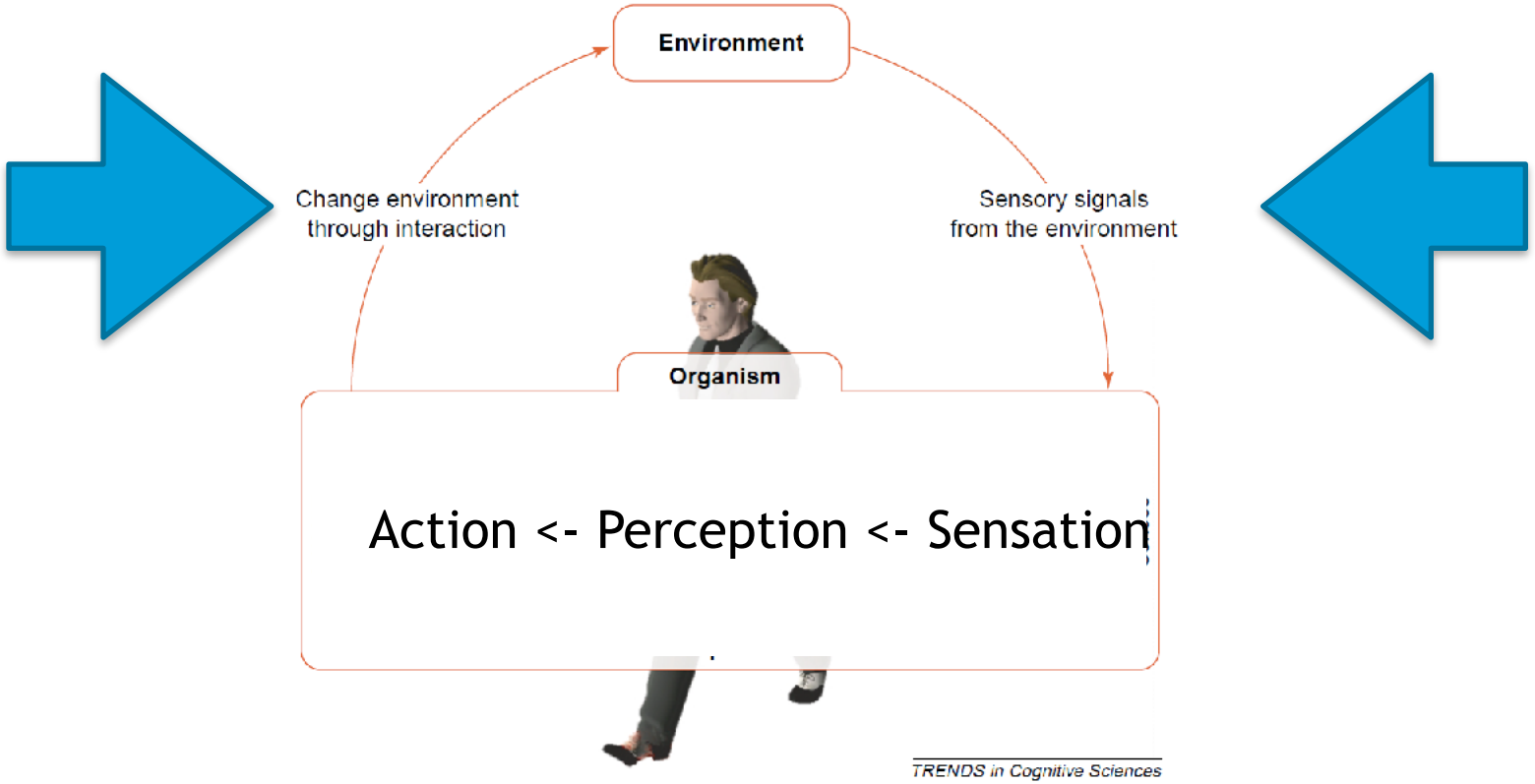
Virtual Reality: CH2
Hardware & Software

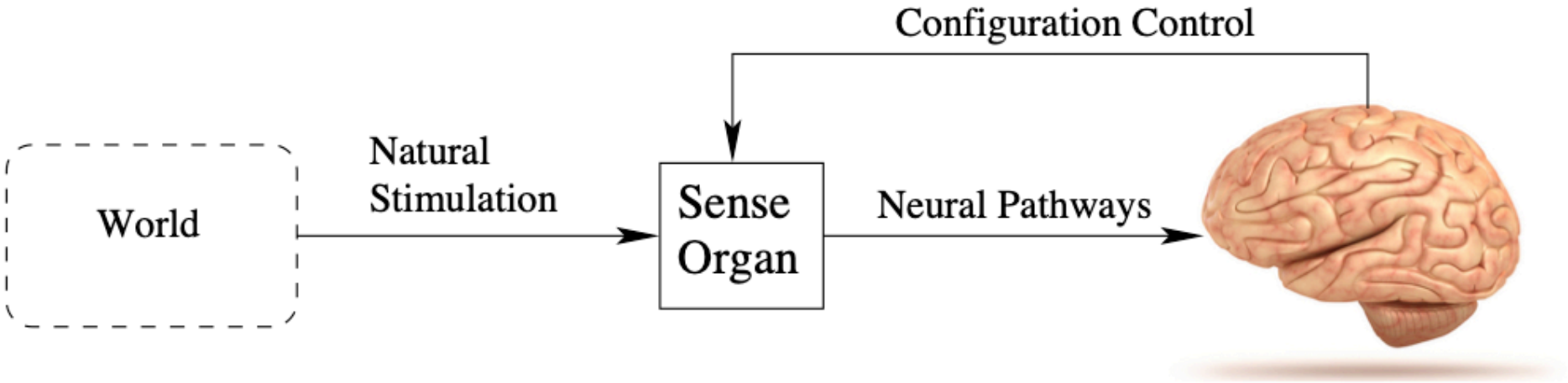
Goal of this chapter

- Provide high level overview (hardware + software)
- Easier to understand following chapters.

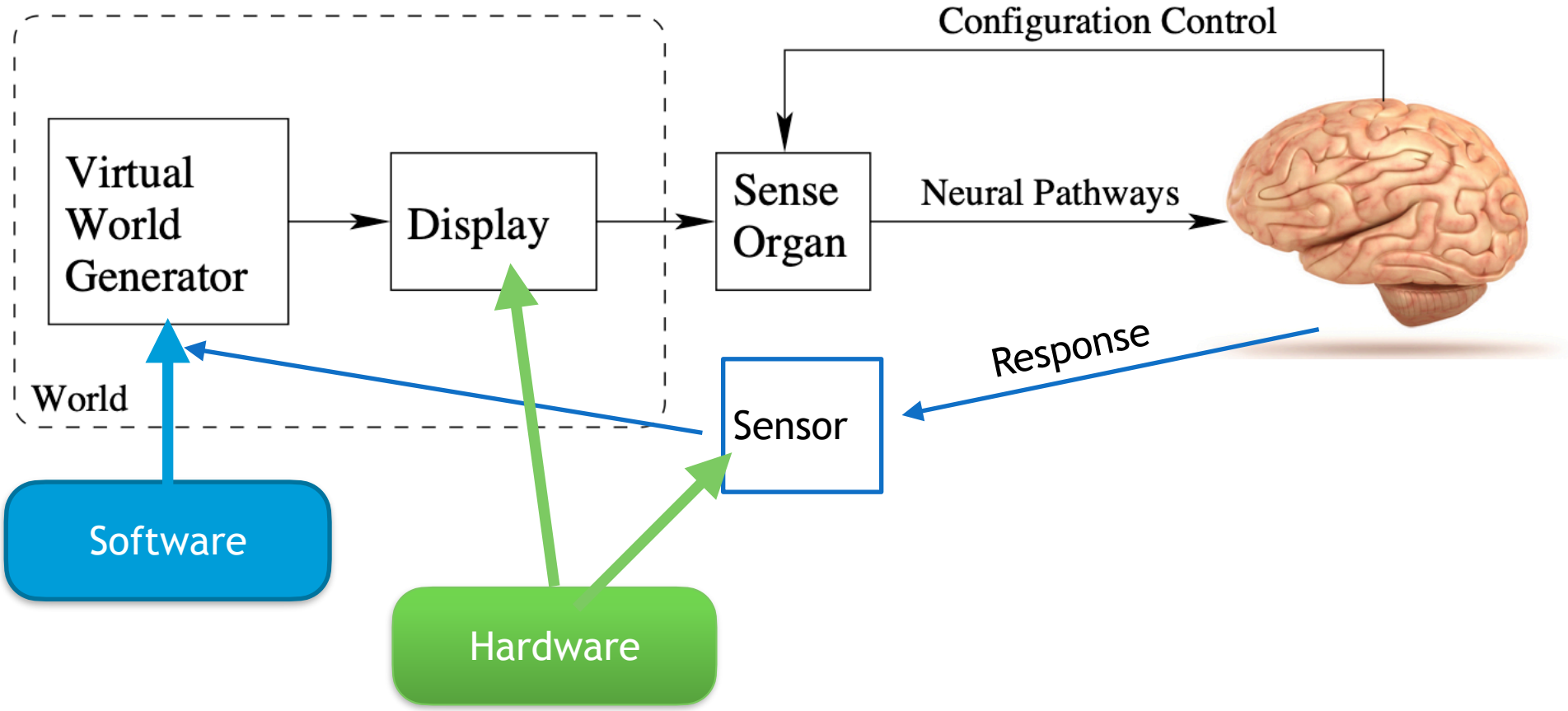
VR Hardware


Environment
Change environment through interaction
Sensory signals from the environment
Organism
Action <- Perception <- Sensation
TRENDS in Cognitive Sciences

