

# Virtual Reality Systems

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# Outline

## First Part:

- Head Mounted Display (HMD)
- Display Interface (Screen, Mura, God Ray, Screen Door Effect, Contrast, FOV, Resolution)
- Tracking System
- Input Devices ( Controller, Camera, Suit, Voice, Eye Tracking, BCI)
- Standalone vs Wireless vs Tethered vs Backpack

# Head Mounted Display (HMD) Virtual Reality (VR)

- Oculus Rift
  - 1 Display
  - 2 IR cameras
  - 2 Wireless controllers
  - Active trackers



# Head Mounted Display (HMD) Virtual Reality (VR)

- HTC Vive
  - 1 Display
  - 2 Laser emitters
  - 2 wireless controllers
  - Active trackers





# Head Mounted Display (HMD) Virtual Reality (VR)

- Windows Mixed Reality
  - 1 Display
  - 2 RGB cameras (Attached)
  - 2 Wireless controllers
  - Active trackers



# Head Mounted Display (HMD) Virtual Reality (VR)

- PSVR (PS4 Pro/PS4 Sony)
  - One Display
  - 1 External Camera
  - 2 wireless controllers
  - Active trackers



# Head Mounted Display (HMD) Virtual Reality (VR)

- Gear VR
  - One Display Stand-alone
  - No wireless controllers
  - No positional tracking



# VR HMD comparison

| Features        | GearVR                  | Oculus                                     | HTC Vive                                              | Mixed Reality                                       | PSVR                                                            |
|-----------------|-------------------------|--------------------------------------------|-------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------|
| PC requirements | Smartphone<br>Galaxy S7 | Nvidia<br>GTX970<br>AMD 290<br>I5, 8G+DDR3 | Nvidia<br>GTX970<br>AMD 290<br>I5, 4G+ DDR3           | GPU NVidia<br>GTX 960<br>AMD RX 460<br>I5, 2G+ DDR3 | CPU x86-64<br>AMD“Jaguar”, 8<br>cores<br>GPU 1.84<br>TFLOPS,AMD |
| Connection      | HDMI+USB                | HDMI 1.3<br>3USB 3.0                       | HDMI 1.3+<br>2USB 3.0                                 | HDMI 2.0+<br>USB 3.0                                | HDMI+USB 3.1                                                    |
| Sensor Types    | Acc, Gyro,<br>Mag       | Acc, Gyro,<br>Mag,Tracking<br>Sensor Array | Acc, Gyro,<br>Front-Facing<br>Camera, Laser<br>sensor | Acc, Gyro,<br>Inside-out<br>Tracking                | Acc, Gyro,<br>External Camera                                   |
| Field of View   | Appr. 90<br>degrees     | Appr. 110<br>degrees                       | Appr. 110<br>degrees                                  | Appr.105<br>degrees                                 | Appr.110 degrees                                                |
| Resolution      | 1920*1080               | 2160*1200                                  | 2160*1200                                             | 2880*1 440                                          | 1920x1080                                                       |
| Refresh Rate    | 60hz                    | 90hz                                       | 90hz                                                  | 90hz                                                | 120Hz                                                           |
| €€€             | 99€ +699€               | 449 €                                      | 799 €                                                 | 449 €                                               | 319€                                                            |

# Head Mounted Display (HMD) Augmented Reality (AR) Optical See Through

- Meta
  - 1 Display LCD
  - 2 Depth cameras (Attached)
  - Finger Tracking
  - 1 RGB Camera



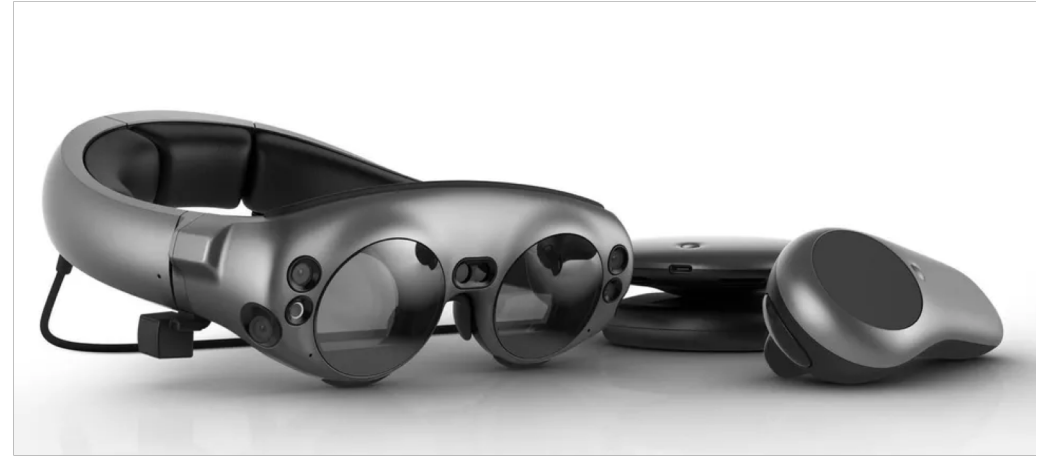
# Head Mounted Display (HMD) Augmented Reality (AR) Optical See Through

