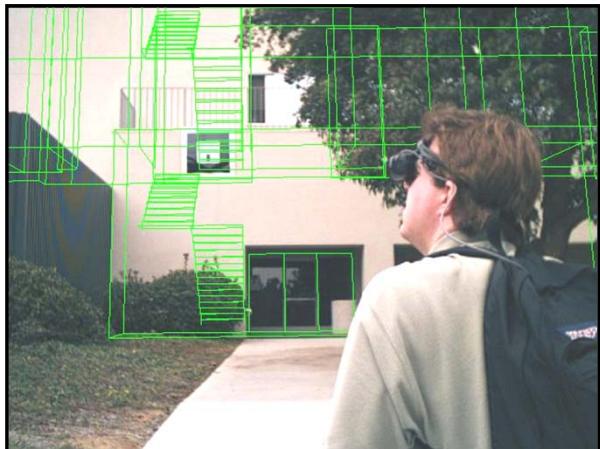


Virtual and Augmented Reality

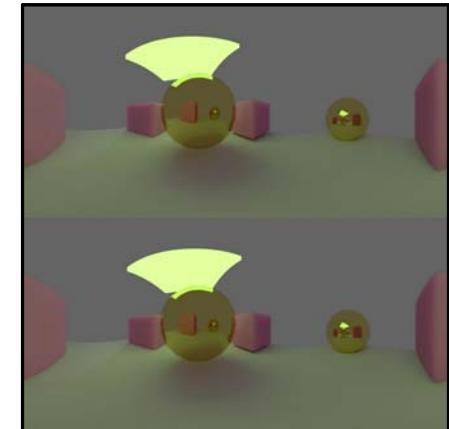


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**Oregon State
University**
Mike Bailey

mjb@cs.oregonstate.edu



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Computer Graphics

“Reality, what a concept!”
-- Robin Williams

VrAr.pptx

mjb – September 1, 2020

Virtual Reality Definition

Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world. Applications of virtual reality can include entertainment (i.e. video games) and educational purposes (i.e. medical or military training). Other, distinct types of VR style technology include augmented reality and mixed reality, sometimes referred to as extended reality or XR.

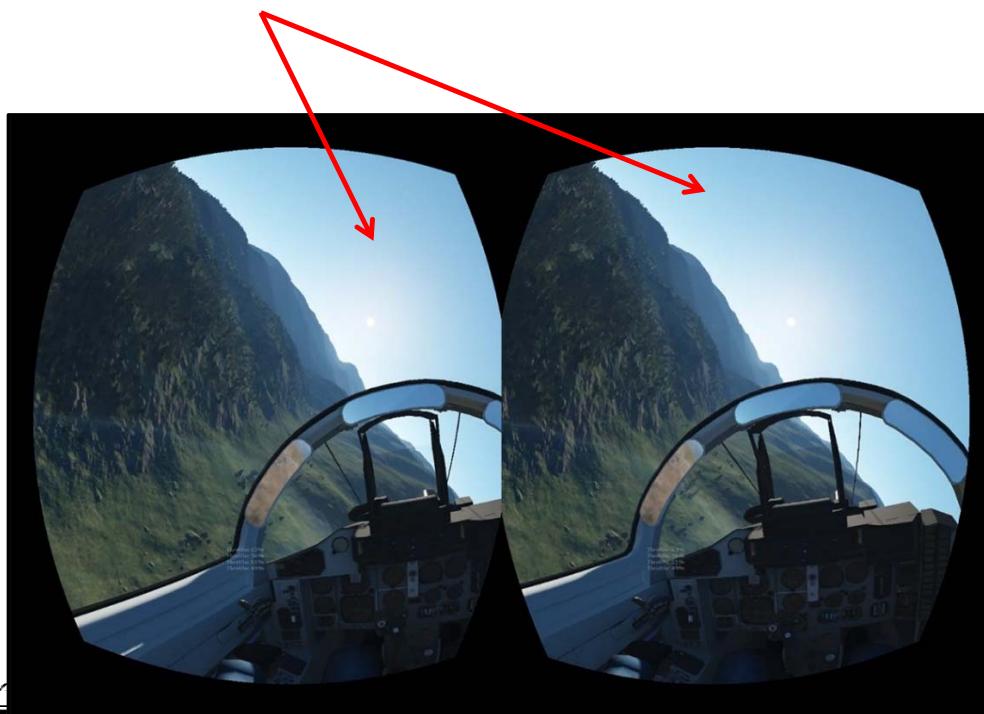
Currently standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback, but may also allow other types of sensory and force feedback through haptic technology.

https://en.wikipedia.org/wiki/Virtual_reality



VR Headsets

Uses shaders to get the correct non-linear fisheye lens distortion



Using an accelerometer and a gyroscope to know the head position and orientation



Inexpensive VR Viewer for your Cell phone

Uses OpenGL-ES shaders to get the correct non-linear fisheye lens distortion

Uses your phone's gyroscope to know the head orientation

Uses a moving magnet and the phone's digital compass to perform a "left-click"



Aquarium game, SideKick



Surround-VR: The CAVE

A **Cave Automatic Virtual Environment** (better known by the recursive acronym **CAVE**) is an immersive virtual reality environment where projectors are directed to between three and six of the walls of a room-sized cube.

https://en.wikipedia.org/wiki/Cave_automatic_virtual_environment



<https://www.mechdyne.com>

Augmented Reality Definition

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. AR can be defined as a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The overlaid sensory information can be constructive (i.e. additive to the natural environment), or destructive (i.e. masking of the natural environment). This experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one.

