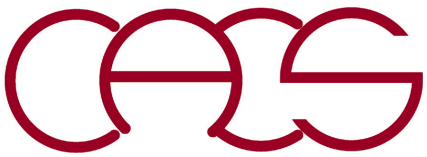
Virtual Reality Application

Aiichiro Nakano

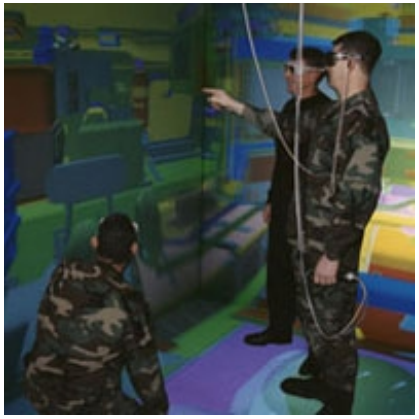
Collaboratory for Advanced Computing & Simulations
Department of Computer Science
Department of Physics & Astronomy
Department of Chemical Engineering & Materials Science
Department of Biological Sciences
University of Southern California

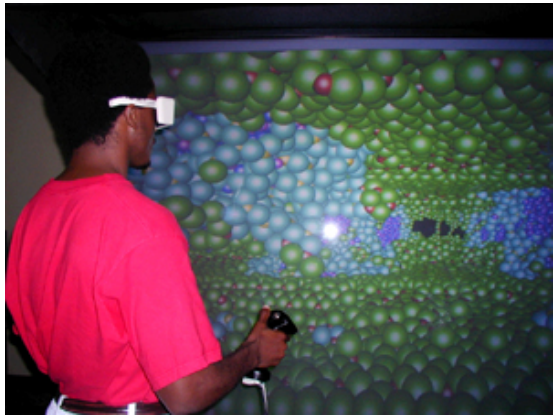
Email: anakano@usc.edu

