Virtual Reality
Introduction

CS 415: Game Development

Professor Eric Shaffer

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vir·tu·al re·al·i·ty

vir·tu·al re·al·i·ty

vərCH(əw)əl rēʻalədē

the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors

What is VR…or AR….or XR?

- **Extended Reality (XR)** refers to all real-and-virtual environments generated by computer technology and wearables. The 'X' in XR is a variable that can stand for any letter.

- **Virtual Reality (VR)** encompasses all immersive experiences. These could be created using purely real-world content (360 Video), purely synthetic content (Computer Generated), or a hybrid of both.

- **Augmented Reality (AR)** is an overlay of computer generated content on the real world that can superficially interact with the environment in real-time. With AR, there is no occlusion between CG content and the real-world.

- **Mixed Reality (MR)** is an overlay of synthetic content that is anchored to and interacts with objects in the real world—in real time. Mixed Reality experiences exhibit occlusion, in that the computer-generated objects are visibly obscured by objects in the physical environment.

Schematic of a VR System
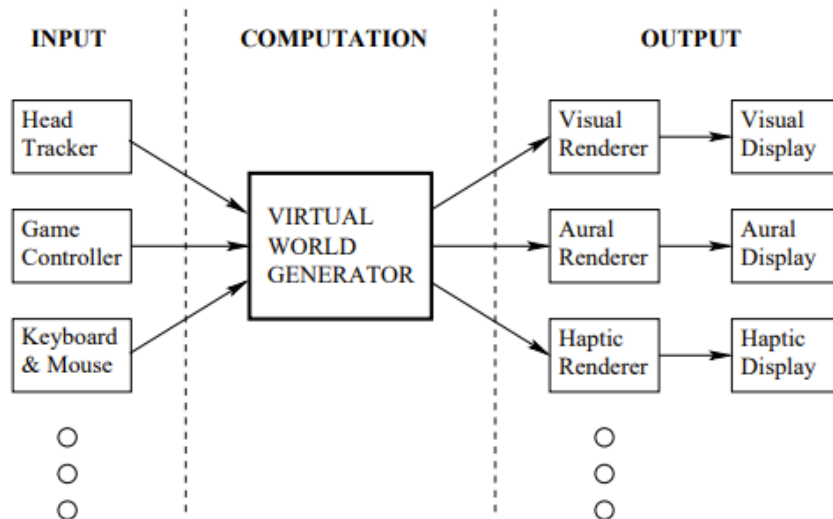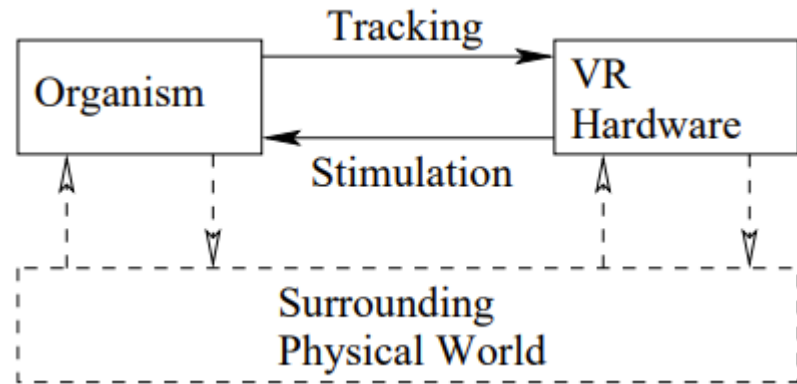
Applications

simulation & training

visualization & entertainment

remote control of vehicles, e.g. drones

gaming

robotic surgery

architecture walkthroughs

education

virtual travel

a trip down the rabbit hole

Applications...in Education

ECE Immersive Learning Lab

❑The **pilot VR Lab** was introduced as an additional instructional tool for the ECE 329 course during the Fall 2019 semester and continued (partially) during Spring 2020 semester.