https://en.wikipedia.org/wiki/Augmented_reality

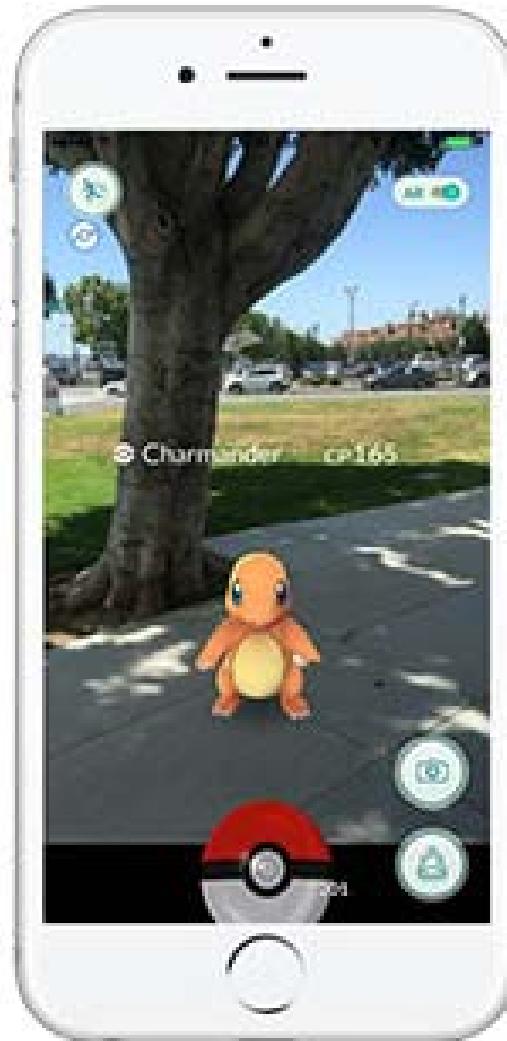


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Augmented Reality -- Pokémon Go

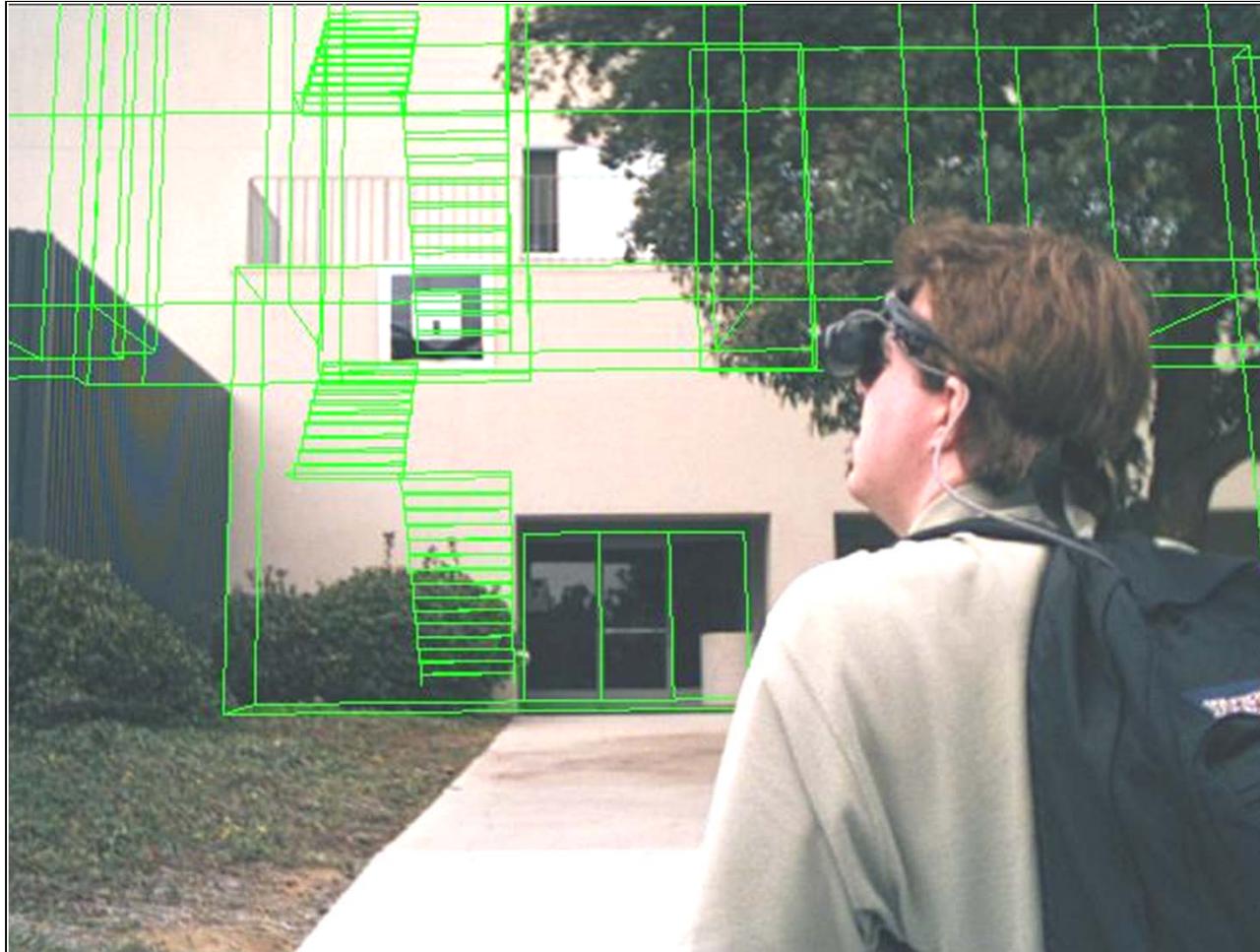


Pokemon.com



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Architectural Augmented Reality



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Matt Clothier

mjb – September 1, 2020

High-end Augmented Reality -- Microsoft Hololens 2



<https://www.wired.com/story/microsoft-hololens-2-headset/>

Microsoft Hololens 2



The lasers in the HoloLens 2 shine into a set of mirrors that oscillate as quickly as 54,000 times per second so the reflected light can paint a display. Those two pieces together form the basis of a microelectromechanical system (MEMS) display. That's all tricky to make, but the really tricky part for a MEMS display is getting the image that it paints into your eyeball.