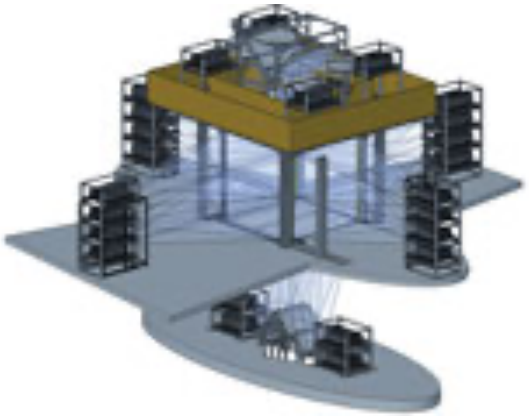


CAVE Visualization System

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







CAVE

C6 at Iowa-State VRAC

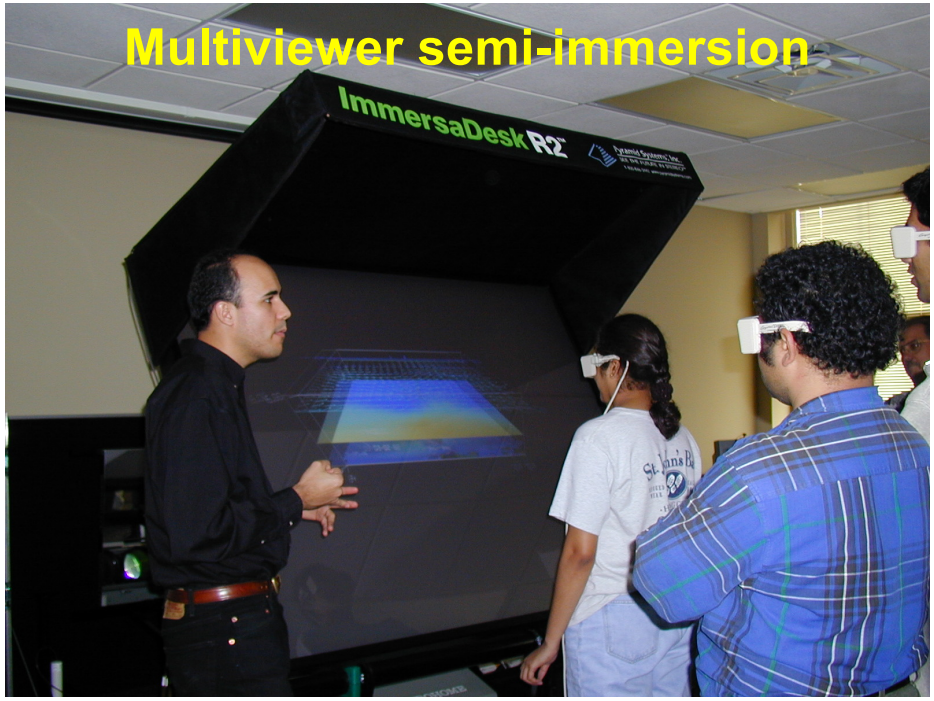
ImmersaDesk

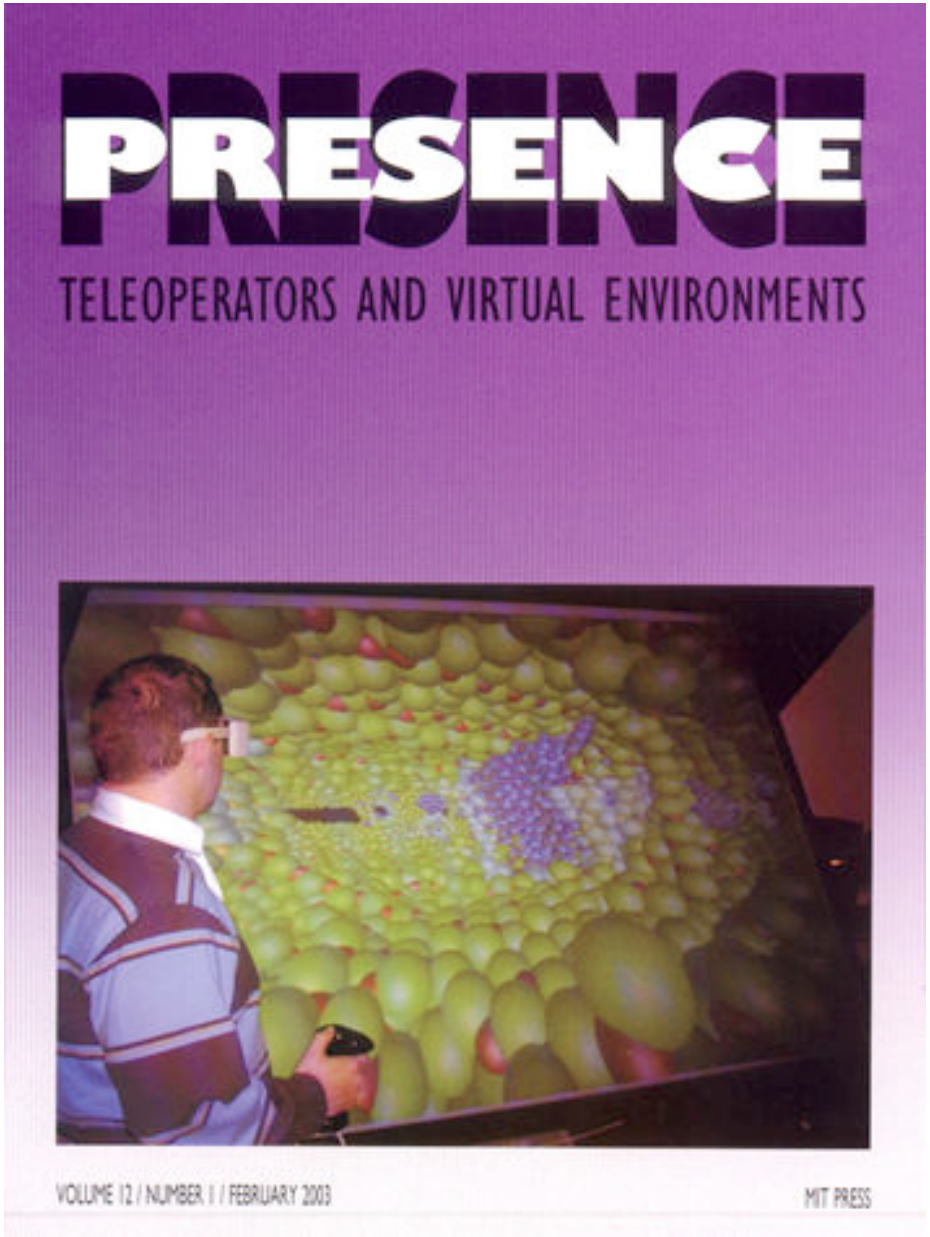
`http://www.vrac.iastate.edu`

`http://www.mechdyne.com`

Billion-Atom Walkthrough

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



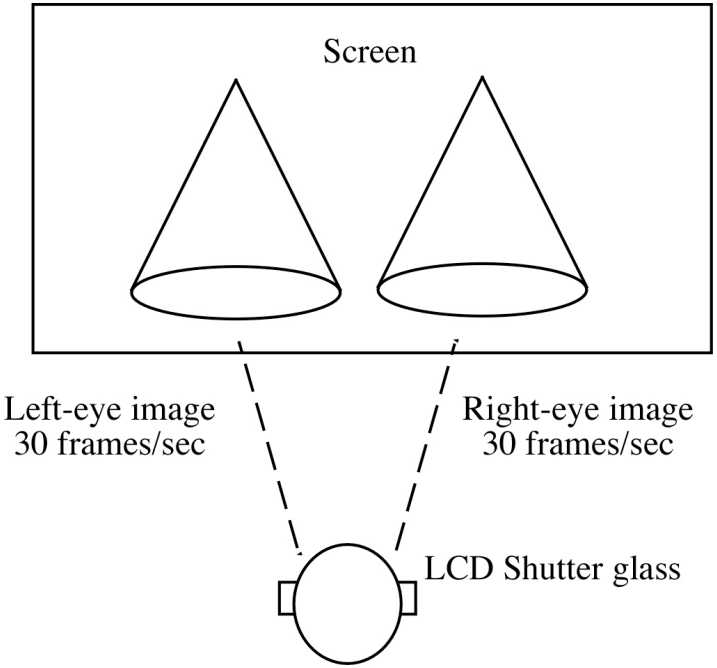


IEEE Virtual Reality Best Paper