- Hololens
  - 1 Display Wave Guide
  - 4 Monochrome cameras
  - 1 Depth camera
  - 1 Photo / HD video camera



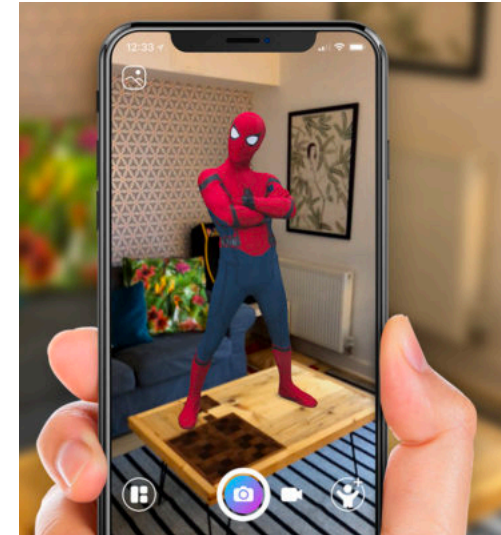
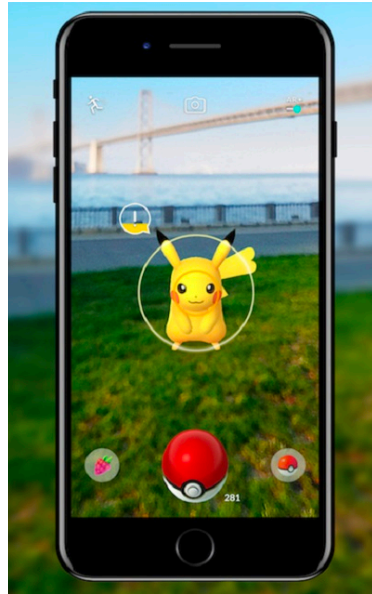
# Head Mounted Display (HMD) Augmented Reality (AR) Optical See Through

- Magic Leap
  - 1 Display Wave Guide
  - 4 Monochrome cameras
  - 1 Depth camera
  - 1 Photo / HD video camera
  - 1 Eye Tracking



# Head Mounted Display (HMD) Augmented Reality (AR) Video See Through

- ARkit (Apple)/ ARCore(Google)
  - One Display Stand-alone ( Iphone/ Android Phone)
  - No wireless controllers
  - No positional tracking