The Hololens uses **waveguides**, pieces of glass in front of your eye that are carefully etched so they can reflect the 3D displays. When you put the whole system together — the lasers, the mirrors, and the waveguide — you get a bright display with a wide field of view that doesn't have to be precisely aimed into your eyes to work.

The internal processor is an ARM-based Qualcomm Snapdragon 850, which is designed to be very battery-efficient.



Microsoft Hololens 2 Components



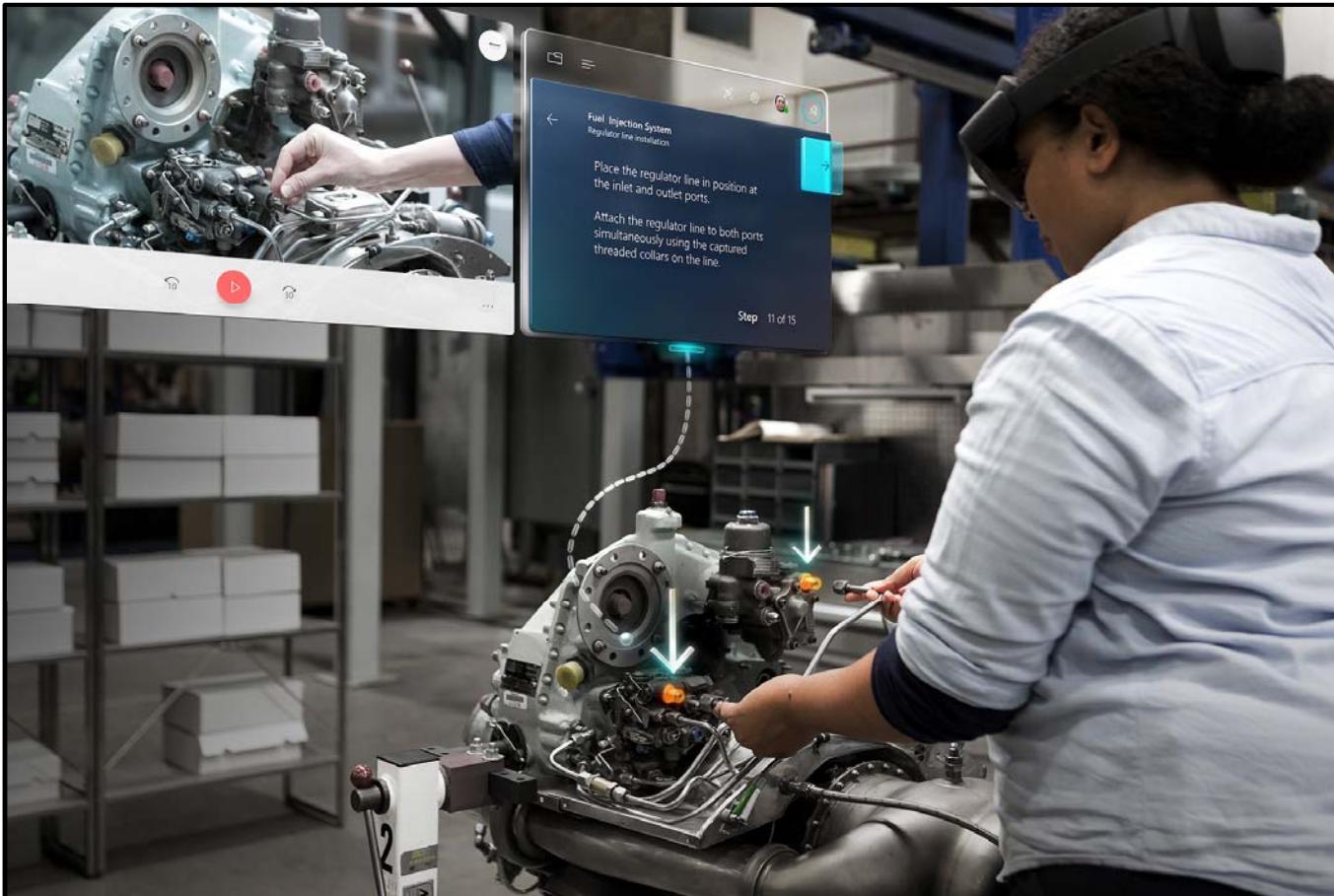
Microsoft



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Microsoft Hololens 2 used to Guide Mechanical Assembly Operations



Microsoft

Extended Reality

Extended reality (XR) is a term referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables, where the 'X' represents a variable for any current or future spatial computing technologies. It includes representative forms such as augmented reality (AR), mixed reality (MR), and virtual reality (VR) and the areas interpolated among them. The levels of virtuality range from partially sensory inputs to immersive virtuality, also called VR.

XR is a superset which includes the entire spectrum from "the complete real" to "the complete virtual" in the concept of reality–virtuality continuum ... Still, its connotation lies in the extension of human experiences especially relating to the senses of existence (represented by VR) and the acquisition of cognition (represented by AR). With the continuous development in human–computer interactions, this connotation is still evolving.

https://en.wikipedia.org/wiki/Extended_reality



Definitions of Mixed Reality and Augmented Virtuality

Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time. Mixed reality does not exclusively take place in either the physical or virtual world, but is a hybrid of reality and virtual reality, encompassing both augmented reality and augmented virtuality via immersive technology.

https://en.wikipedia.org/wiki/Mixed_reality

Augmented virtuality (AV) is a subcategory of mixed reality that refers to the merging of real-world objects into virtual worlds. As an intermediate case in the virtuality continuum, it refers to predominantly virtual spaces, where physical elements (such as physical objects or people) are dynamically integrated into and can interact with the virtual world in real time. This integration is achieved with the use of various techniques, such as streaming video from physical spaces, like through a webcam, or using the 3D digitalization of physical objects.

