Virtual Reality Application

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CAVE Visualization System

- **CAVE (CAVE Automatic Virtual Environment):** A fully immersive & interactive 10'³ virtual environment (VE)
- **ImmersaDesk:** A semi-immersive with a 4'×5' display

http://www.vrac.iastate.edu
http://www.mechdyne.com
Billion-Atom Walkthrough

- Achieved real-time walkthrough for a billion atoms in ImmersaDesk

Multiviewer semi-immersion

IEEE Virtual Reality Best Paper

http://cacs.usc.edu/education/cs596/Sharma-Viz-Presence03.pdf
• **Stereographics:** The projector interleaves images for left & right eyes at a rate of 120 frame/s synchronized with an LCD shutter glass via an infrared emitter; 3D perception is created by showing the two eyes slightly rotated objects

• **Wand:** A 3D mouse with buttons; the position & angle of the wand as well as button press are user inputs (*cf.* Wii)

• **Magnetic tracking system:** A sensor is attached to a user’s head so that the scene can be changed according to the user’s position (*cf.* `gluLookat()`)

![CAVE Components](image)
CAVE Programming

- **CAVE library**: A library of C functions & macros to control the operation of the CAVE: keep all the devices synchronized; produce the correct perspective for each wall; & provide the applications with the current state of all the CAVE elements

- **Compiling a CAVE application**:
  
  ```
  LIBS = -L/usr/local/CAVE/lib32 -lcave_ogl -lGLU -lGL -lXi -lX11 -lm
  cc -O -o ball ball.o $(LIBS)
  ```

- **CAVE coordinate system**: $10^{3}$ with the origin at the central floor

http://www.evl.uic.edu/pape/CAVE/prog
Example: ball.c

#include <cave_ogl.h>
#include <GL/glu.h>

void main(int argc, char **argv) {
    CAVEConfigure(&argc, argv, NULL); CAVEInit(); // Initialize the CAVE
    CAVEInitApplication(init_gl, 0); // Pointer to GL initialization function
    CAVEDisplay(draw_ball, 0); // Pointer to drawing function
    while (!CAVEgetbutton(CAVE_ESCKEY)) sgnap(10); // Continue until ESC hit
    CAVEExit();
}

void init_gl(void) {
    float redMaterial[] = { 1, 0, 0, 1 };  
    glEnable(GL_LIGHT0);
    glMaterialfv(GL_FRONT_AND_BACK, GL_AMBIENT_AND_DIFFUSE, redMaterial);
    sphereObj = gluNewQuadric();
}

void draw_ball(void) {
    glClearColor(0., 0., 0., 0.);
    glClear(GL_DEPTH_BUFFER_BIT|GL_COLOR_BUFFER_BIT);
    glEnable(GL_LIGHTING);
    glPushMatrix();
    glTranslatef(0.0, 4.0, -4.0);
    gluSphere(sphereObj, 1.0, 8, 8);
    glPopMatrix();
    glDisable(GL_LIGHTING);
}

http://www.evl.uic.edu/pape/CAVE/prog
X3D

- X3D is an open standards XML (extensible markup language)-enabled 3D file format for real-time communication of 3D data across applications over network.
- With X3D browsers and plug-ins, X3D becomes immersive allowing a user to walk through the 3D scene.
- An X3D file is publishable directly on the World Wide Web; an X3D browser acts as a helper application at the client side.

- X3D homepage
  http://www.web3d.org

- X3D plug-ins for Windows, Macintosh, and Linux
  http://www.web3d.org/x3d/content/examples/X3dResources.html

See also Quicktime VR: https://en.wikipedia.org/wiki/QuickTime_VR
3D in Hollywood

http://www.youtube.com/watch?v=avecKPWqYqM
3D in Science

- **Anaglyph**: Stereoscopic 3D effect by means of encoding each eye’s image using filters of different colors (typically red & cyan).

3D in Molecular Dynamics (1)

Y. Chen et al., Appl. Phys. Lett. 93, 171908 ('08)
How to Make Anaglyph Stereo

• In the main window of the VMD software, go to the Display menu, then the Stereo submenu
• Select the Left view & save the image as an image file
• Next select the Right view & save the image as another image file
• Use software such as Photoshop to make an anaglyph by image processing
• Or, simply select Anaglyph option

http://www.ks.uiuc.edu/Research/vmd/
Commodity Virtual Reality

- Immersive visualization to every scientist’s desktop:
  Exported VMD animation to a VR platform — Oculus Rift head mounted display (HMD) — using Unity game engine to increase the perceptive depth

- In VMD, File → Render as wavefront object & material (texture) files; then, use Blender (3D editor software, https://www.blender.org) to make it compatible with Unity

C. M. Nakano, E. Moen, H. Byun, H. Ma, B. Newman, A. McDowell, T. Wei, & M. Y. El-Naggar,

*iBET: Immersive visualization of biological electron-transfer dynamics*,
*Journal of Molecular Graphics & Modelling* **65**, 94 (’16)
GEARS (Game-engine-assisted research platform for scientific computing) allows scientists to develop & perform immersive & interactive simulations within commodity virtual reality (VR) platforms.

- Implemented simulation workflows in VR-capable Unity & Unreal game engines
- Enhanced interaction utilities, e.g., virtual confocal microscopy
- Developed an interface with community MD software, LAMMPS, & demonstrated immersive & interactive 250K-atom simulations on desktop

https://github.com/USCCACS/GEARS
B. Horton, E. Moen, K. Nomura et al., SoftwareX 9, 112 (‘19)
New Model

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⭐⭐⭐⭐⭐ (259)
Scientific Augmented Reality?

Microsoft mixed reality (MR) academic seeding program at USC

“Million-atom shared immersion?”

cf. CSCI 538: Augmented, Virtual and Mixed Reality