http://cacs.usc.edu/education/cs596/Sharma-Viz-Presence03.pdf

CAVE Components

- **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()`)

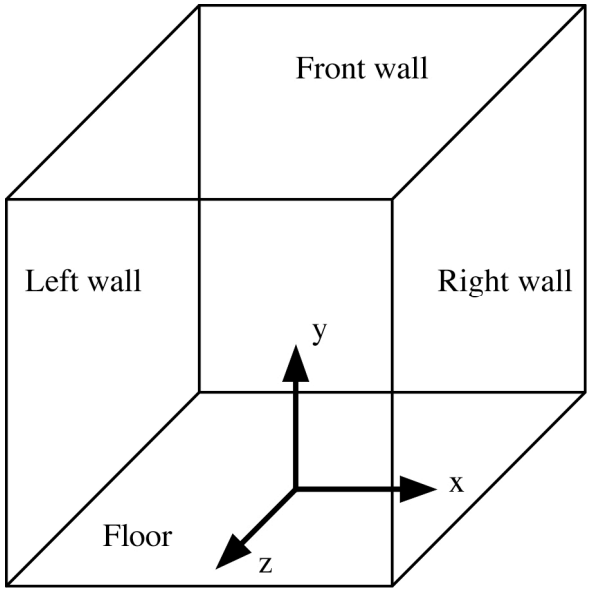


CAVE Programming

- **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)) sginap(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`

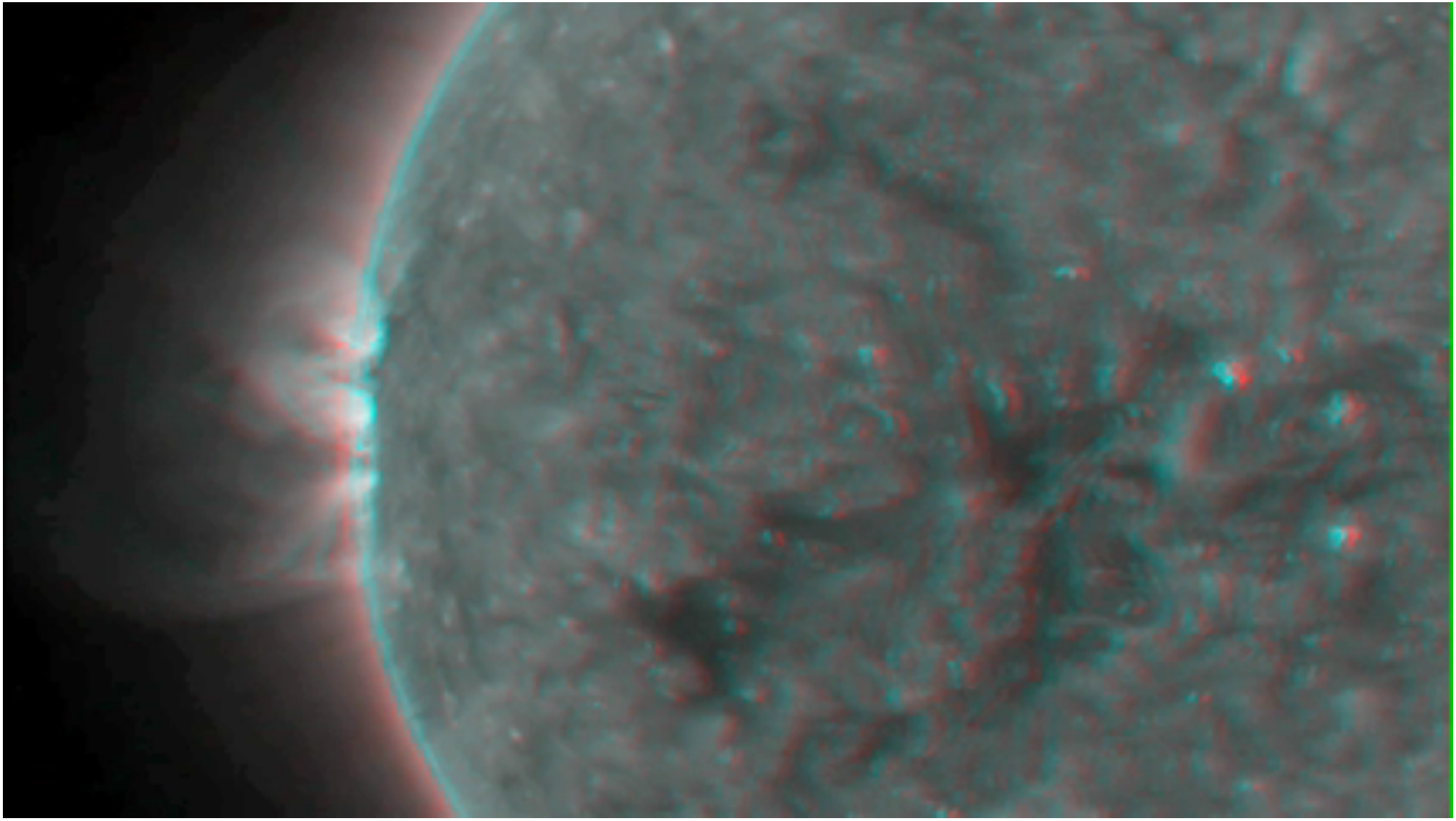
See also Qucktime VR: https://en.wikipedia.org/wiki/QuickTime_VR

