2001.