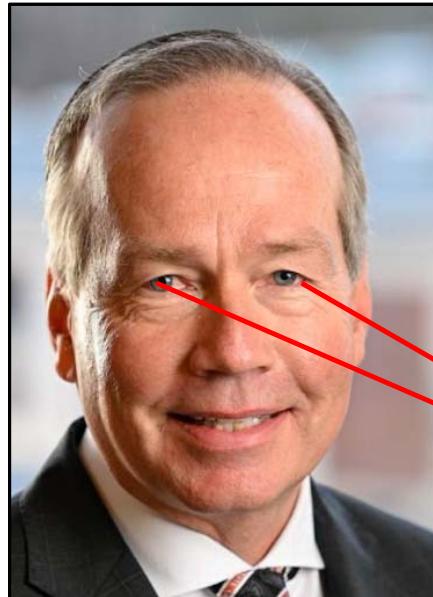
The use of real-world sensor information, such as gyroscopes, to control a virtual environment is an additional form of augmented virtuality, in which external inputs provide context for the virtual view.

https://en.wikipedia.org/wiki/Mixed_reality

VR/AR usually involves Binocular Vision, but Doesn't Have To

In everyday living, part of our perception of depth comes from the slight difference in how our two eyes see the world around us. This is known as *binocular vision*.

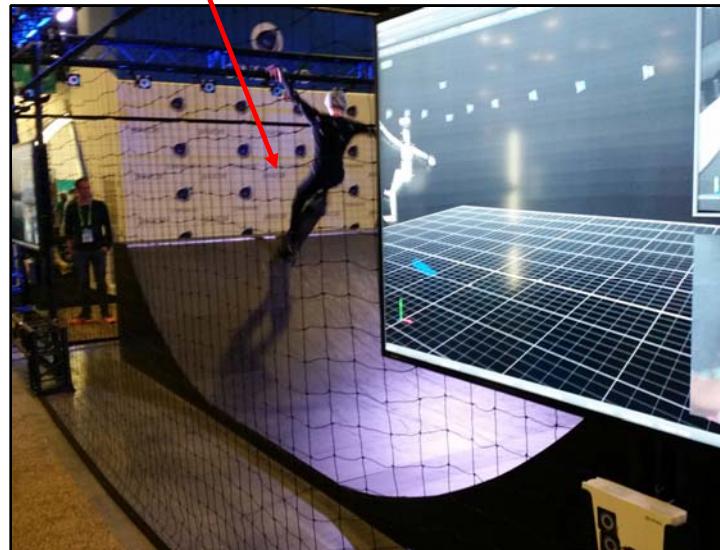
We care about this, and are discussing it, because stereo computer graphics can be a great help in de-cluttering a complex 3D scene. It can also enhance the feeling of being immersed in a movie.



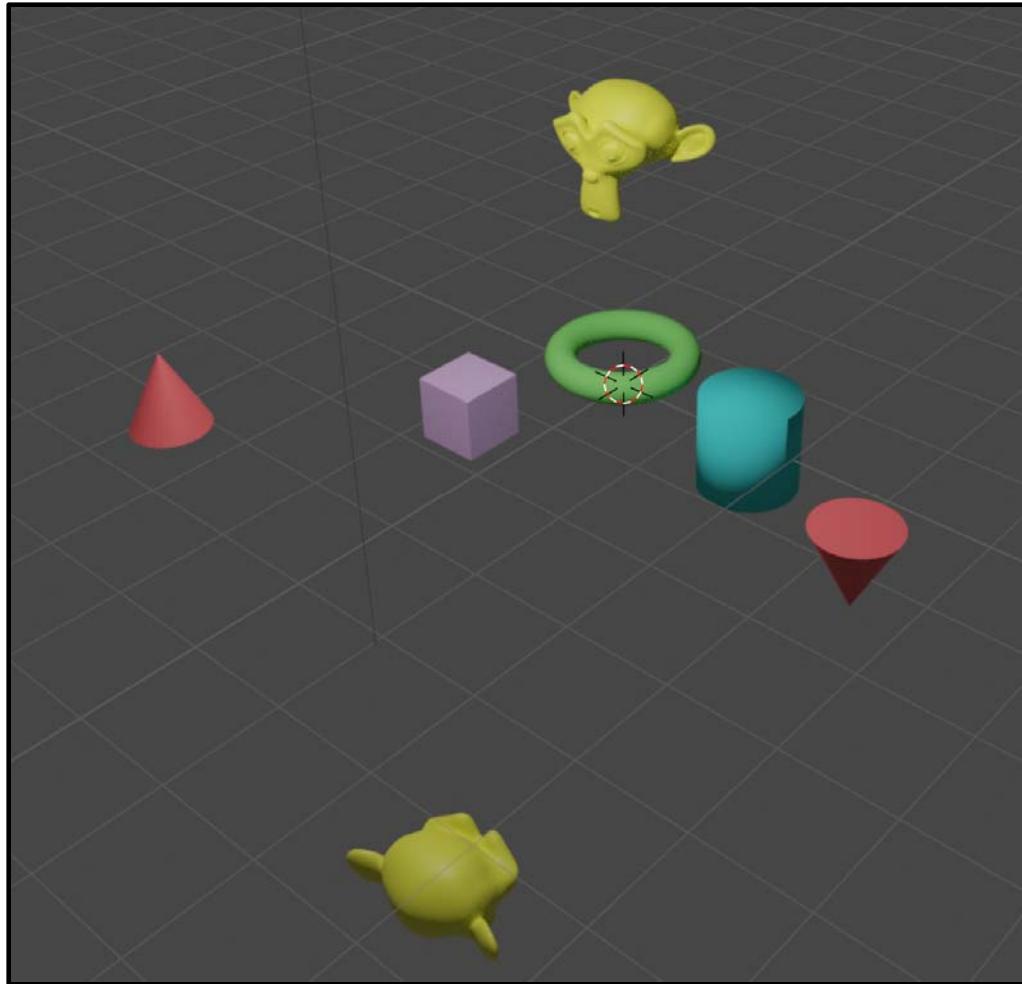
Tracking – Knowing where your Head is and How it is Oriented