❑Over **200 students were enrolled** in the VR section during these semesters

❑ Created by Professor Raluca Ilie and over 65 student developers

Learn about Wave Polarization in VR

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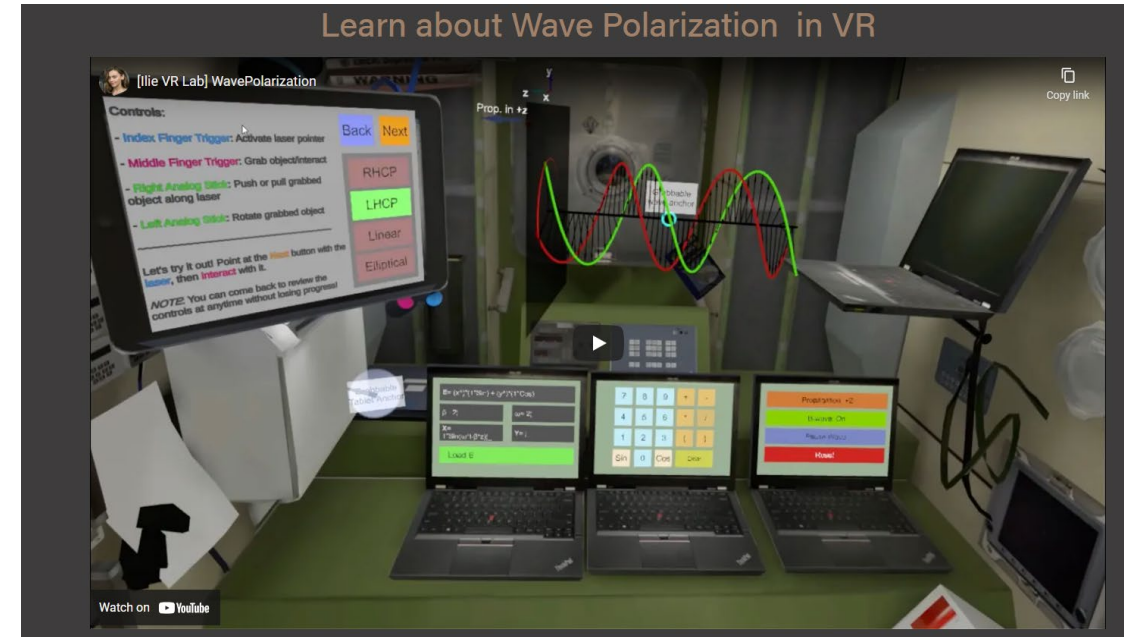
A Brief History of Virtual Reality

Stereoscopes
Wheatstone, Brewster, …

VR & AR
Ivan Sutherland

Nintendo
Virtual Boy

VR explosion
Oculus, Sony, HTC, MS, …

???

1838   1968   1995   2012-2022

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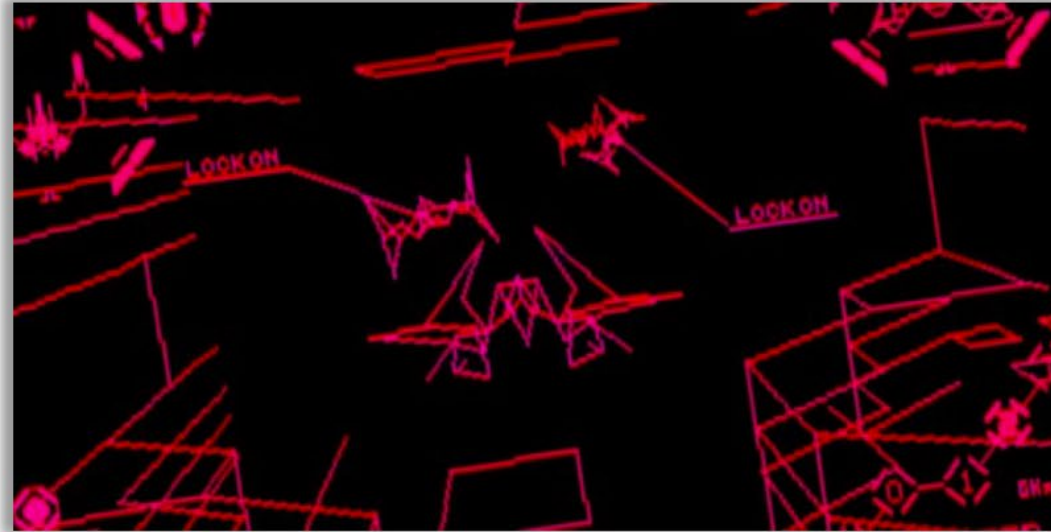# Ivan Sutherland's HMD