3D in Hollywood

http://www.youtube.com/watch?v=avecKPWqYqM

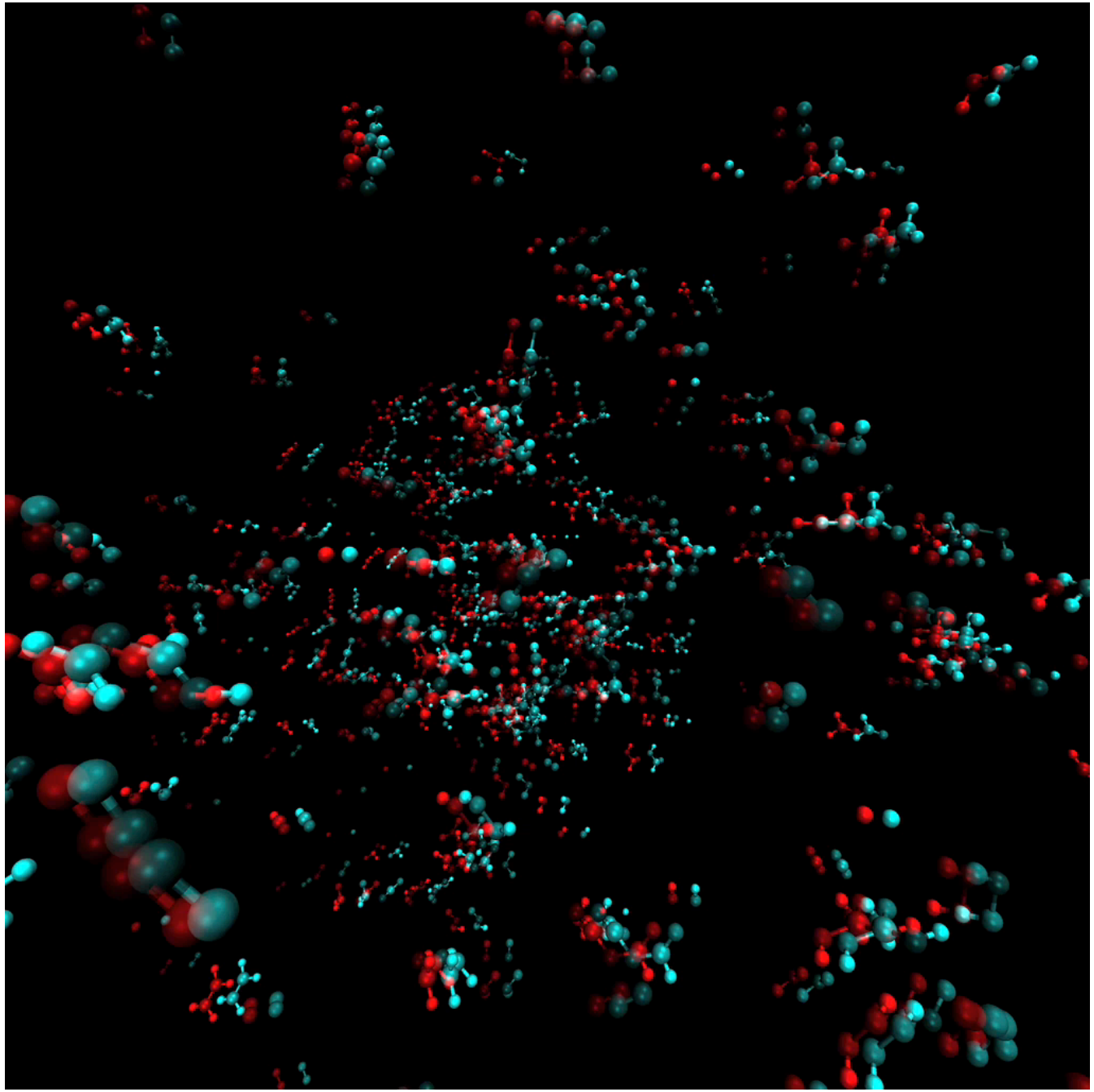
3D in Science

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



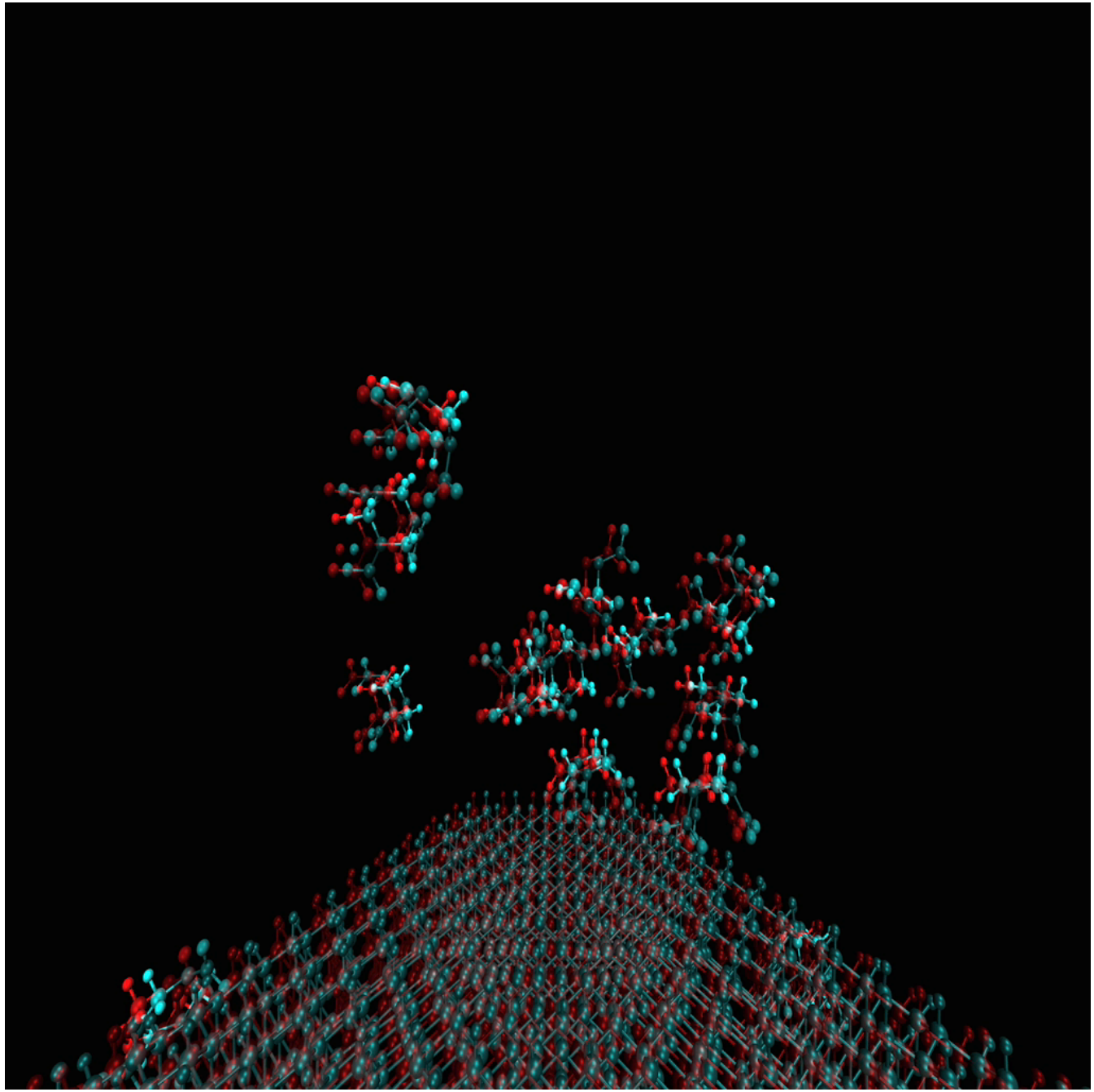
http://www.nasa.gov/mission_pages/stereo/news/stereo3D_press.html

3D in Molecular Dynamics (1)



K. Nomura *et al*., *Phys. Rev. Lett*. **99,** 148303 ('07)

3D in Molecular Dynamics (2)