How it works in the real world

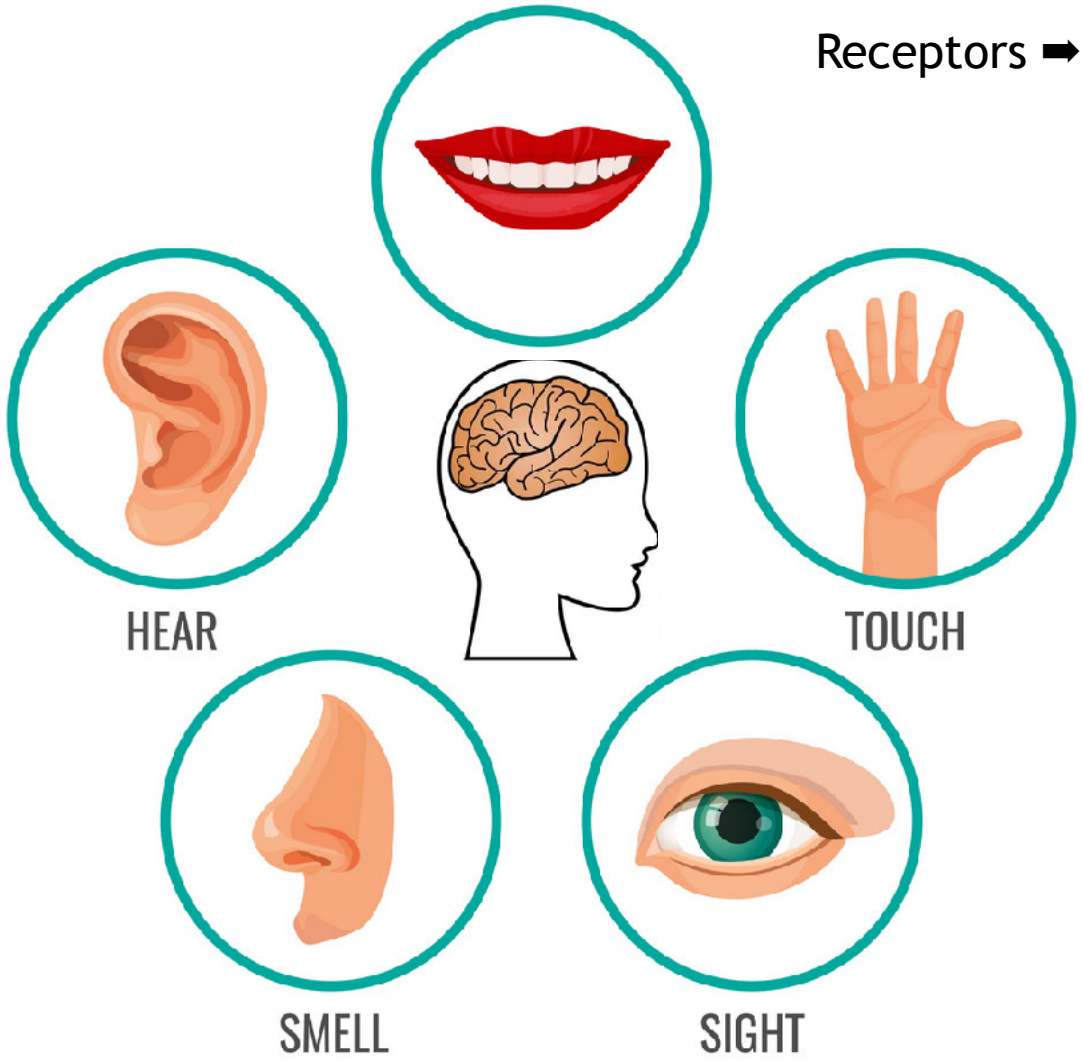


Tricking the human senses



The 5 human senses

Receptors ➡ neural signals



Definitions

- **Displays** (output) - devices that each stimulate a sense organ / CH4+5
- **Sensors** (input) - devices that extract information from the real world CH9
- **Computers** - devices that process inputs and outputs sequentially

Electronic “sense” organs

TRANSDUCER

A TRANSDUCER IS A DEVICE THAT CONVERTS ENERGY FROM ONE FORM TO ANOTHER. USUALLY A TRANSDUCER CONVERTS A SIGNAL IN ONE FORM OF ENERGY TO A SIGNAL IN ANOTHER.

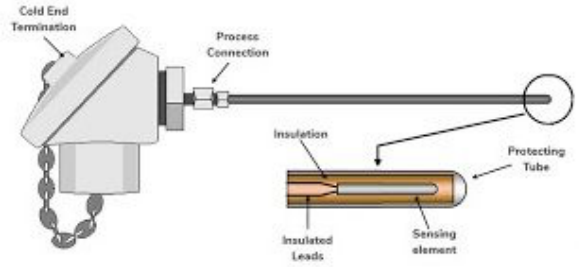
SENSOR

SENSOR IS A DEVICE, MODULE, OR SUBSYSTEM WHOSE PURPOSE IS TO DETECT EVENTS OR CHANGES IN ITS ENVIRONMENT AND SEND THE INFORMATION TO OTHER ELECTRONICS, FREQUENTLY A COMPUTER PROCESSOR.