- optical see-through AR, including:

  - displays (2x 1" CRTs)

  - rendering

  - head tracking

  - interaction

  - model generation

- computer graphics

- human-computer interaction

I. Sutherland "A head-mounted three-dimensional display", Fall Joint Computer Conference 1968

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Nintendo Virtual Boy

- computer graphics & GPUs were not ready yet!

Game: Red Alarm

- 1995
- Monochrome
- No tracking

"Electronic Engineering Times and CMP Media's TechWeb speculated that using any immersive headset such as the Virtual Boy could cause sickness, flashbacks, and even permanent brain damage." -Wikipedia

Modern Tech….Thanks Cell Phones

HTC Vive 2015

- Color Display
- Decent Resolution
- Low Latency Rendering
- IMU for Tracking

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Oculus Quest 2

- Released 2020
- Untethered
- 1832×1920 pixels-per-eye
- No Eye-tracking
- No HDR
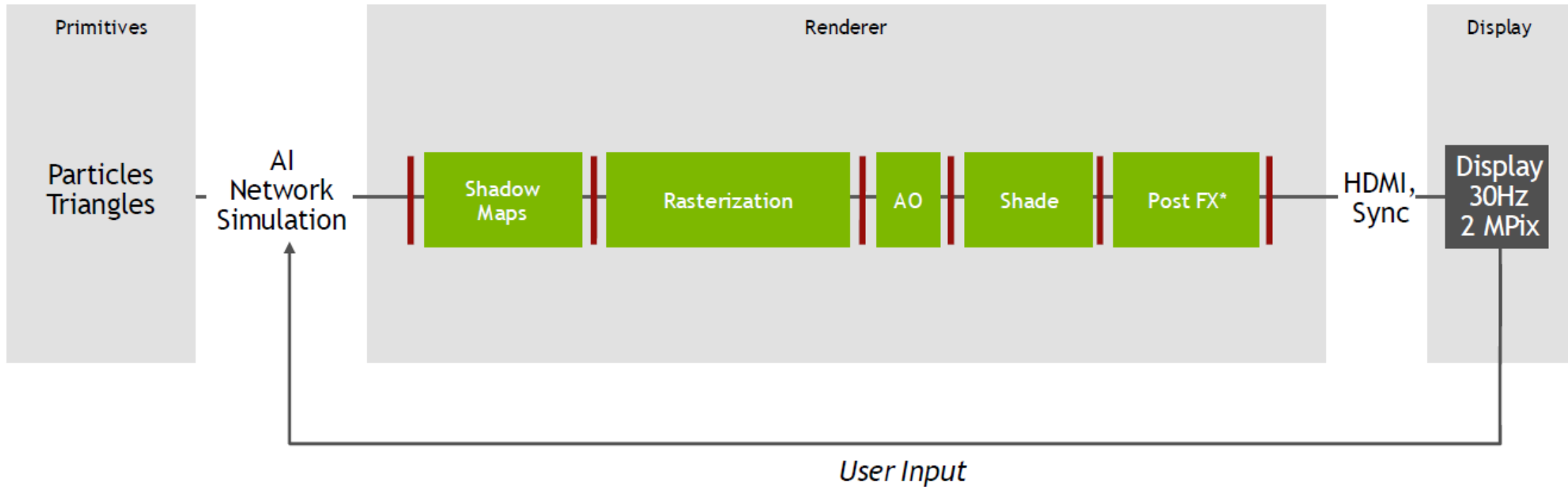- 90 degree FOV
- Inside-out tracking
- Hand Tracking
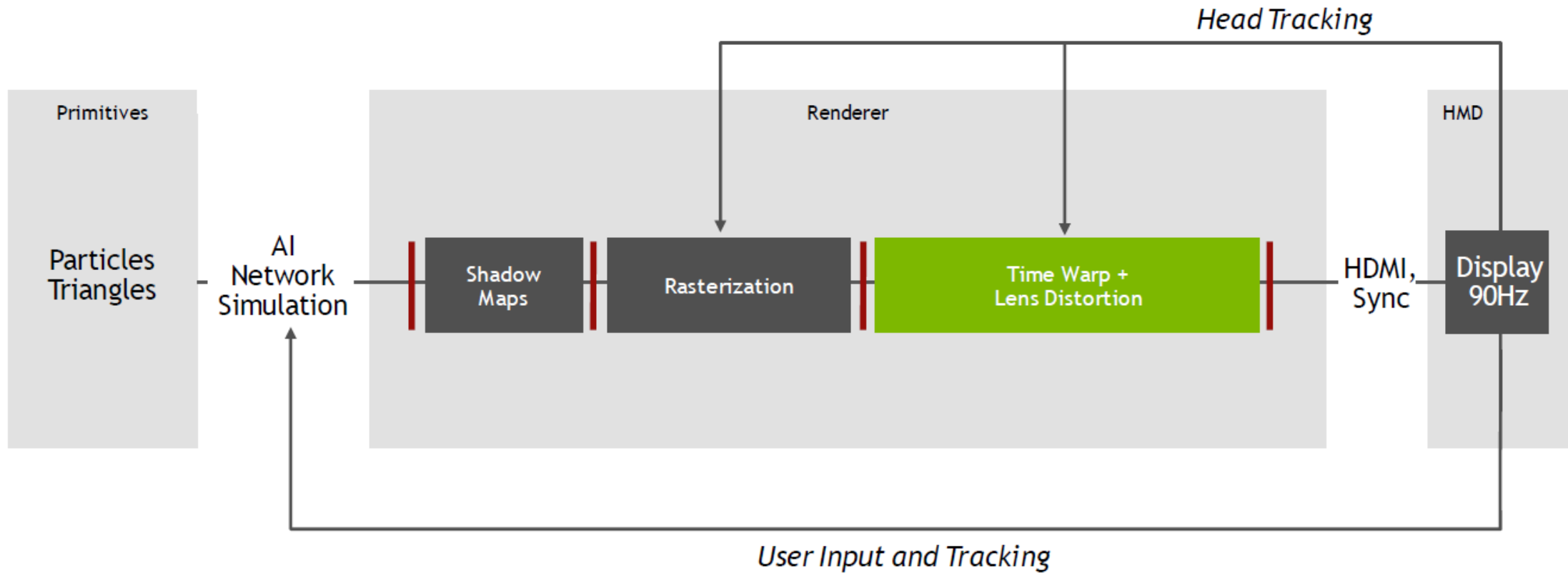- $300