# AR HMD comparison

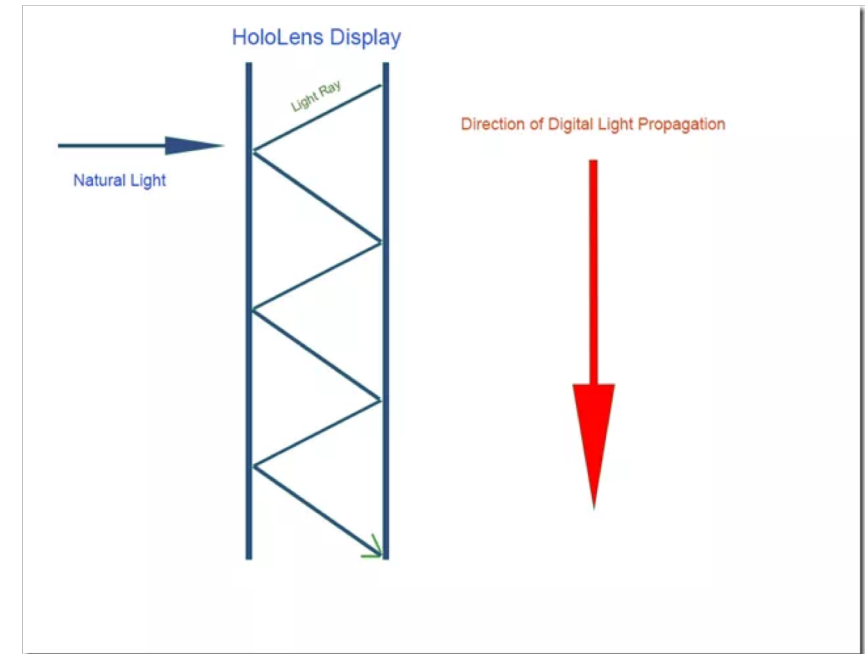
| Features        | Meta2                                         | Hololens                                  | Magic Leap                                | Smartphone                     |
|-----------------|-----------------------------------------------|-------------------------------------------|-------------------------------------------|--------------------------------|
| PC requirements | Nvidia GTX960<br>AMD R9 280,<br>Intel Core i7 | Intel Atom x5-Z8100                       | NVIDIA Tegra X2 SOC                       | Smartphone<br>Iphone7<br>Pixel |
| Sensor Types    | Acc, Gyro, Monochrome Camera, Depth Camera.   | Acc, Gyro, Monochrome Camera, Depth Camea | Acc, Gyro, Monochrome Camera, Depth Camea | Acc, Gyro, RGB Camera .        |
| Field of View   | Appr. 90 degrees                              | Appr. 30 degrees                          | Appr. 40 degrees                          | Appr.73 degrees                |
| Resolution      | 2560 x 1440                                   | 2160*1200                                 | 2160*1200                                 | 2880*1 440                     |
| Refresh Rate    | 60Hz                                          | 60hz                                      | ...                                       | 60hz                           |
| \$\$\$          | \$949                                         | \$3000                                    | \$2295                                    | \$449                          |

# Display Interface Screen

- Human Characteristic:
  - Field of View (FOV)  $\sim 210$  deg ( $\sim 180$  deg horizontal, 130 deg vertical)
  - Retina Resolution 9000x7800 pixels per eye.
  - Accommodation ( Infinite Focal Plane Displays )
  - Refresh Rate 120 Hz (Motion Blur)

# Display Interface Screen

- Wave Guide (1280 x 960) at 60Hz
- LCD 8K (7680 × 4320) at 60Hz
- OLED 8K (7680 × 4320) at 60Hz
- LCD 2K (2048×1080) at 90Hz
- OLED 2K (2048×1080) at 90Hz

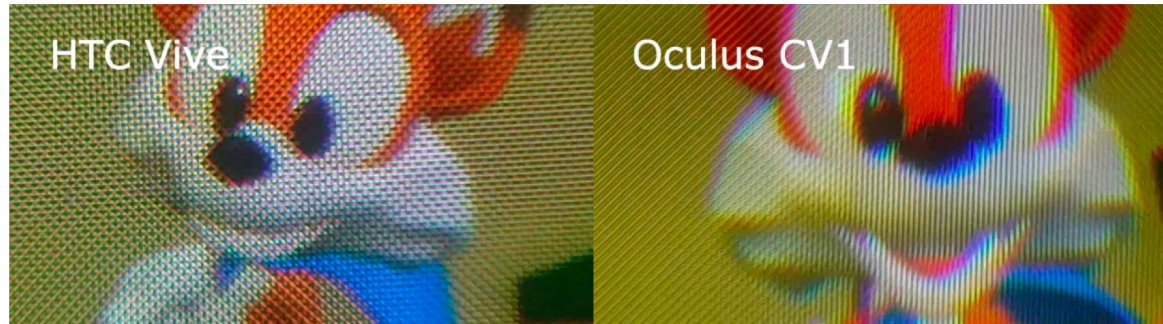


Wave Guide :  
Schematic general diagram of basic principle\*

# Display Interface Screen

- Screen Door Effect

We see the line  
between pixels.