3D Tracking Possibilities:

- Mechanical linkages
- Accelerometers and gyroscopes
- Motion Capture (“MoCap”)
- Electromagnetic trackers



VR with Head Tracking is Good for Walking Through a 3D Scene, Even Without Stereographics 17



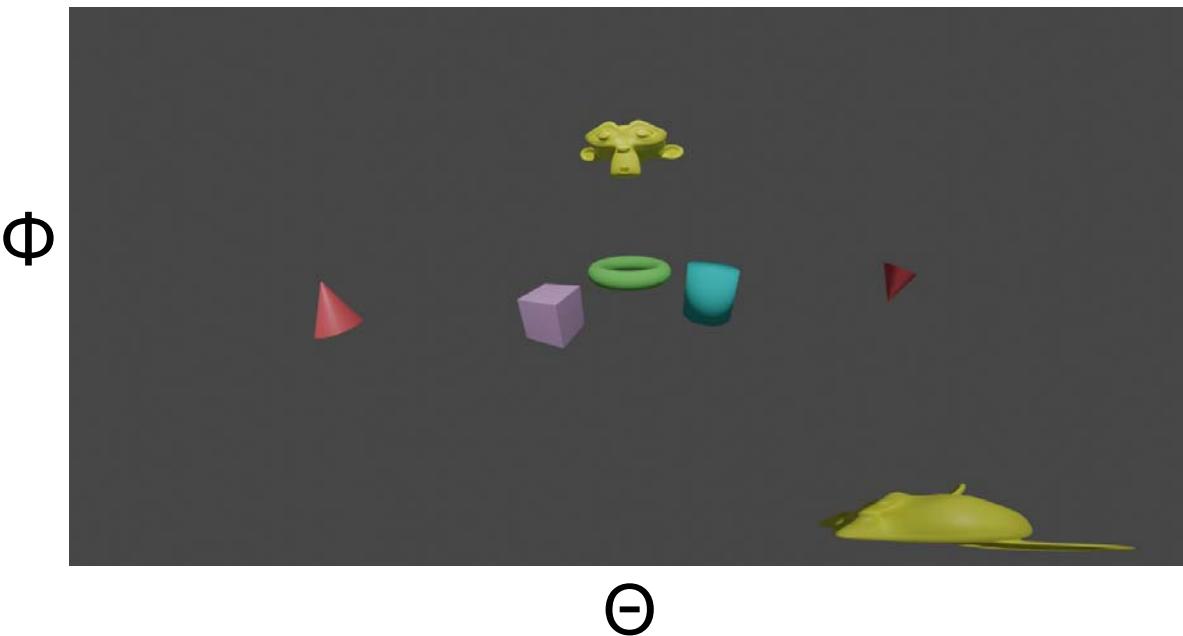
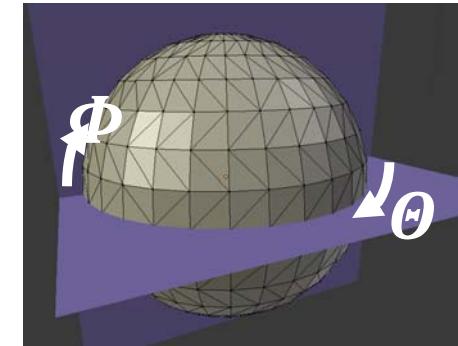
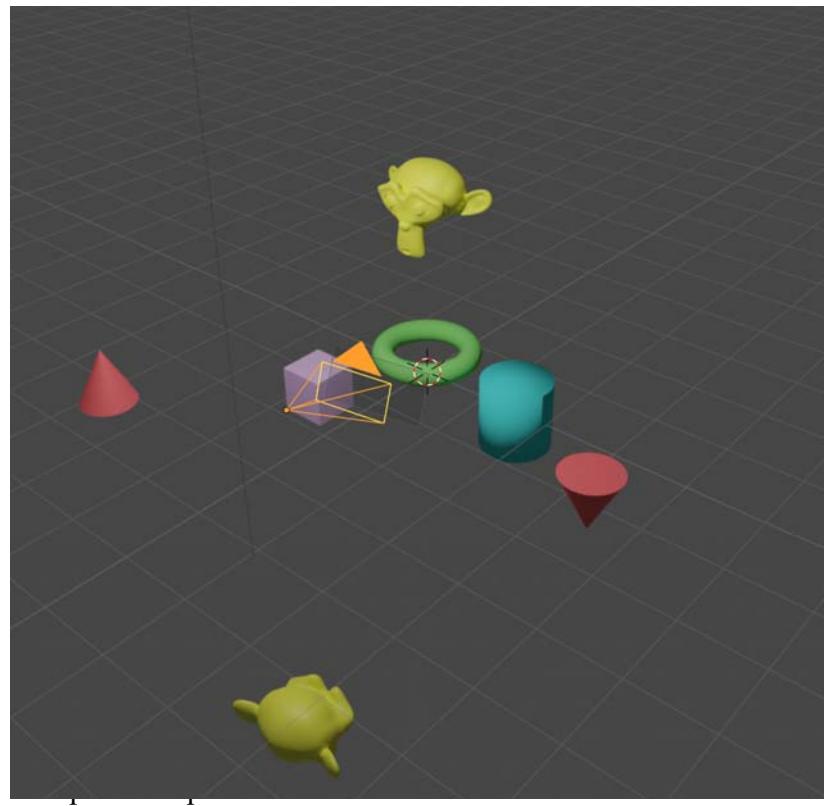
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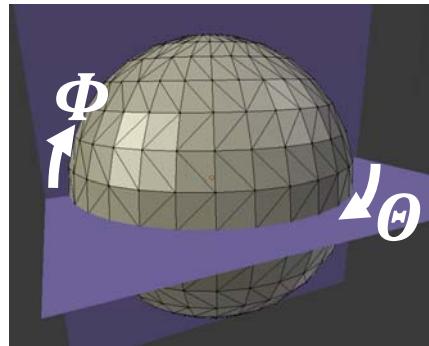
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You Can Also Use VR to View a 360° 2D Spherical Image of the Scene