Playstation VR 2

- USB-C Tether to PS5
- 2,000x2,040 pixels-per-eye
- Eye-tracking
- HDR
- 110 degree FOV
- Inside-out tracking
- 4th quarter 2022?
- $400?

Typical 3D Game Graphics Processing

* Includes depth of field, reflections, fog, color grading, motion blur, antialiasing

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Modern VR Graphics Processing

Latency becomes a big concern...view changes rapidly and people get sick if the rendering lags behind the view change
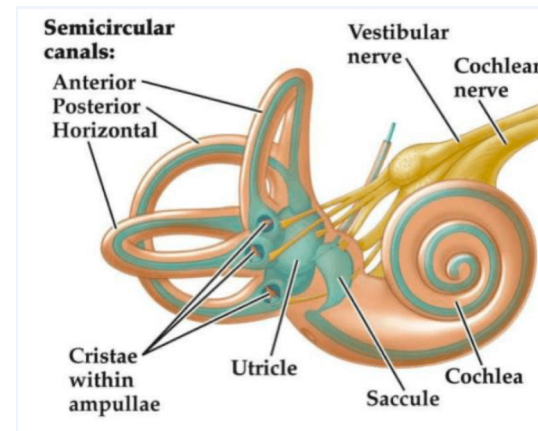
Interface Design: Vection