- Mura Effect

Issue with  
Colour  
consistency



- God Ray Effect/Lens Flare

Lens  
Diffract the  
light



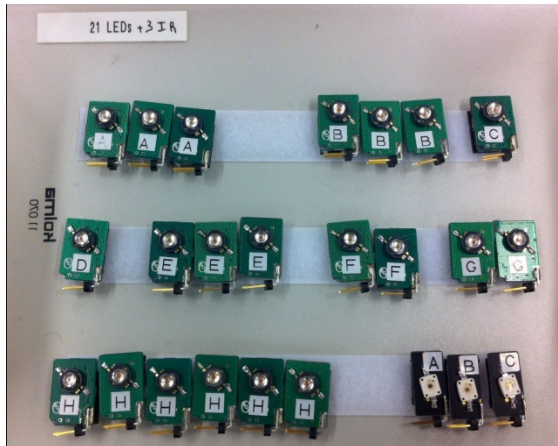
# Tracking system

- With markers
  - Active
  - Passive
- Markerless



# Tracking system (Head tracking)

- With markers: Active motion capture system
  - PhaseSpace optical motion capture
    - Motion tracking
    - Position sensing

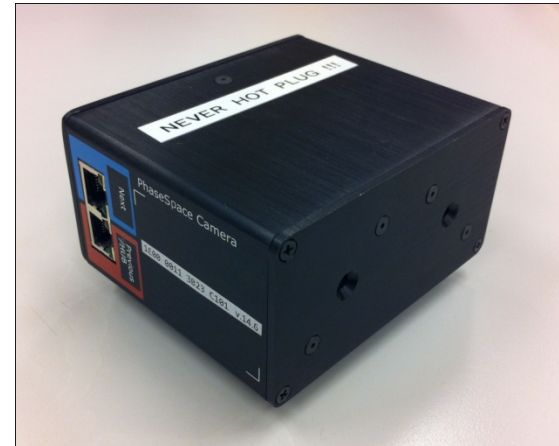


LEDs

Dimensions: 20 mm x 14 mm x 3.2 mm

Weight: 4.5 grams

Each LED modulates at a unique frequency resulting in a unique digital ID. LEDs are available in Red visible and Infra-red versions.



Cameras

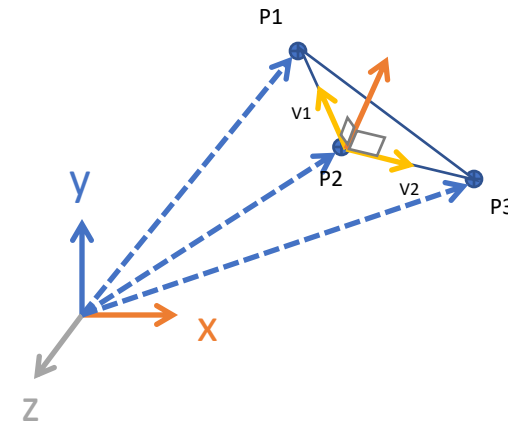
Dimensions: 108 mm x 92 mm x 57 mm

Weight: 380 grams

Each camera achieves an Optical Resolution of 3600 x 3600 (12 Megapixel) using two linear detectors with 16-bit dynamic range. Onboard processors produce an impressive Subpixel Resolution of 30,000 x 30,000 at 480 Hz.

# Tracking system (Head tracking)

- Active motion capture system
  - Only Head Tracking



# Tracking System

- Data sent to headset
- Proprietary Protocol

Data  
streaming



- IR filter on the Camera
- Triangulate its position in the tracking space

Positional  
Tracking





# Tracking System

- Data sent to headset
- Proprietary Protocol

Data  
streaming



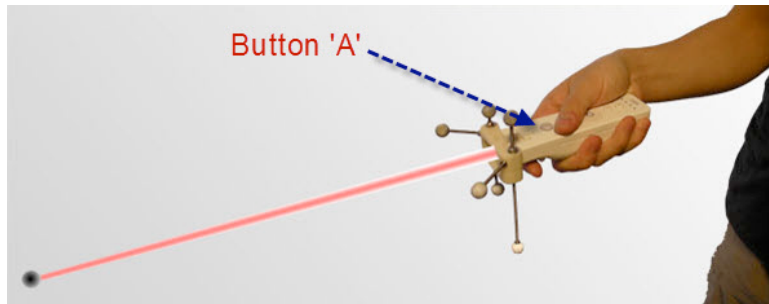
- Laser Emitter
- Triangulate its position in the tracking space