Example transducers

RTD

Temp into resistance

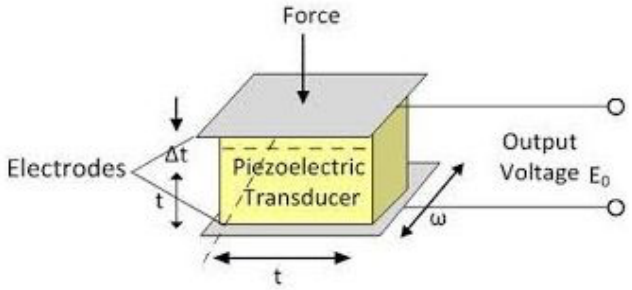


THRMOCOUPLE

Temp into voltage

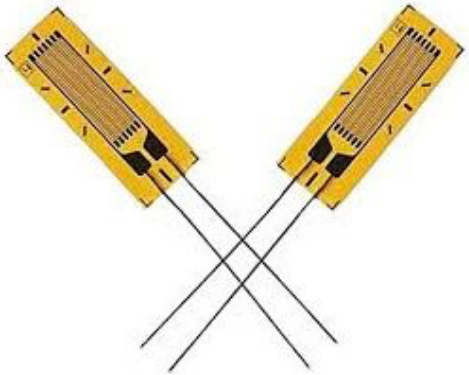
POTENTIOMETER

Displacement into voltage



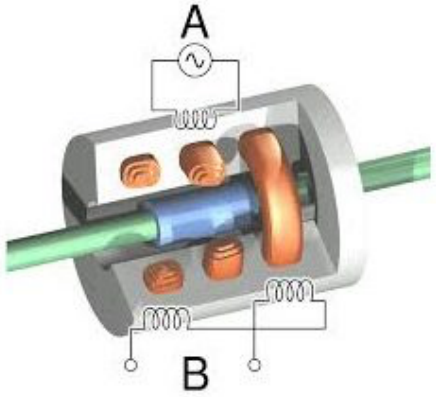
PIEZO ELECTRIC CRYSTAL

Mechanical energy into voltage



STRAIN GAUGE

Deformation into resistance



LVDT

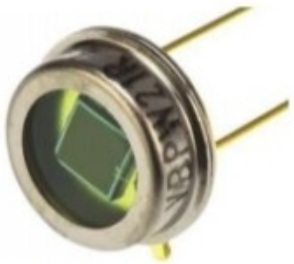
Linear displacement into voltage

Example sensors

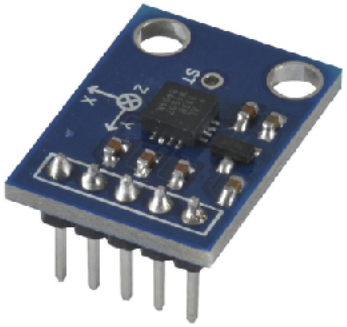
Temperature Sensor

Humidity Sensor

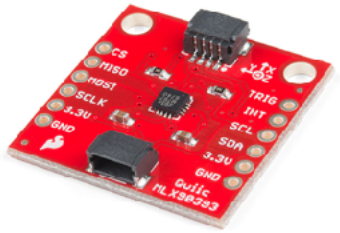
Proximity Sensor



Light Sensor



Accelerometer



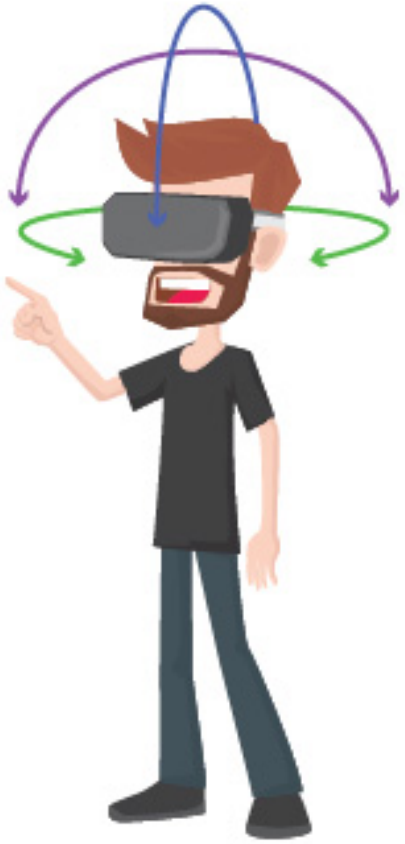
Magnetometer

Sensors in VR

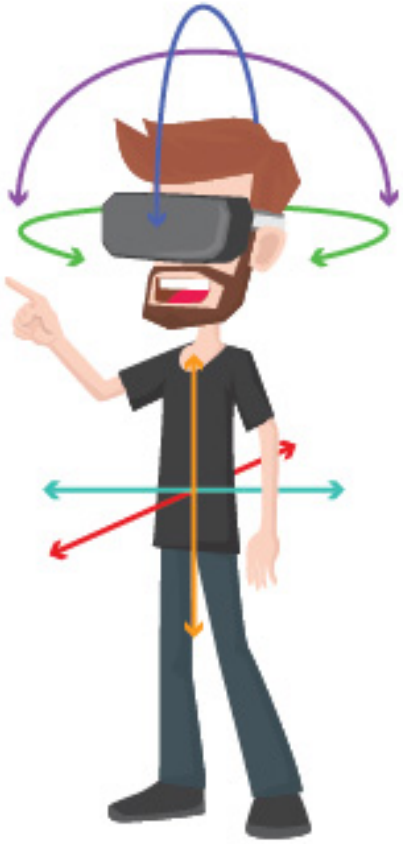
Gyroscope
Accelerometer
Magnetometer
IR sensor /Optic sensors

Eye tracking using IR cameras

Configuration space

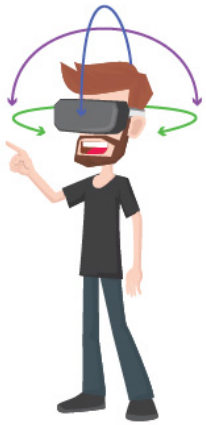


3DoF

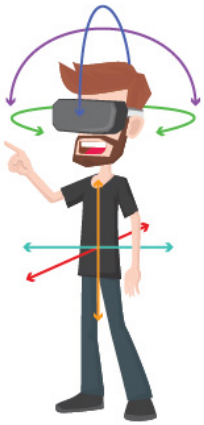


6DoF

Configuration space

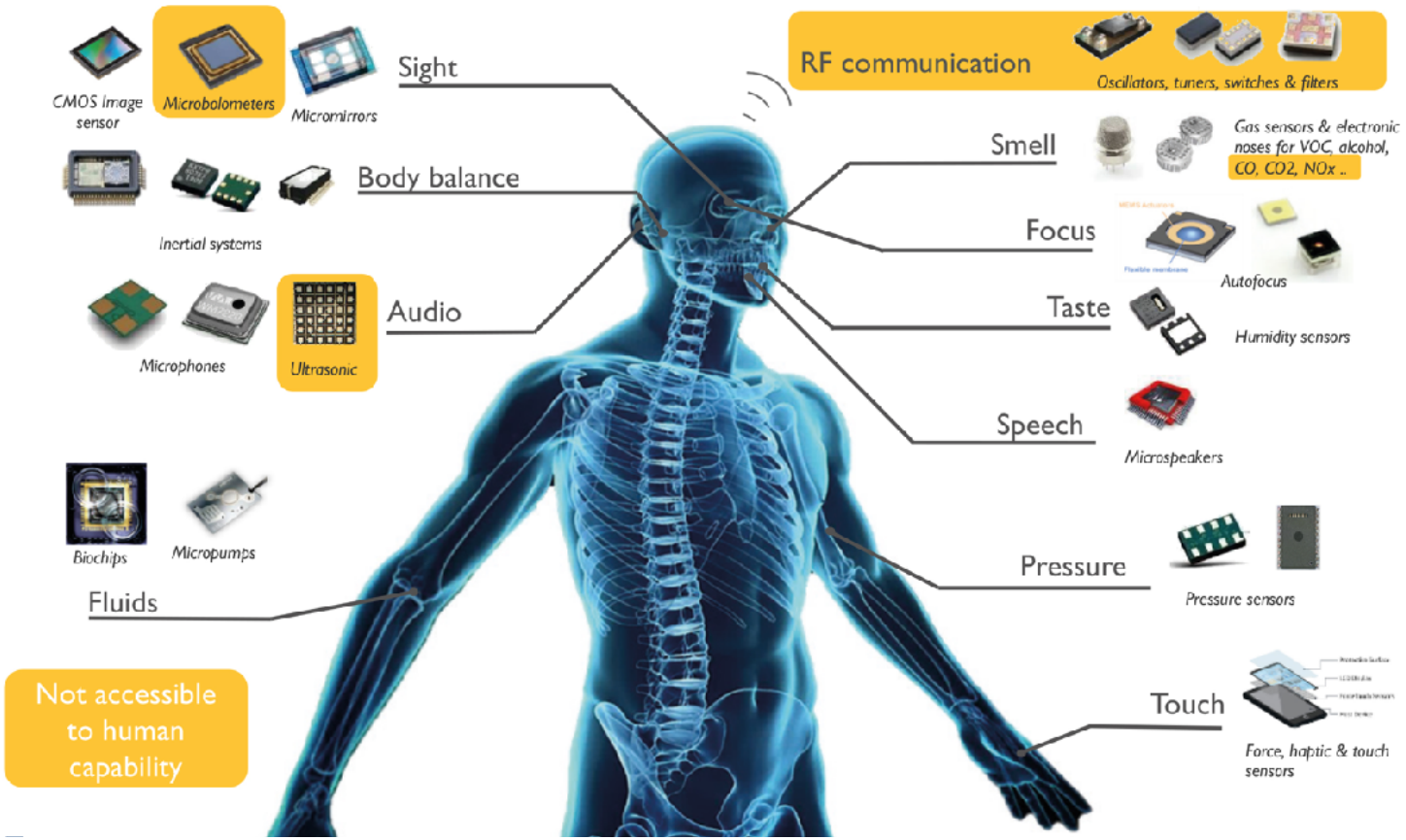


3DoF



6DoF

The 5 senses: sensors & actuators



Track as much as possible

Why?

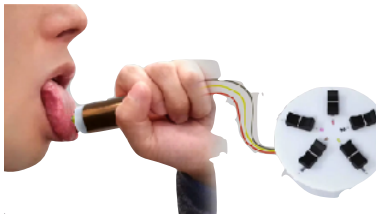

Vive 3.0 Trackers
Vive Ultimate Trackers
VIVE ULTIMATE TRACKER
REVIEW
VIVE

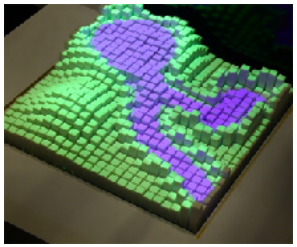
Every body was ….

Full body no trackers

Display

Display, which emits energy that is specifically designed to mimic the type of stimulus that would appear without VR