Vection is an illusion of self-motion

Results in mismatch in motion perception between vision and vestibular senses
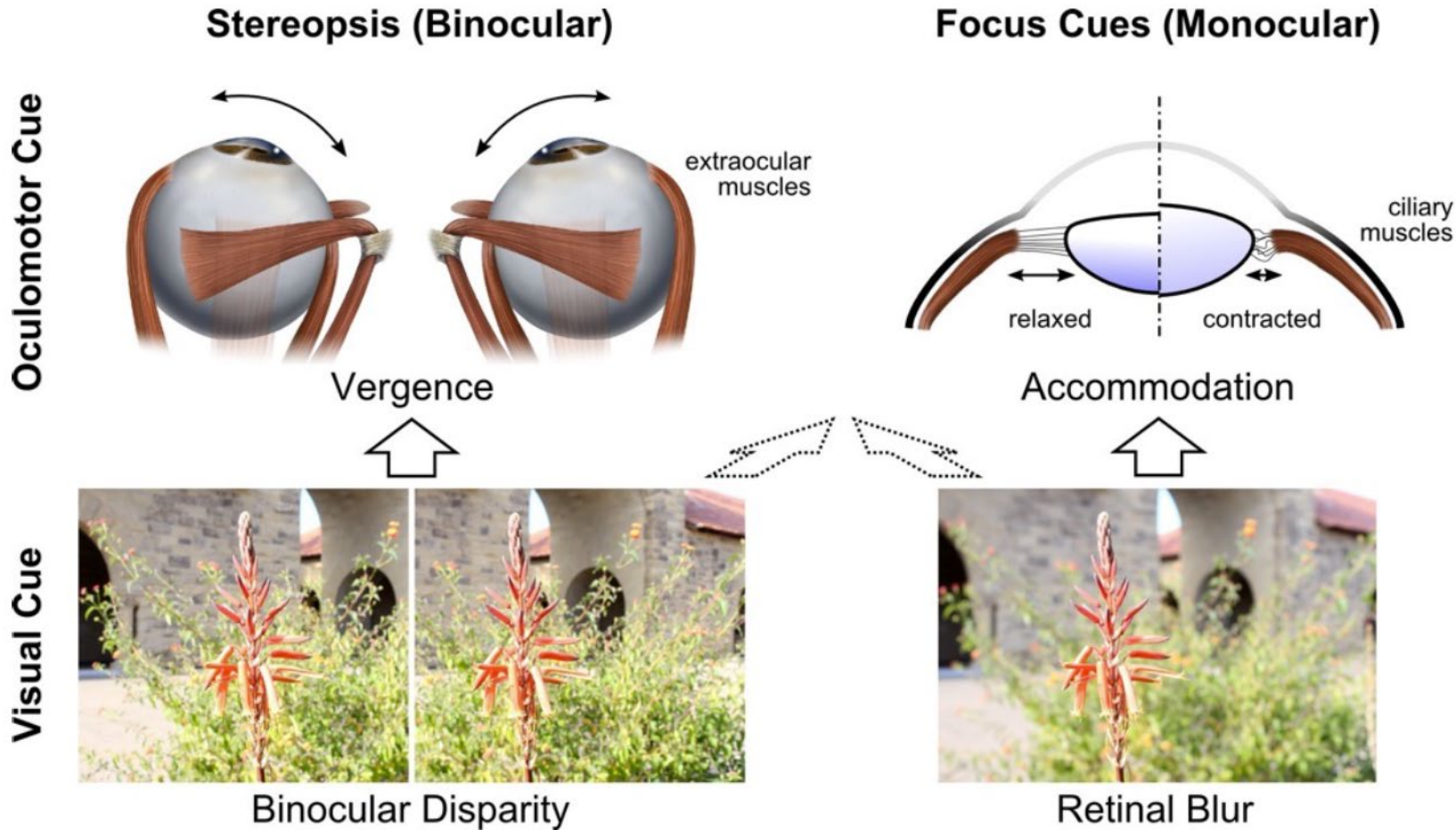
Often induces nausea

UI design tip: use teleportation instead of visual acceleration

The vestibular system is **a sensory system that is responsible for providing our brain with information about motion, head position, and spatial orientation**; it also is involved with motor functions that allow us to keep our balance, stabilize our head and body during movement, and maintain posture.