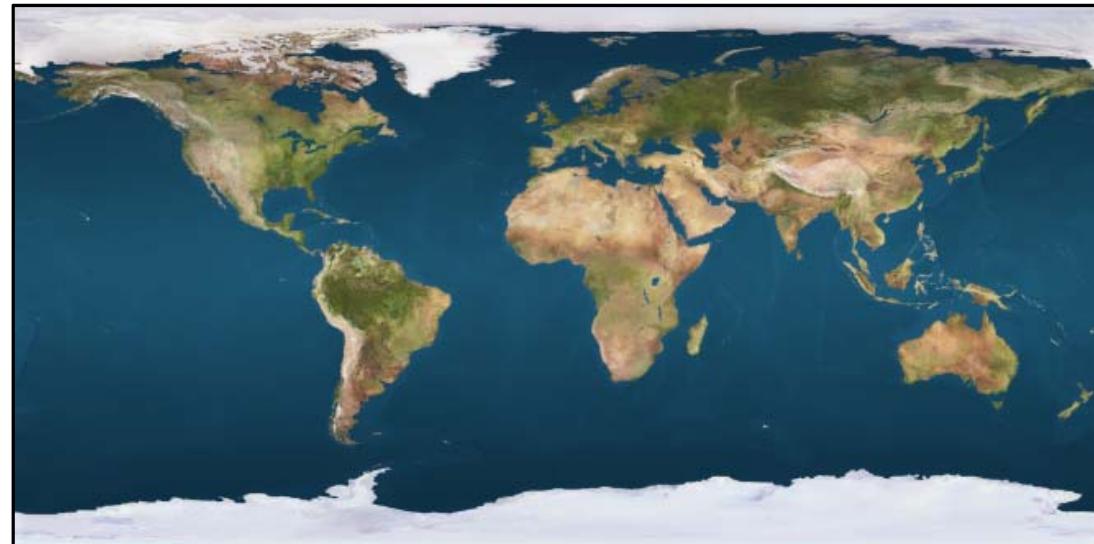
1. Put the eye/camera in the middle of the scene.
2. Render the scene, a vertical strip at a time, onto the inside of a sphere.
3. Save the image, where $\Theta \rightarrow s$ and $\Phi \rightarrow t$



It's Roughly the Same Idea as Mapping a Texture Image onto a Sphere,
but it's the Reverse Process of Mapping a Sphere onto an Image



$$\begin{aligned}\Theta &\rightarrow s \\ \Phi &\rightarrow t\end{aligned}$$



How to Create a 2D Spherical Image of a 3D Scene

```

void DrawAndWriteSegments()
{
    unsigned char array[3*PIXELS_PER_SEG*HEIGHT];
    glViewport( 0, 0, PIXELS_PER_SEG, HEIGHT );
    glMatrixMode( GL_PROJECTION );
    glLoadIdentity( );
    gluPerspective( PHIDEGR, ASPECT_Y_OVER_X, ZNEAR, ZFAR );
    int col = 0; // column in the full array
    for( int lookDeg = -90.; lookDeg < 270; lookDeg += PHIDEGR )
    {
        glMatrixMode( GL_MODELVIEW );
        glLoadIdentity( );
        float lx = Sind( (float)lookDeg ) + EX;
        float ly = 0. + EY;
        float lz = Cosd( (float)lookDeg ) + EZ;
        gluLookAt( EX, EY, EZ, lx, ly, lz, 0., 1., 0. );
        glCallList( LidarList );
        glFlush( );
        glutSwapBuffers( );
        glFinish( );

        glPixelStorei( GL_PACK_ALIGNMENT, 1 );
        glReadPixels( 0, 0, PIXELS_PER_SEG, HEIGHT, GL_RGB, GL_UNSIGNED_BYTE, array );

        for( int y = 0; y < HEIGHT; y++ )
        {
            memcpy( &FullArray[3*col*HEIGHT+y], &array[3*y*PIXELS_PER_SEG], 3*PIXELS_PER_SEG );
        }
        col += PIXELS_PER_SEG;
    }

    WriteArray( (char *)"Middle.bmp", FullArray );
}

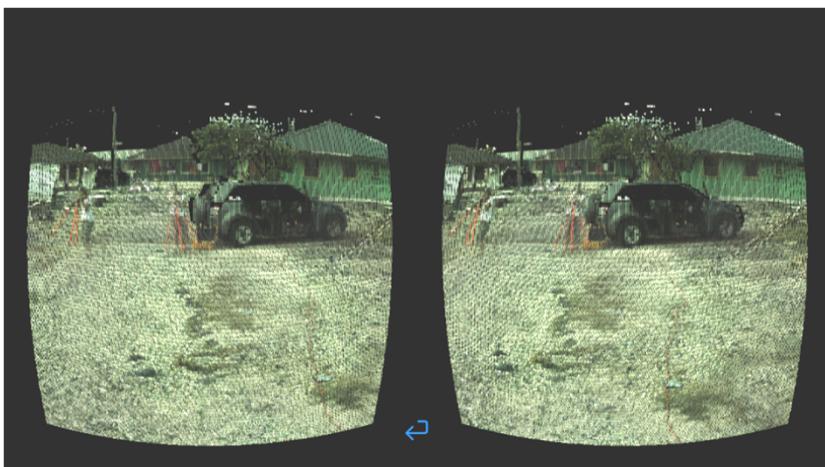
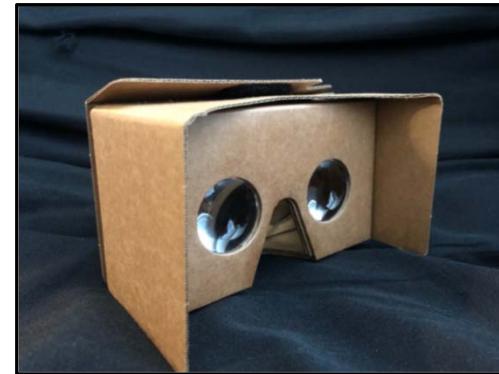
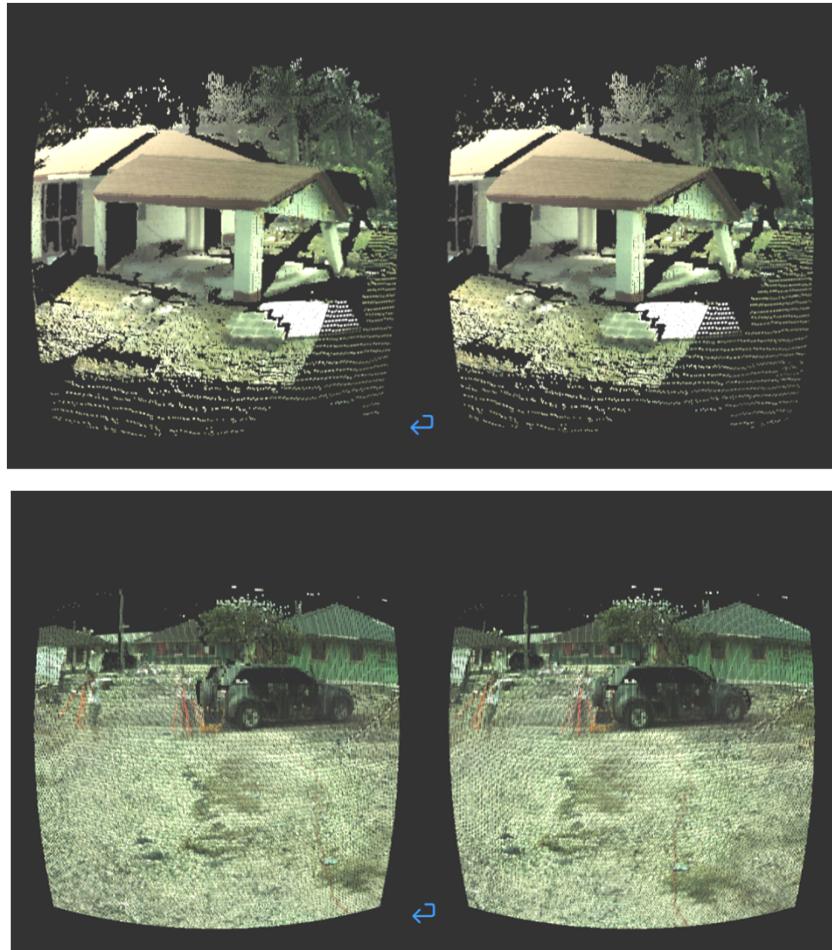
```