Displays

World-fixed

Head-fixed

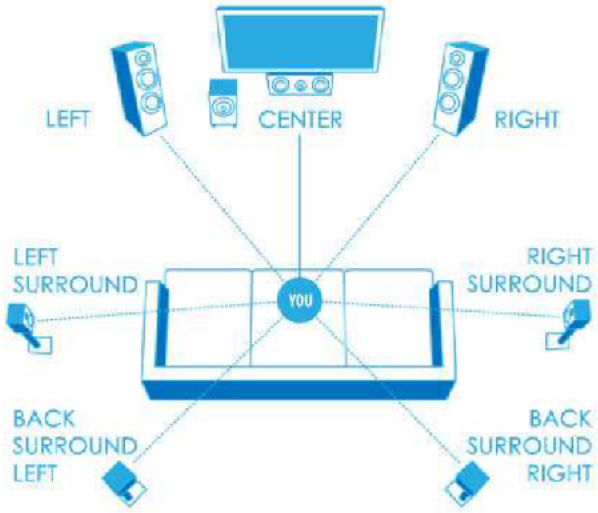
Visual

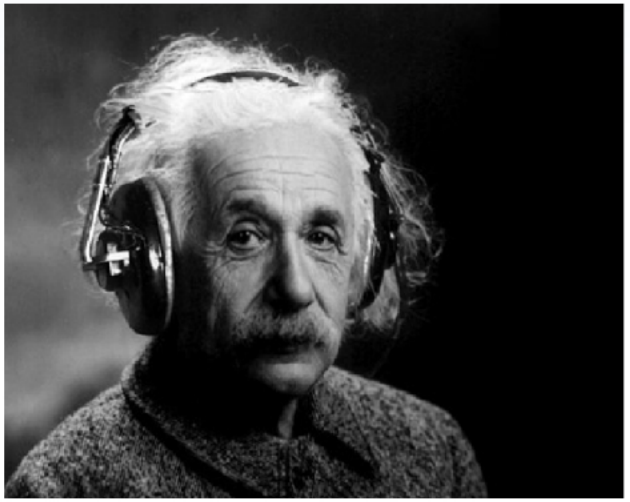
$

Single user

privacy

Auditory





More Displays

Your skin is the largest organ. Haptics/Taste/Smell largely unexplored

Vibrotactile

Gyro forces

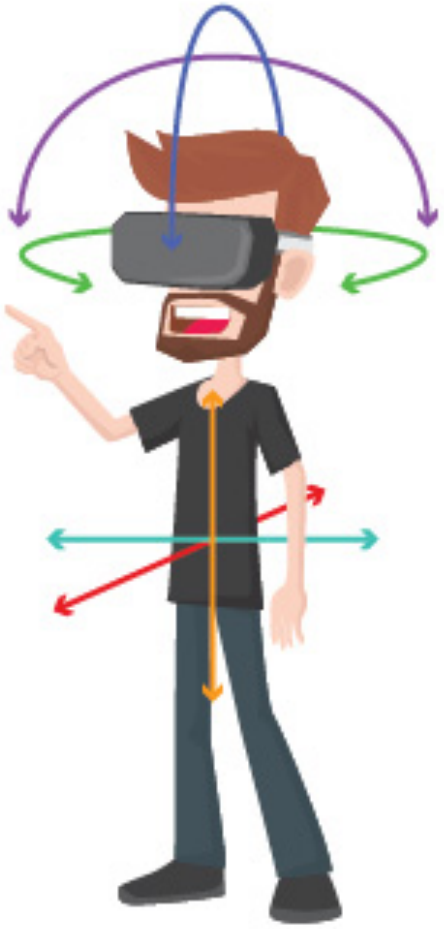
Haptic gloves

olfaction

Taste

Air

Positional tracking

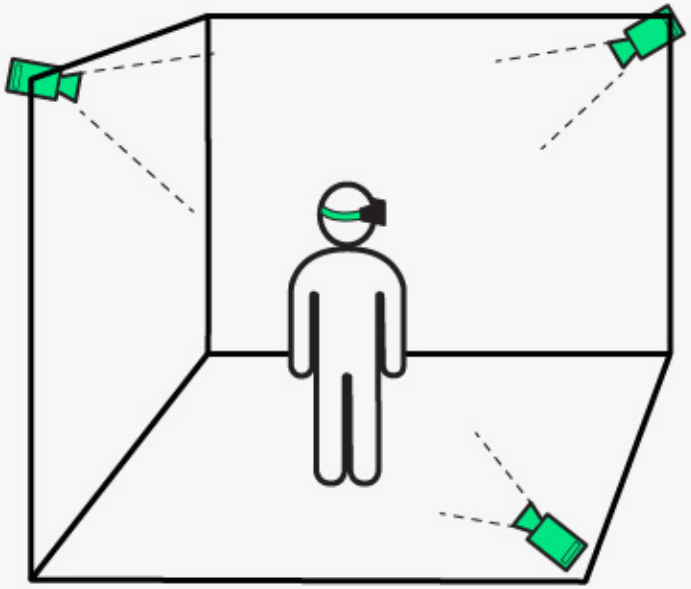


6DoF

- head
- Hands

Two distinct approaches

Cameras are fixed to the environment



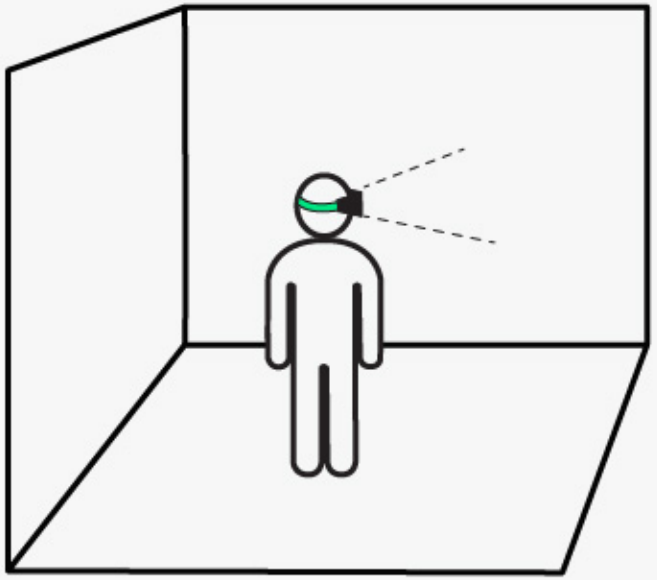
Outside - In

Range limited

Requires installing sensors

Most accurate no interference

A camera is attached to a user



Inside - Out

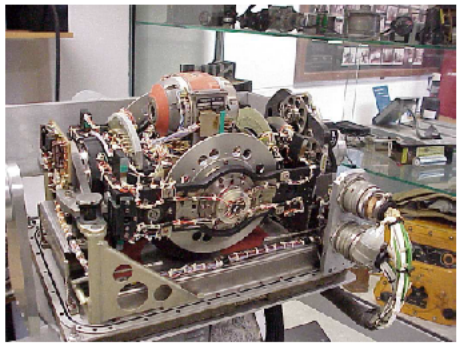
Computationally intensive
Less accurate / Cheaper

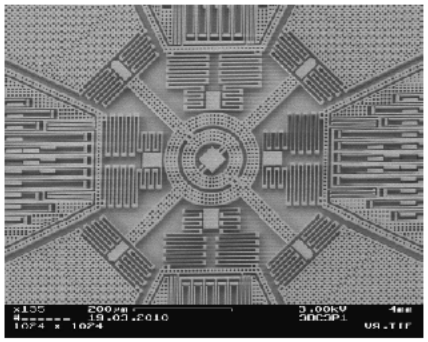
Does not work well in low light

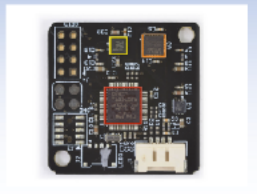
Hand tracking

IMU-based Tracking

- IMU – inertial measurement unit
  - Accelerometer -> gravity plus linear acceleration
  - Gyroscope -> angular velocity
  - Magnetometer -> magnetic north



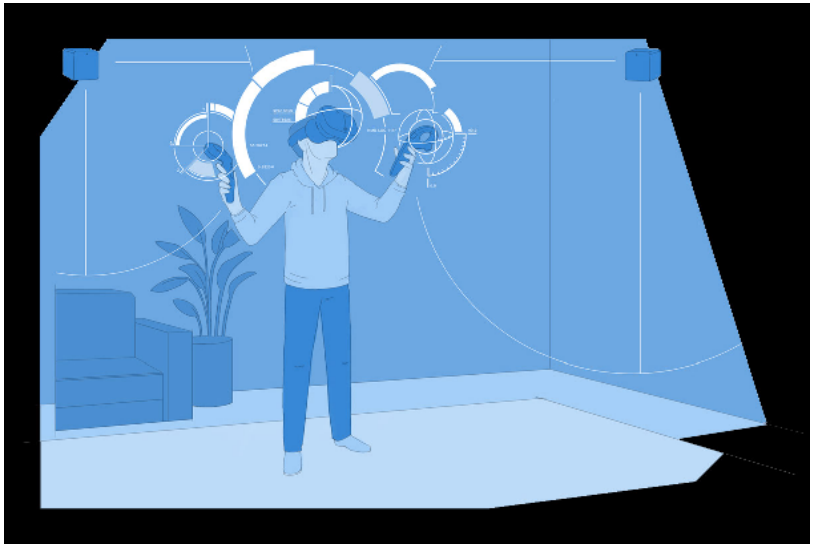




- Sensor fusion, drift

Camera-based Tracking

- 6-degrees-of-freedom:
  - Position (x,y,z), Orientation (pitch,roll,yaw)
- Video-based



- Geometric transformation, occlusion, FOV

Sensor fusion

- IMU : drift over time
- Camera: occlusion/low light problems or out of view
- Approach: Combine both inputs together
  - Use camera to calibrate IMU over time
  - Rely on IMU when occlusion or out of view

Vive Tracking

- IMU + infrared tracking (sensor fusion)

How accurate??