Semicircular canals:
Anterior
Posterior
Horizontal

Vestibular nerve
Cochlear nerve

Cristae within ampullae
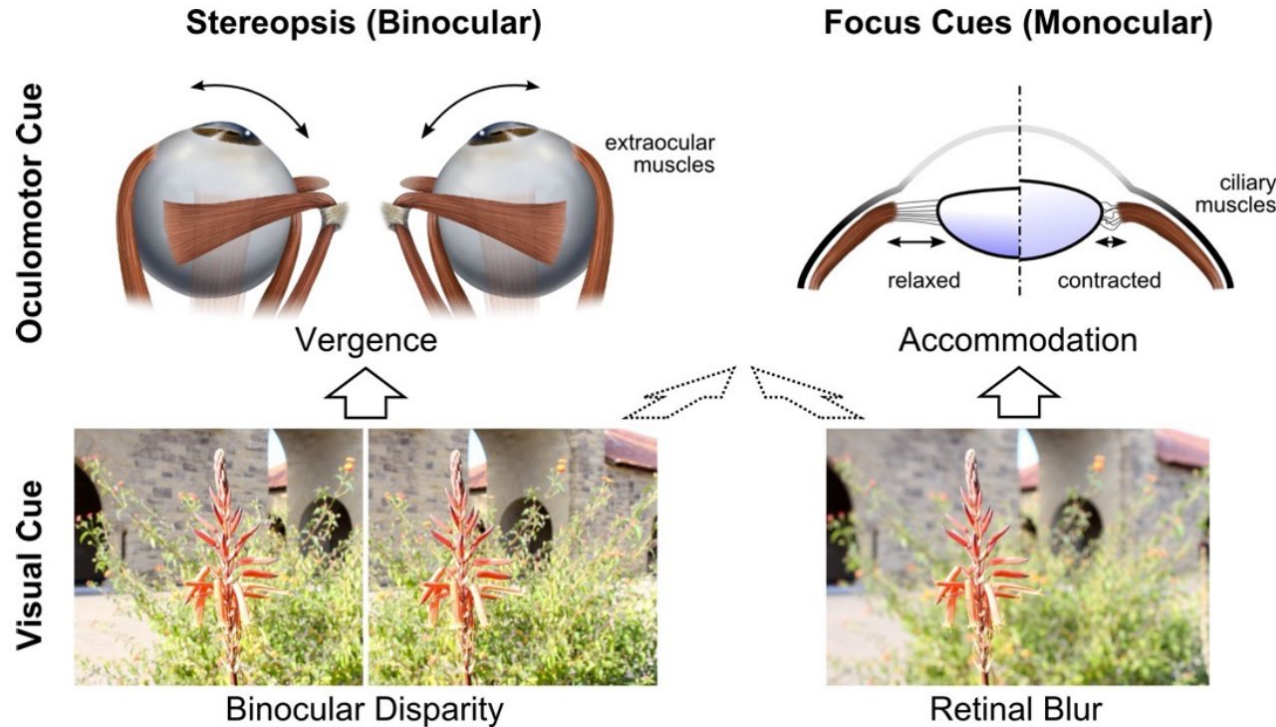Utricle
Saccule
Cochlea

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Vergence and Accommodation Mismatch

Vergence-accommodation conflict occurs when your brain receives mismatching cues between the distance of a virtual 3D object (vergence), and the focusing distance (accomodation) required for the eyes to focus on that object.

Interface Design: VAC Conflict

Stereopsis (Binocular)

Oculomotor Cue

extraocular muscles

Vergence

Visual Cue

Binocular Disparity

Focus Cues (Monocular)

ciliary muscles

relaxed   contracted

Accommodation

Retinal Blur

1. Move objects in and out of depth slowly (ish)

2. Try not to stack multiple smaller objects at widely-varying depths overlapping each other.

3. ...and more...consult VR design guides

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