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You Can Also Do the Spherical Image Projection *with* Stereographics



How to Create Two 2D Spherical Stereographics Images of a 3D Scene

```

void DrawAndWriteSegments( )
{
    unsigned char array[3*PIXELS_PER_SEG*HEIGHT];
    for( int eye = 0; eye <= 1; eye++ )
    {
        glViewport( 0, 0, PIXELS_PER_SEG, HEIGHT );
        glMatrixMode( GL_PROJECTION );
        glLoadIdentity();
        StereoPersp( PHIDEG, ASPECT_Y_OVER_X, ZNEAR, ZFAR, Z0P, eye == 0 ? -EYESEP : EYESEP );
        unsigned char *FullArray = ( eye == 0 ? Left : Right );
        int col = 0; // column in the full array
        for( int lookDeg = -90.; lookDeg < 270; lookDeg += PHIDEG )
        {
            glMatrixMode( GL_MODELVIEW );
            glLoadIdentity();
            float lx = Sind( (float)lookDeg ) + EX;
            float ly = 0. + EY;
            float lz = Cosd( (float)lookDeg ) + EZ;
            gluLookAt( EX, EY, EZ, lx, ly, lz, 0., 1., 0. );
            glCallList( LidarList );
            glFlush();
            glutSwapBuffers();
            glFinish();

            glPixelStorei( GL_PACK_ALIGNMENT, 1 );
            glReadPixels( 0, 0, PIXELS_PER_SEG, HEIGHT, GL_RGB, GL_UNSIGNED_BYTE, array );

            for( int y = 0; y < HEIGHT; y++ )
            {
                memcpy( &FullArray[3*col*HEIGHT+y], &array[3*y*PIXELS_PER_SEG], 3*PIXELS_PER_SEG );
            }
            col += PIXELS_PER_SEG;
        }

        WriteArray( eye == 0 ? (char *)"Left.bmp" : (char *)"Right.bmp", FullArray );
    }
}

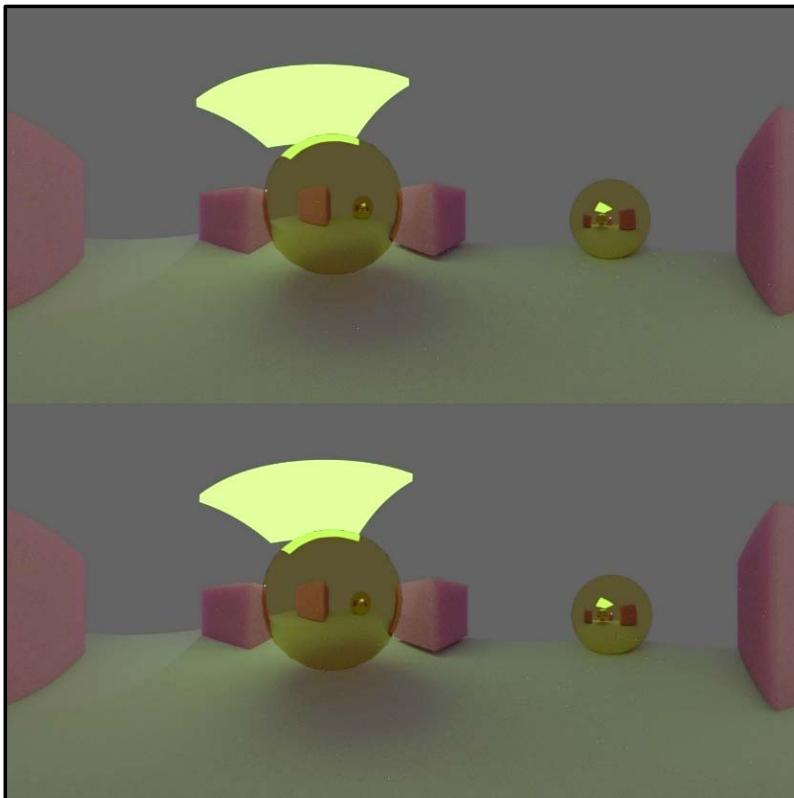
```