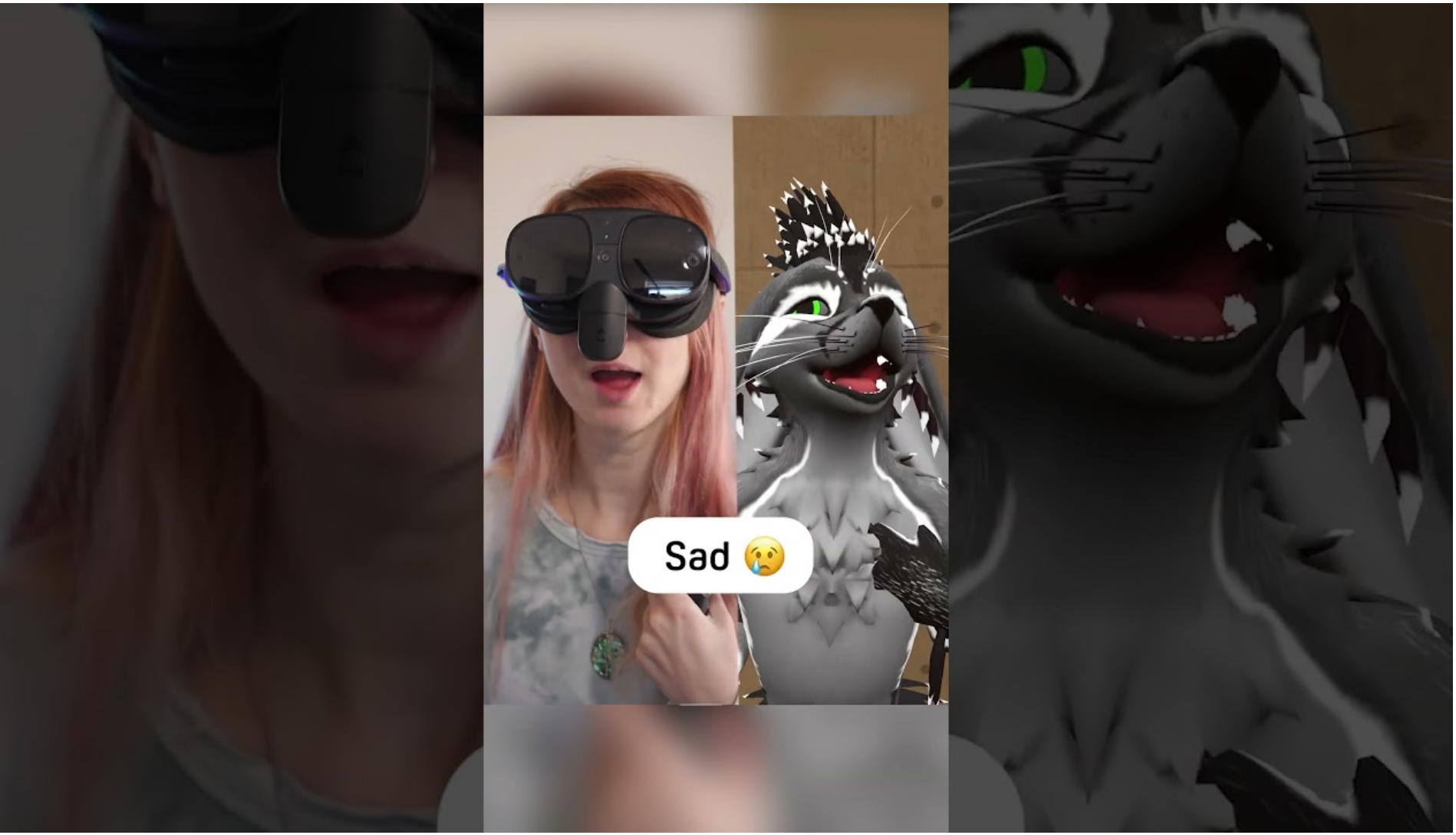
Inside out tracking

– Available at low computational cost with no latency

Other types of Tracking

- Depth cameras: Microsoft Kinect
  - IR
  - Skeletal
  - Full body
- Audio-based
  - Alt
  - Stereotrack

Face tracking



Video (Display) Hardware

Evolution to Next Generation TVs

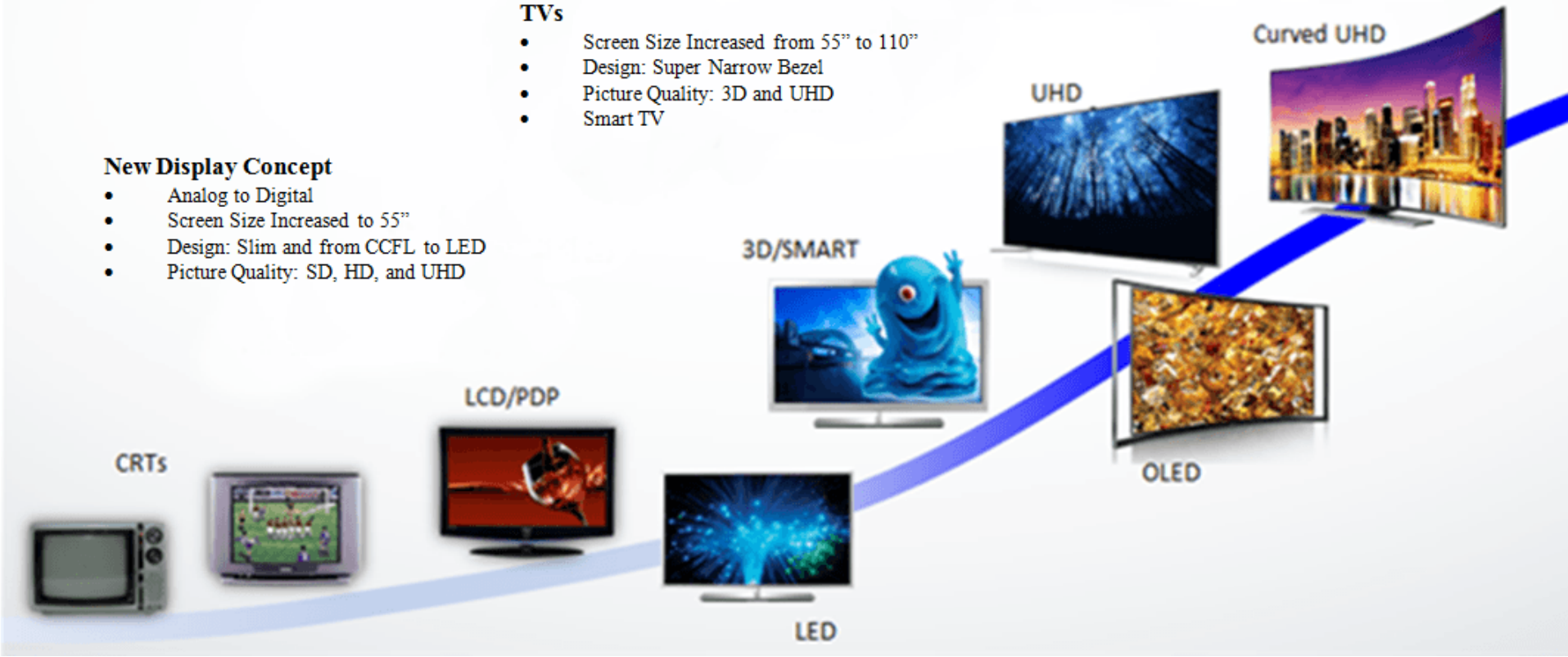
- Design: Zero Bezel, Curved TV, and Cinemascope
- Picture Quality: Glasses-Free 3D and High-Color Gan
- Display: OLED, Transparent, Flexible, and 4K8K

Emergence of New Categories: 3D and Smart TVs

- Screen Size Increased from 55" to 110"
- Design: Super Narrow Bezel
- Picture Quality: 3D and UHD
- Smart TV

New Display Concept

- Analog to Digital
- Screen Size Increased to 55"
- Design: Slim and from CCFL to LED
- Picture Quality: SD, HD, and UHD



Critical Features of Displays

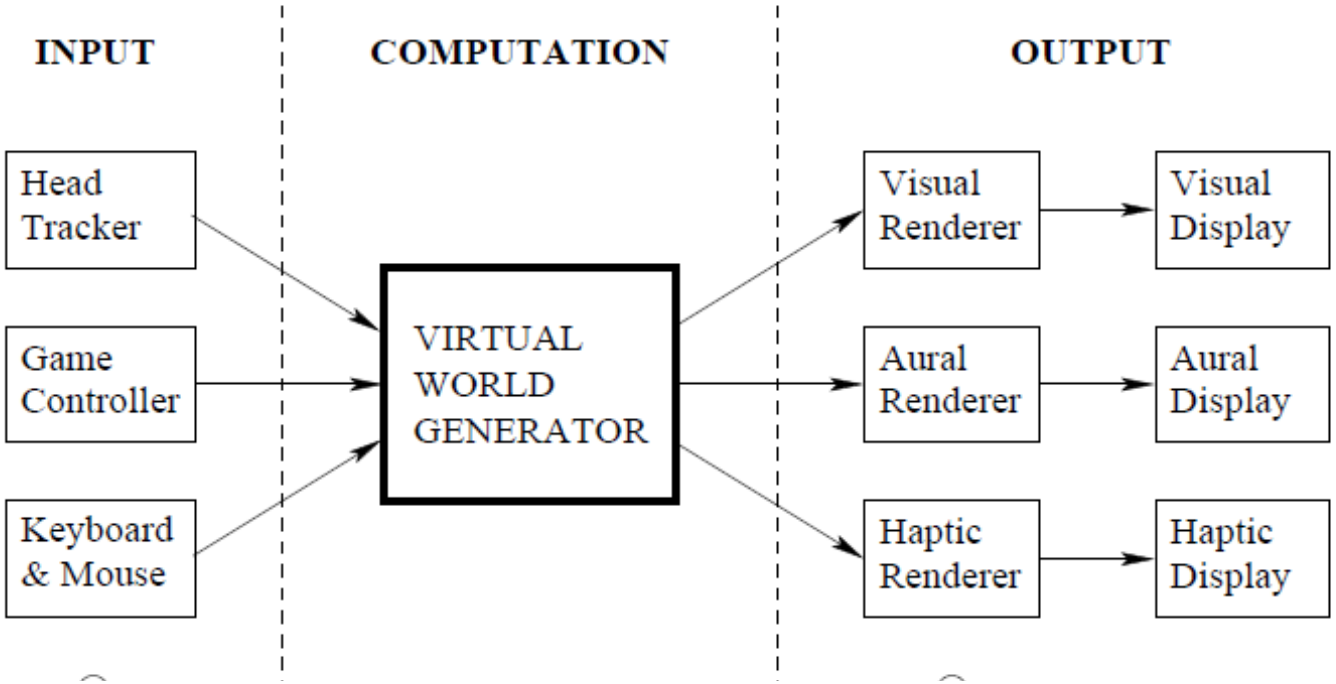
- Resolution
- Refresh rate
- Persistence
- True blackness