Positional  
Tracking



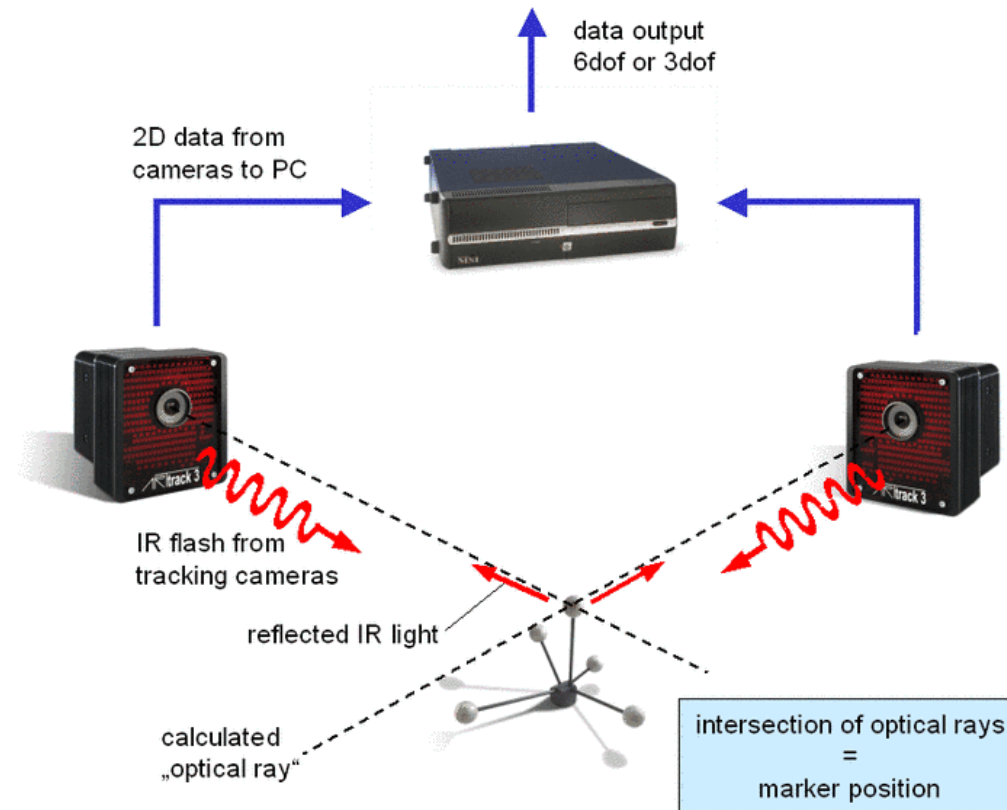
# Tracking system (Head and hand tracking)

- Passive tracking system
  - Reflect incoming IR radiation back in the direction of the incoming light (ART tracking maxi distance = 7m)



# Tracking system

- Passive tracking system architecture



# Tracking system

- IMU motion capture
  - Xsens
  - Perception Neuron



<https://www.youtube.com/watch?v=LtMfrkRqIRs>

# Tracking system

- Markerless Motion capture system
  - Kinect sensor
    - Natural user Interface using
      - Gestures
      - and Spoken commands
  - Connectivity:

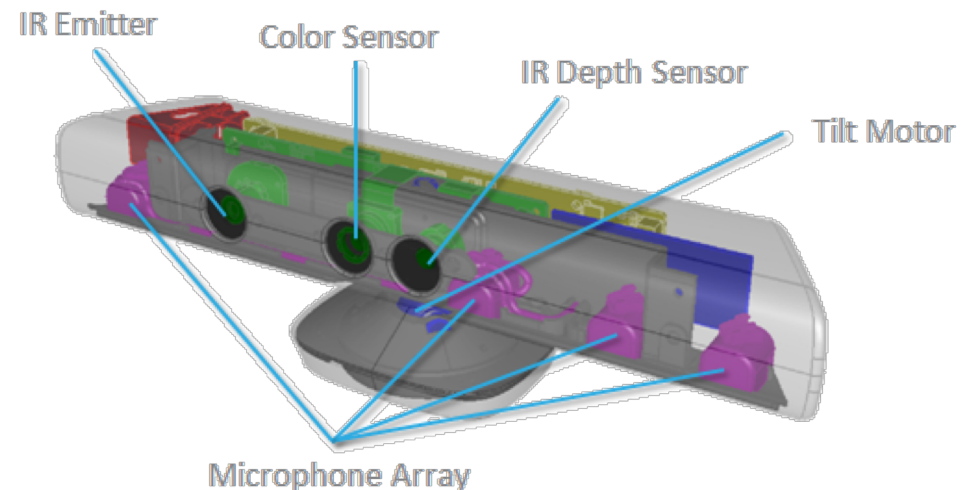
KINECT™  
for XBOX 360

+ *power cable* (for PC)  
CERTIFIED **USB**™



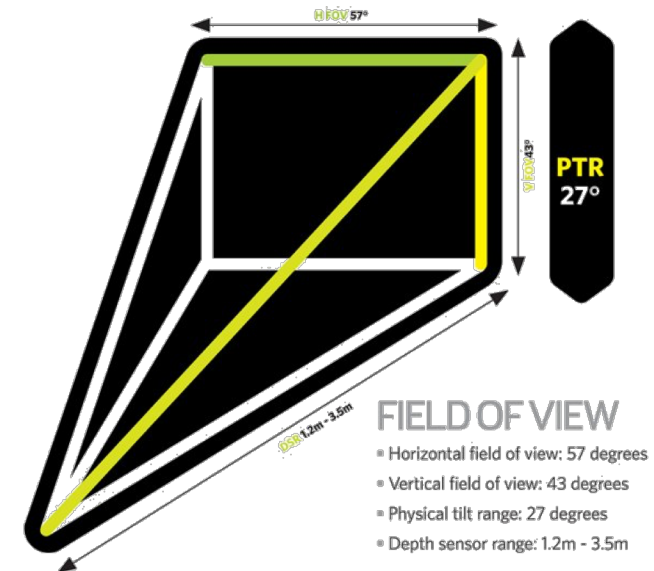
# Tracking system

- Kinect sensors:
  - RGB camera
  - Depth sensor(IR Emitter and IR Depth Sensor)
  - Multi-array microphone
- Functionality:
  - Full-body 3D motion capture
  - Facial recognition
  - Voice recognition



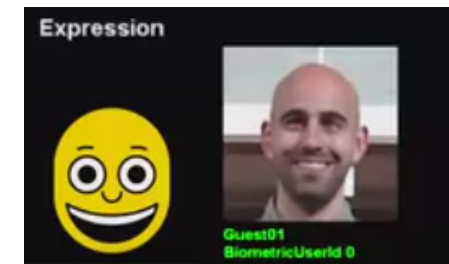
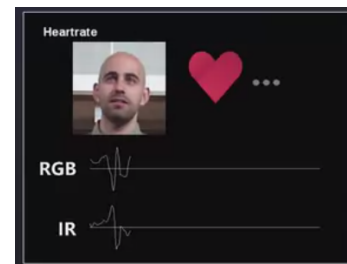
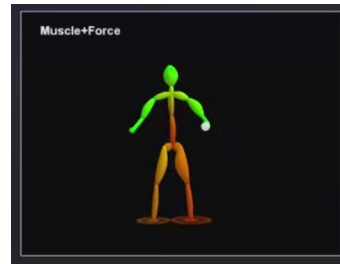
# Tracking system

- Kinect sensor features :
  - Sensor outputs video at 30Hz
  - RGB video 8-bit VGA Resolution (640\*480 pixels/HD)
  - Depth sensing in VGA resolution (320\*240pixels/512\*424pixels)
  - Ranging limit :
    - Distance 4.5m
    - Angular field of view :
      - 57° horizontally / 70°
      - 43° vertically / 60°



# Tracking system

- New Kinect Sensor
  - Improved field of view results in much larger play space.
  - RGB stream is higher quality and higher resolution.
  - See in the dark
  - Biometric scanning
  - Muscle+force
  - Expression engagement





# Tracking System

- Data sent to headset
- Proprietary Protocol

Data  
streaming



- Visible light Cameras
- Identify features in your environment in visible light.

Positional  
Tracking



# Tracking system

|                    | Active                        | Passive               | Markerless (Kinect) |
|--------------------|-------------------------------|-----------------------|---------------------|
| Precision          | High                          | High                  | Low                 |
| Invasiveness       | High                          | Medium                | Low                 |
| Measurement        | Marker pos(/ori) <sup>1</sup> | Marker pos(/ori)      | Pos                 |
| Preparation        | Complex                       | Complex               | Easy                |
| Battery            | Yes                           | No                    | No                  |
| Calibration        | Yes                           | Yes                   | Yes                 |
| Marker recognition | Yes                           | No                    | -                   |
| Price              | High                          | Very High (e.g VICON) | Low                 |