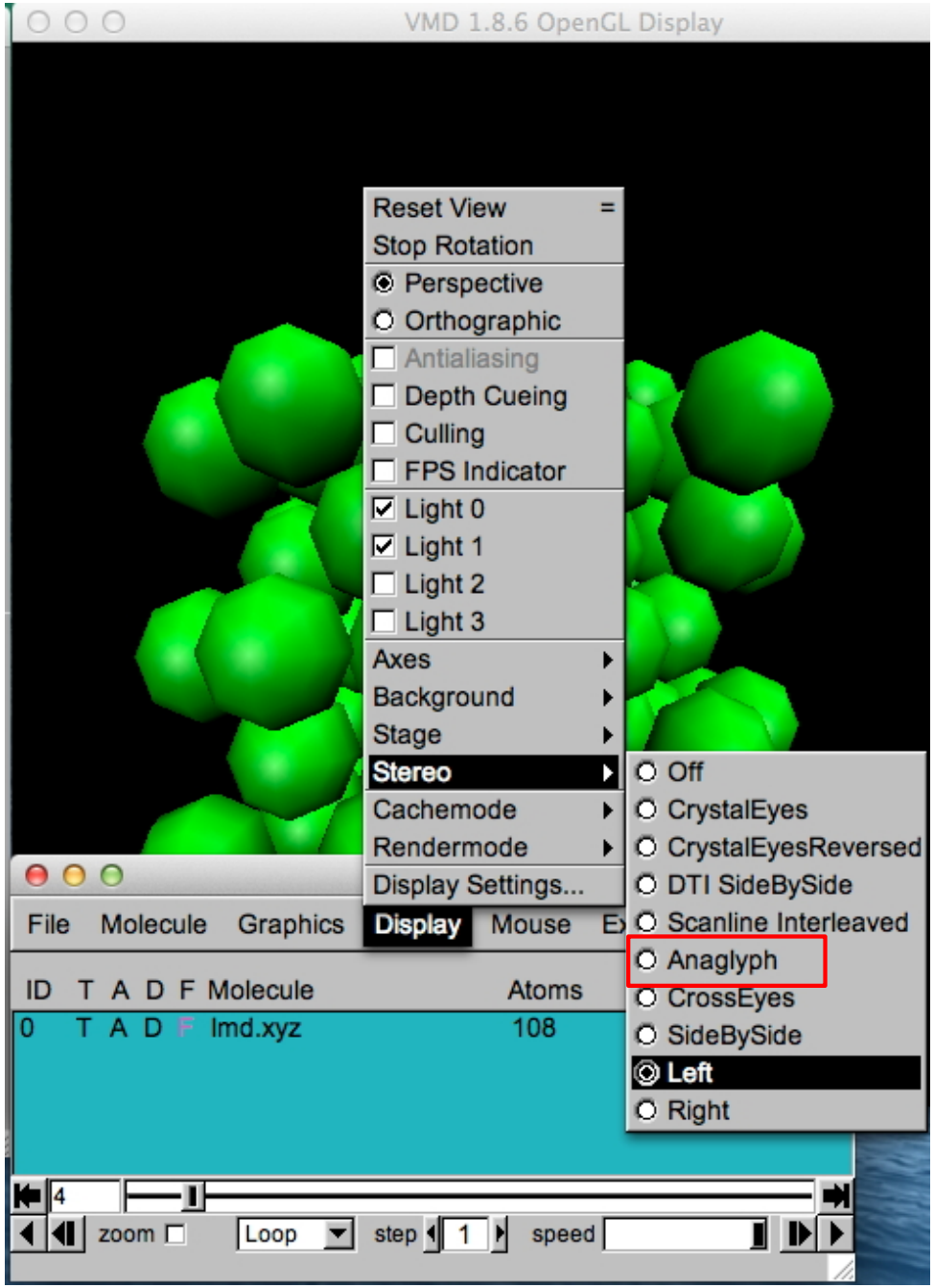


Y. Chen *et al.*,
Appl. Phys. Lett.
93, 171908 (’08)

How to Make Anaglyph Stereo

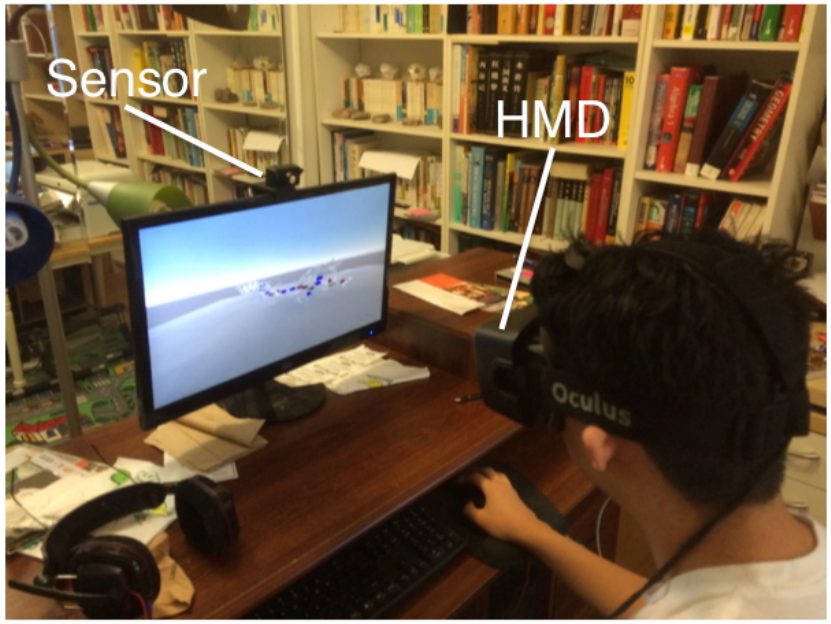
- In the main window of the VMD software, go to the Display menu, then the Stereo submenu
- Select the Left view & save the image as an image file
- Next select the Right view & save the image as another image file
- Use software such as Photoshop to make an anaglyph by image processing
- Or, simply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

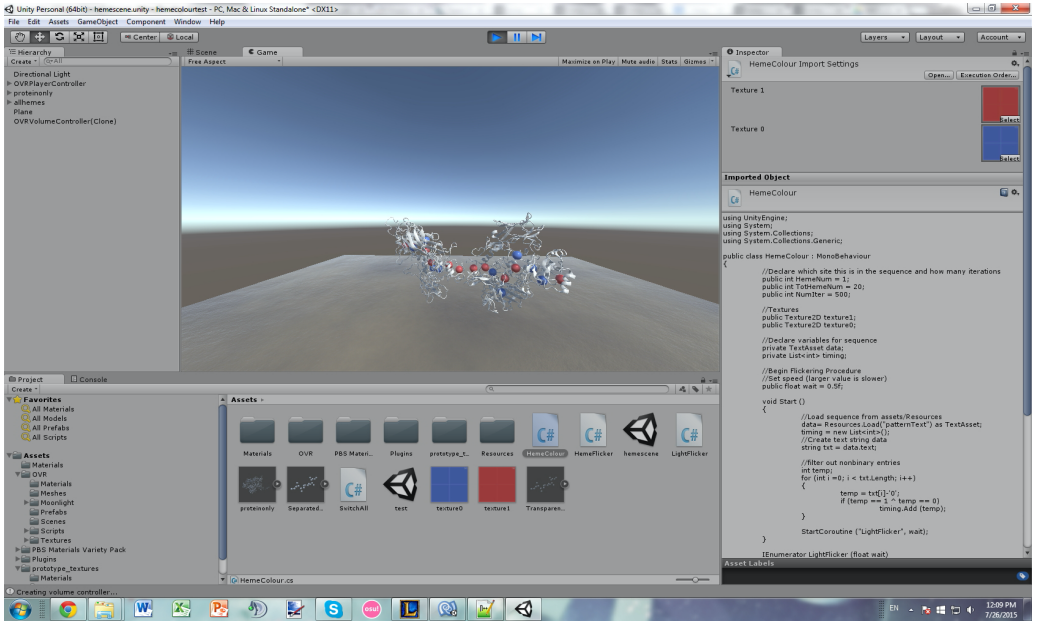
http://www.ks.uiuc.edu/Research/vmd/



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**



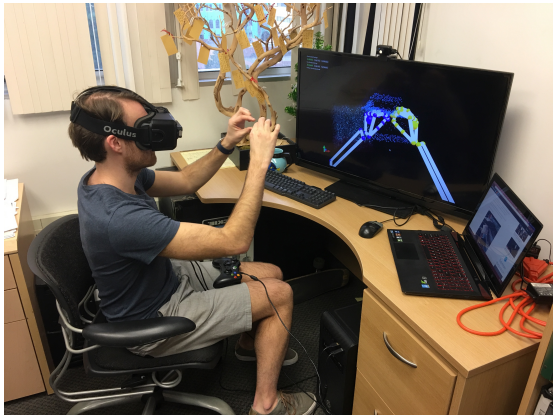


- **In VMD, File → Render as wavefront object & material (texture) files; then, use Blender (3D editor software, https://www.blender.org) to make it compatible with Unity**

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: VR to Every Scientist's Desktop

GEARS (Game-engine-assisted research platform for scientific computing) allows scientists to develop & perform immersive & interactive simulations within commodity virtual reality (VR) platforms