Viewing Geometry

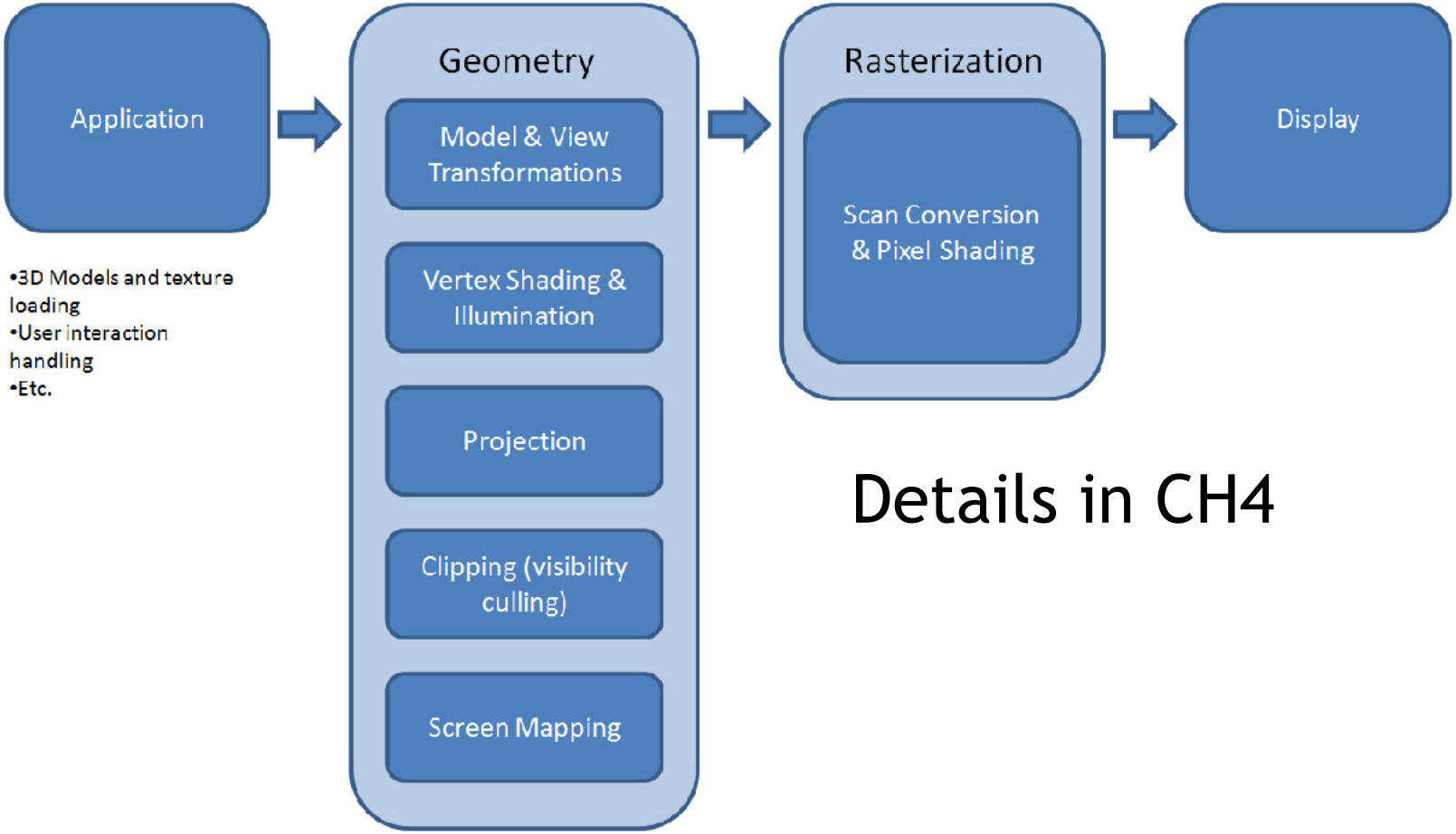
- Visual angle matters (larger is more real)
- In VR, resolution is halved and refresh rate >100 hz