Examples of Spherical Stereographics Images, Suitable for Displaying in a VR Headset

23

Left Eye
View



Right Eye
View

Blender Scene



Fluid Flow Streamtubes

Examples of Spherical Stereographics Images, Suitable for Displaying in a VR Headset

24

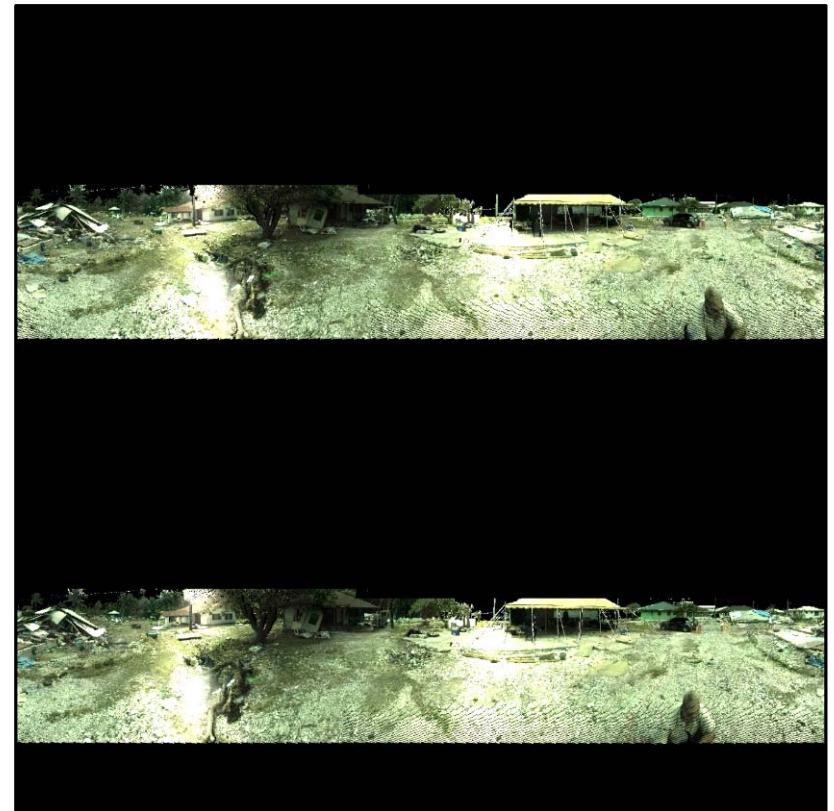
Left Eye
View



Right Eye
View



My Side Yard
(using a Garmin VIRB 360° camera)



Dr. Michael Olsen, OSU CCE
Lidar Scene

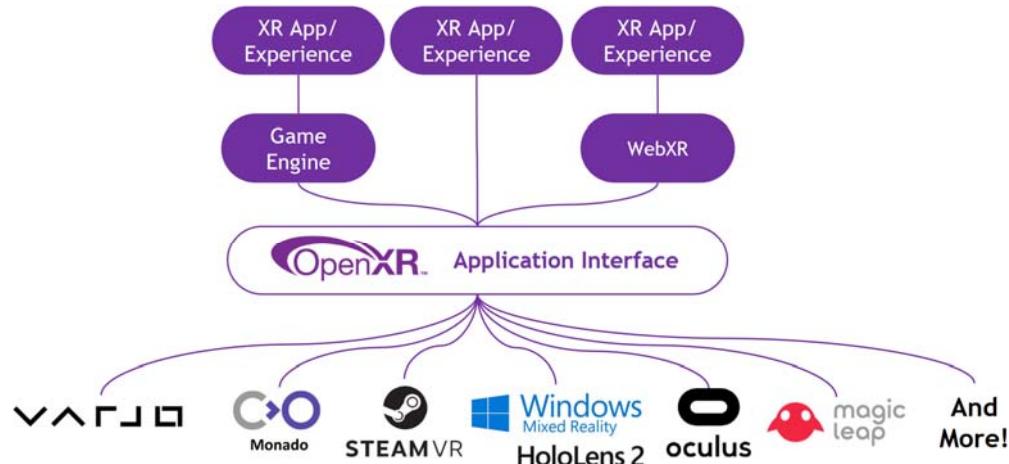
Something to Cut Through the VR/AR “Clutter” -- The Khronos Group’s OpenXR API

25

OpenXR is a royalty-free, open standard that provides high-performance access to Augmented Reality (AR) and Virtual Reality (VR)—collectively known as XR—platforms and devices.

<https://www.khronos.org/openxr/>

**OpenXR Provides a Common API Interface for XR
the same way that OpenGL does for 3D Graphics**



<https://www.khronos.org/openxr/>

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Who was Involved with Creating OpenXR?



<https://www.khronos.org/openxr/>