1: at least, 3 markers are needed for orientation measurement

# Input Devices

- Oculus Touch
  - 4\* Digital buttons
  - 1\* Joystick
  - 3\* Passive buttons
  - Haptic vibration motor
  - Ring of infrared LEDs (24 IR LEDs)
  - Gyroscope and Accelerometer
- Constellation
  - Infrared sensor ( IR camera + filter)
  - USB 3.0



# Input Devices

- Vive Controller
  - 6\* Digital Buttons
  - 1\*Tactile Pad
  - Haptic vibration motor
  - Ring of photodiodes (24)
  - Gyroscope and Accelerometer
- Lighthouse
  - 2\*Laser emitters



# Input Devices

- Motions Controller
  - 4\* Digital Buttons
  - 1\*Tactile Pad
  - 1\*Joystick
  - Haptic vibration motor
  - Ring of visible LEDs (32 LEDs)
  - Gyroscope and Accelerometer
- Inside-out Tracking
  - 2\*low-resolution black and white cameras



# Input Devices

- PlayStation Move for PSVR (PS3 Sony)

- Motion sensing
  - 3-axis accelerometer
  - 3-axis angular rate
- Location tracking
  - Magnetometer
  - Object recognition (via PlayStation Eye)
- 1 \* Analog trigger
- 8 \* Button



Range of distance : 25cm -  $\infty$  (in wide angle view)Field  
of view56° (standard view) - 75° (wide angle view)  
FOV zoom lens



External dimension : Approx. 200mm ×  
46mm (height × diameter)  
Best range : 0.6-3meter from camera

# Input Devices

- PlayStation Move Navigation Controller:
  - Analog stick (for navigation)
  - D-pad (thumb-operated directional control)
  - 1 \* Analog trigger
  - 5 \* Buttons



Class 2: ~10 meters

- Connectivity:



- Sony PlayStation Move trailer:

- <http://www.youtube.com/watch?v=KywklJJJoJ5s>



External dimension : Approx. 138mm × 42mm (height × diameter)

# Input Devices



Knuckles

Leap Motion



Perception Neuron

Manus VR





# Standalone vs Wireless vs Tethered vs Backpack



Vive Pro + Wireless Module  
WiGig 60GHz  
4.6Gbps

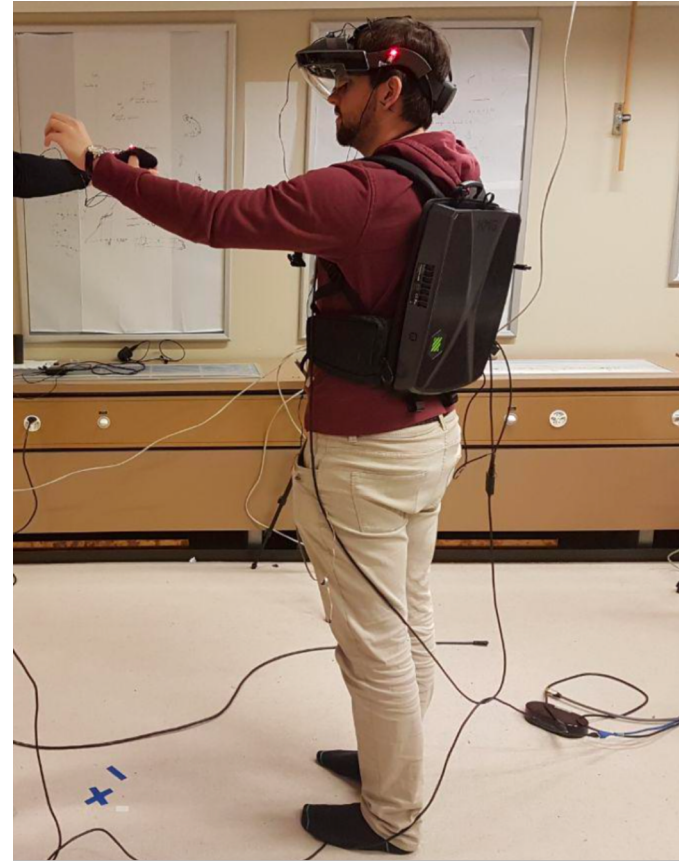


Oculus Quest

# Standalone vs Wireless vs Tethered vs Backpack



HTC Vive



Meta2+ Backpack

Questions ?