Hardware for VWG

Virtual World Generator

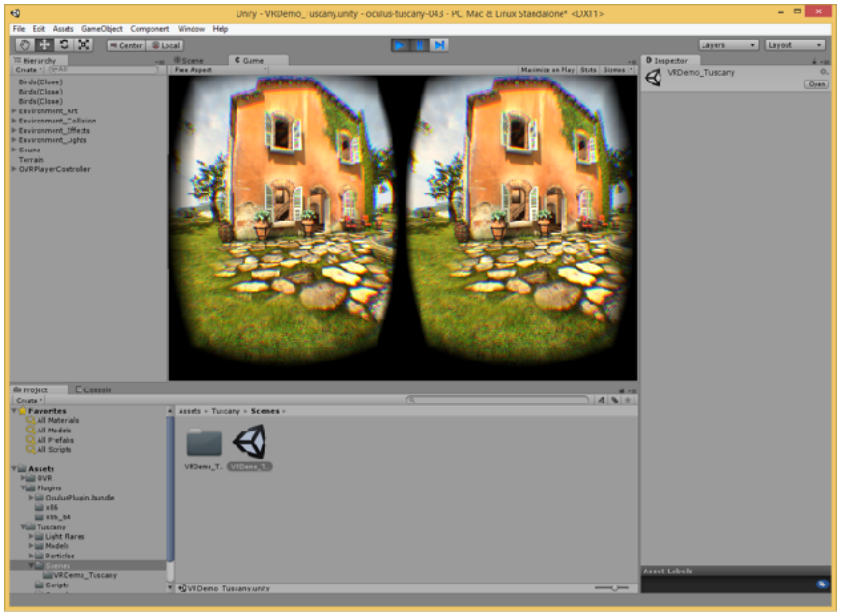


Real-Time Graphics Pipeline

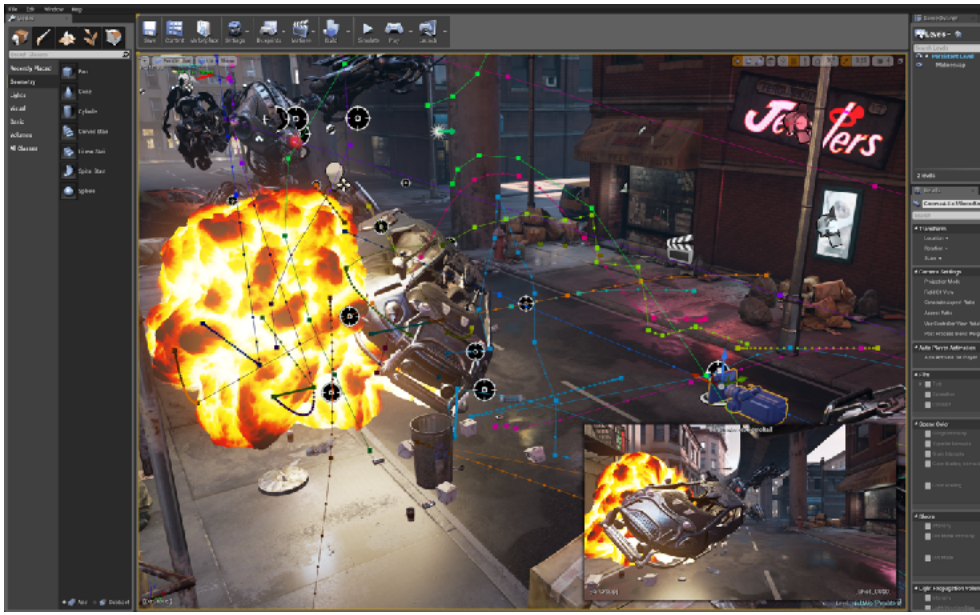


Details in CH4

3D Game engines



Unity



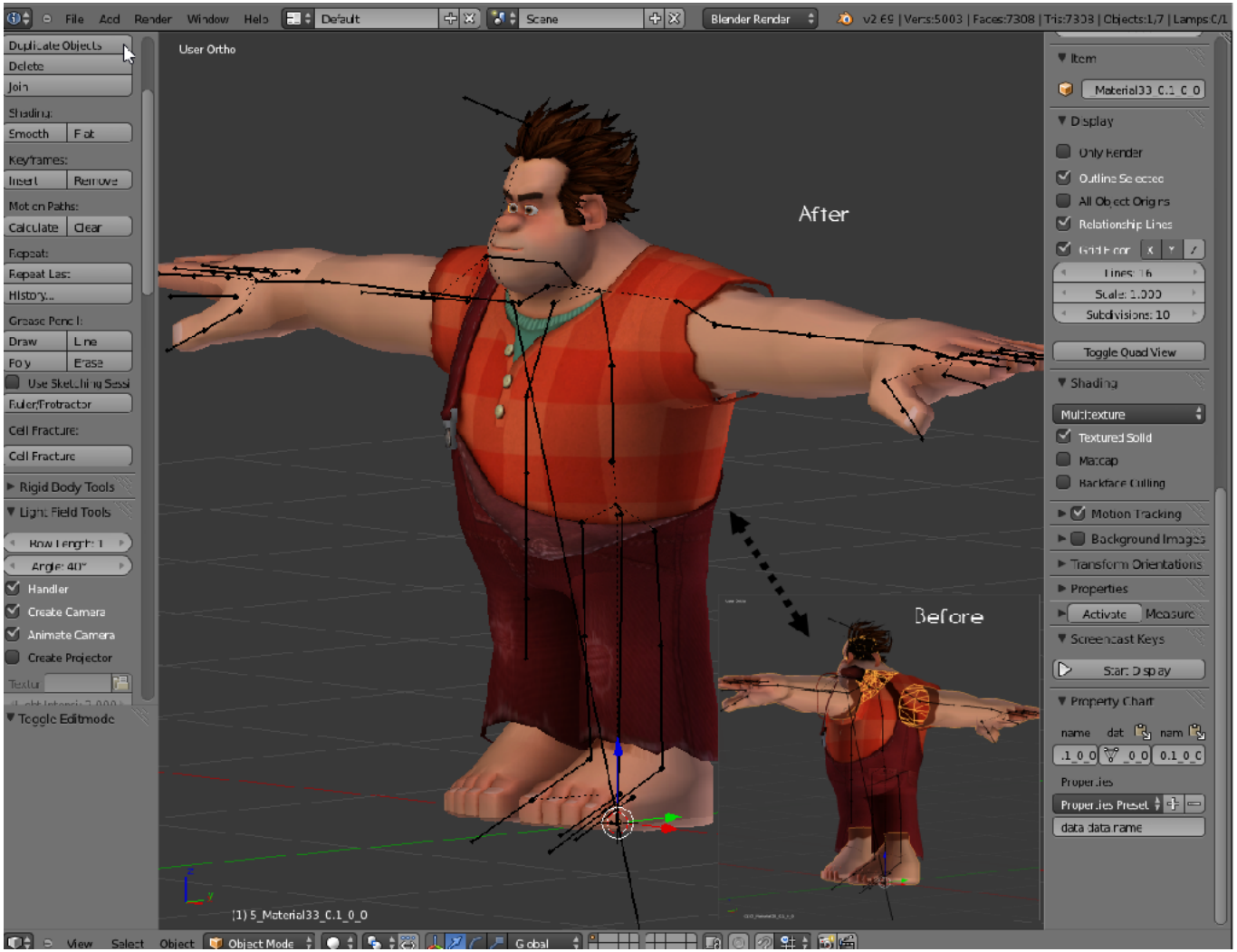
Unreal

No dedicated VR game engines (yet)

Use workaround to render stereo

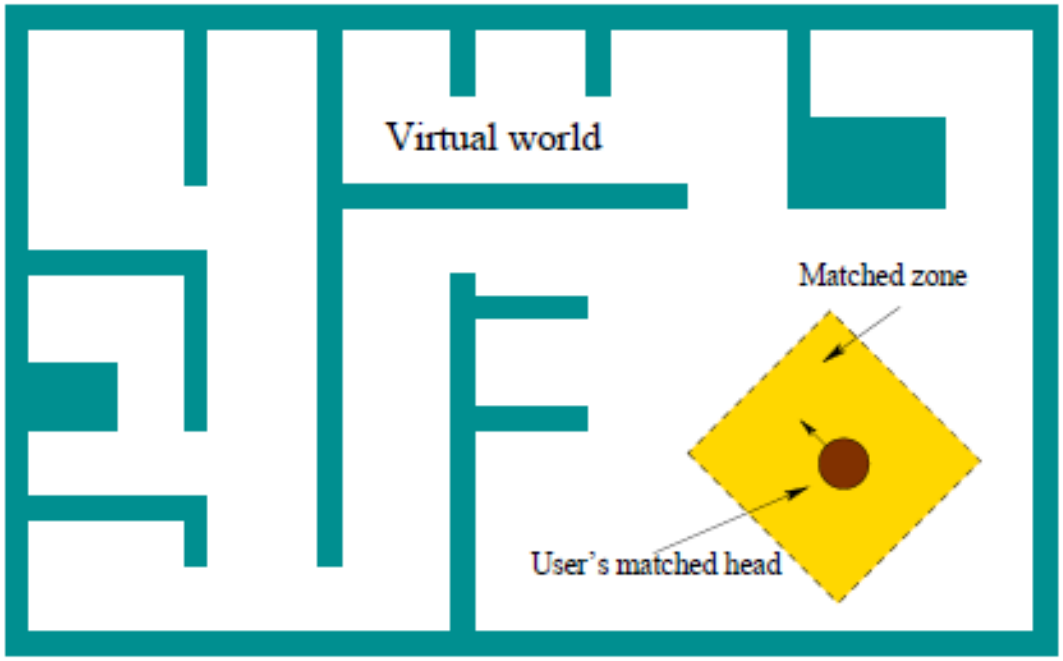
Lighting often not correct

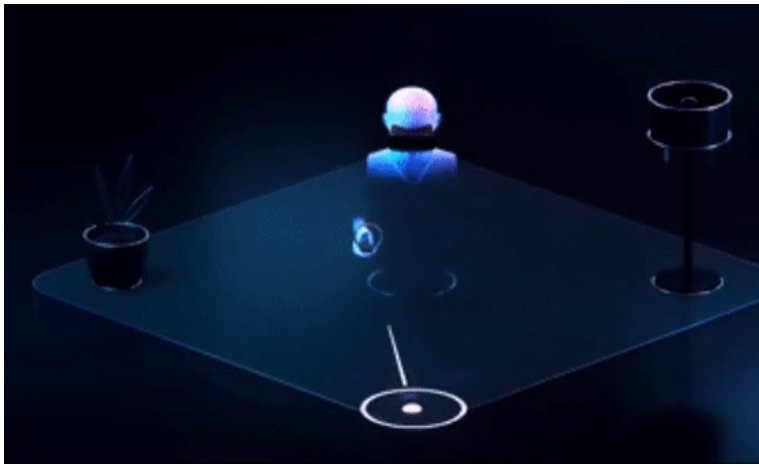
Geometric Models



Blender - export models to game engine

Matched Motion



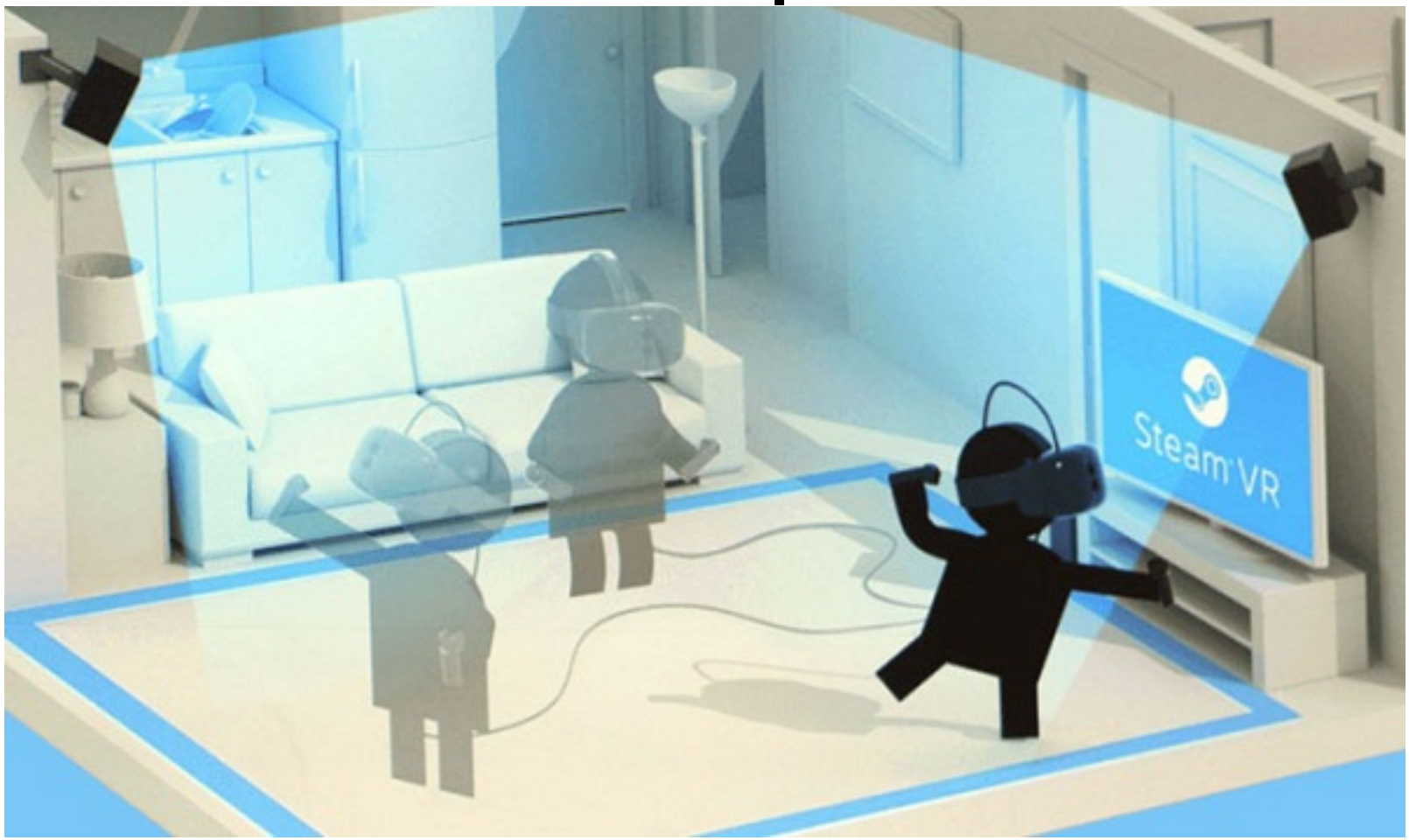


- Even with inside out tracking / physical space is limited
- Locomotion problem: how to travel beyond tracking space?