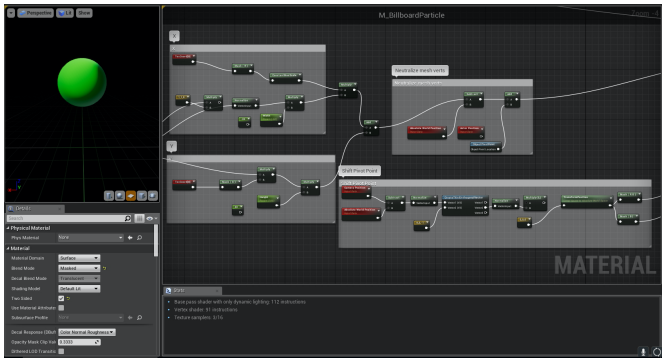


Oculus Rift + Leap Motion

HTC Vive

Exfoliation of MoS_2

- **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**



LammpsVR editor

GEARS

https://github.com/USCCACS/GEARS

B. Horton, E. Moen, K. Nomura *et al.*, *SoftwareX* **9**, 112 ('19)

New Model

256 GB

Oculus Quest 2 256 GB Virtual Reality ...

$399.00

Oculus

Free shipping

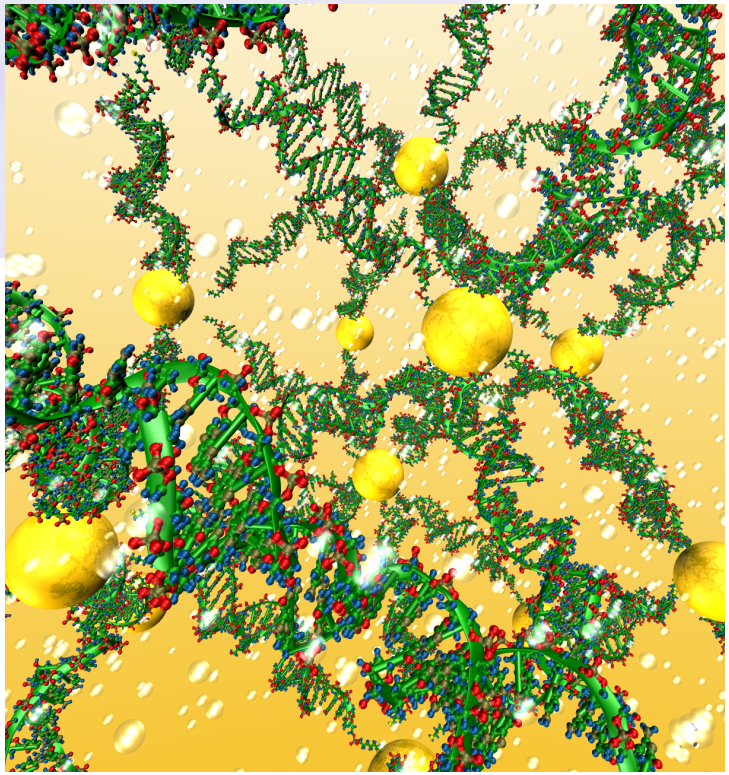
64 GB

Oculus - Quest 2 Advanced All-In-One

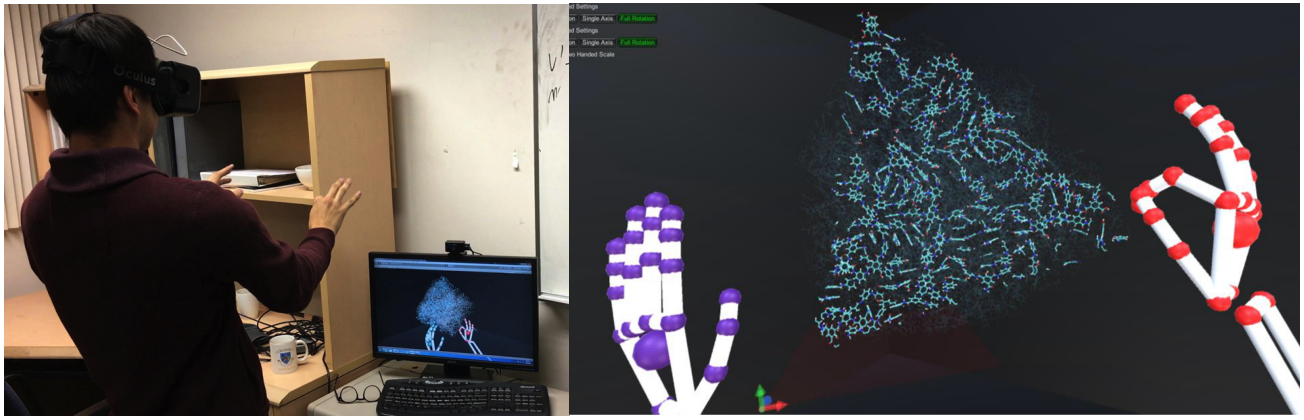
$299.00

Best Buy

★★★★½ (259)



Scientific Augmented Reality?



VR

MR

Microsoft mixed reality (MR) academic seeding program at USC

"Million-atom shared immersion?"

cf. CSCI 538: Augmented, Virtual and Mixed Reality