Virtual locomotion

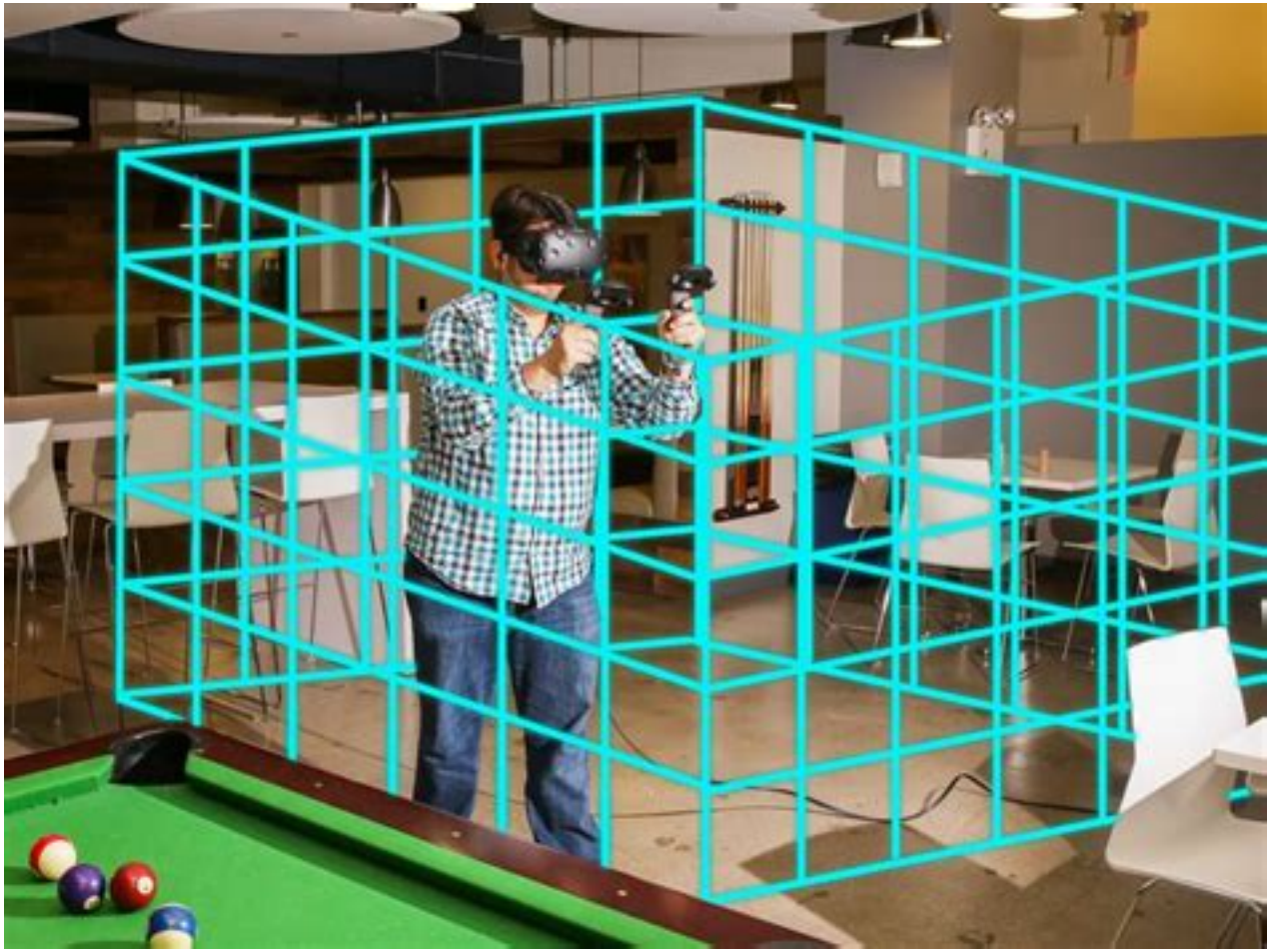
- Avoid VR sickness
- Mimic natural walking
- Many approaches but few widely used

Vive chaperone



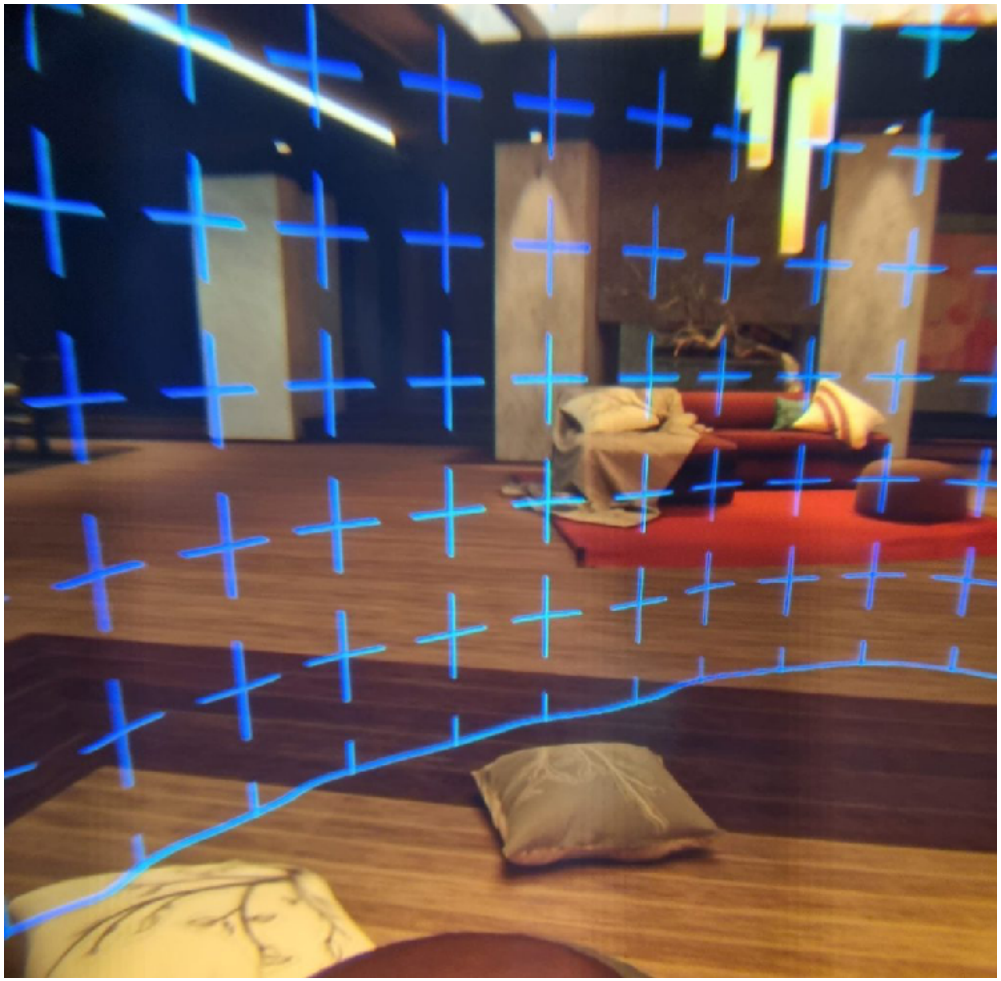
Supports 15 x 15 feet tracking space

Vive chaperone

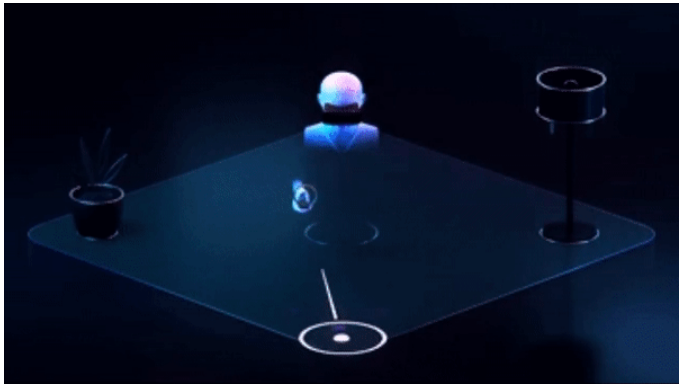


User movement confined by a grid

Oculus Guardian



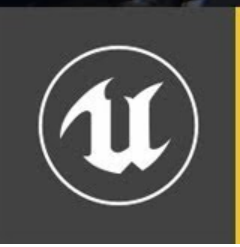
- Works really well
- Save different rooms
- Automatically detect rooms



VWG Software

- Maintains a 3D model of the world that can be used to render a 2D image
- Also incorporates laws of physics
  - Collision detection; objects can't move through each other
  - Gravity; when not supported, objects fall
  - Behavior of light
- This information fed to renderer who produces pixels in your VR HMD

Physics



EVENT COVERAGE