VETreality

VR Glasses and Tracking Systems

MODULE 2 - Unit 2- Master class

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EVOLUTION OF THE VR DEVICES AND MARKET AVAILABILITY

EVOLUTION OF VR DEVICES

1. BASICS
2. PC BASED
3. STAND ALONE

MARKET AVAILABILITY

1. BASIC VR DEVICES
2. MID-RANGE
3. HIGH END

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BASIC VR DEVICES

- Google Cardboard
- Samsung Gear VR

“ If an app needs more than one button, it’s not for cardobard”

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PC BASED VR DEVICES

- HTC VIVE PRO
- HTC VIVE COSMOS
- OCULUS RIFTS
- VALVE INDEX VR

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STAND ALONE VR DEVICES

- GEN 1 STAND ALONE HEADSETS
  - Oculus GO
  - Pico Goblin
- GEN 2 STAND ALONE HEADSETS
  - Oculus quest
  - Oculus quest 2
  - VIVE Focus

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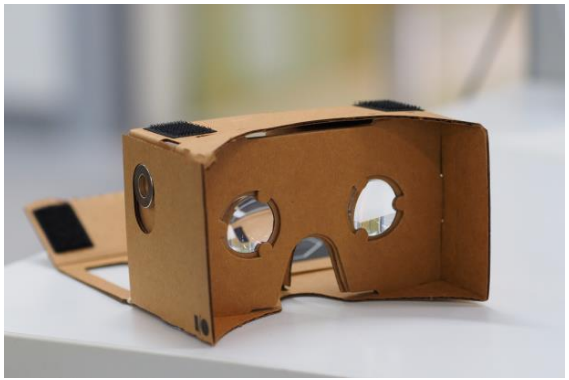
MARKET VR PRODUCTS



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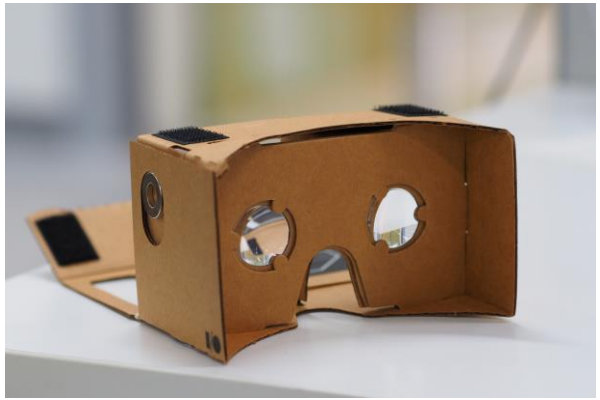
BASIC VR DEVICES: DESIGN



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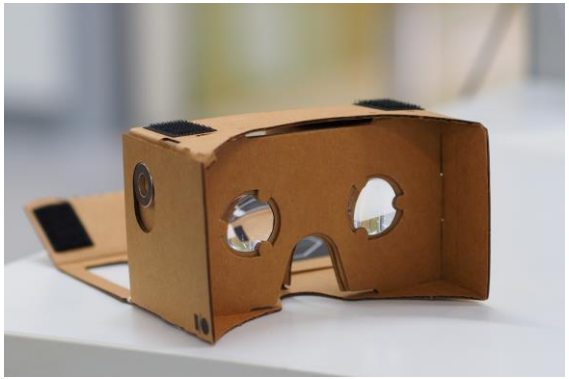
BASIC VR DEVICES: DESIGN

- **Simplest form of VR: pair of plastic magnifying lenses and a sheet of cardboard, using a standard smartphone as a screen.**
- Most people refer to this now as "Google Cardboard," but the idea was around for years before Google branded it.
- Some made of plastic or aluminum.
- Limited interactivity, most suited for watching 360-degree video. Not meant to be used for long periods of time
- Pretty uncomfortable



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BASIC VR DEVICES: UP-FRONT PRICE and HIDDEN COSTS

- **You only need a smartphone**
- Google sells basic Cardboards for 15€ a piece.
- They're mostly in the 20€ to 30€ range, including models made of more durable plastic.
- If the smartphone is old there’s no guarantee it can handle Google Cardboard apps well. The quality will be lower.

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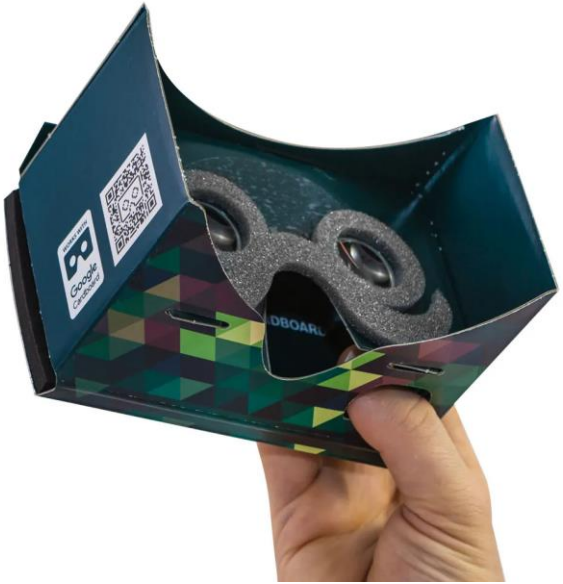
BASIC VR DEVICES: AVAILABILITY

- The simplest VR headsets aren't just the cheapest, **they're also the most widely available**.
- Over a dozen Cardboard-compatible headsets are on sale through Google's site, and others
- Google Cardboard: https://arvr.google.com/cardboard/get-cardboard/



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PC BASED AND STAND ALONE VR DEVICES:
DESIGN (Mid Range)

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PC BASED AND STAND ALONE VR DEVICES:
DESIGN (Mid Range)

- They have **additional tracking sensors, more sophisticated built-in controls, focus wheels,** or **their own screens.**
- The best-known is **Samsung's Gear VR.**
- There are more obscure options: Zeiss VR One or the French Homido device
- The Gear VR is the clear front-runner right now, for example.
- Homido and Zeiss' designs, are more like Google Cardboard than either of the above.

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PC BASED AND STAND ALONE VR DEVICES:
UP-FRONT PRICE (Mid Range)

- The prices can vary between 70€ to 115€.
- The Gear VR offers software optimization, a **better control system** than Cardboard, and a lot of **attention to detail,** including a **dedicated app store.**

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PC BASED AND STANDALONE VR DEVICES: *SPACE NEEDS (Mid Range)*

- **Mid-range headsets** have the best of both worlds: **easily portable**, but also **more comfortable and immersive** than Google Cardboard.
- They offer experiences that would be too interactive or fast-moving for Cardboard to handle, they also open the door to motion sickness.

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PC BASED AND STAND ALONE VR DEVICES:
CONTROLLERS (Mid Range)

- **The controllers on mid-range headsets are all over the place.**
- LG’s virtual reality headset has a simple **two-button set-up**.
- The Gear VR has a laptop-like trackpad that sits on the side of the headset. It’s not perfect, but **it offers several different input options,** like swiping, tapping, or pressing a separate "Back" button.

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PC BASED AND STAND ALONE VR DEVICES:
AVAILABILITY (Mid Range)

- The Gear VR was the first major virtual reality headset to see consumer release and **it is easy to find**.
- It's actually got a **couple of hundred games, apps, and little experiments**, many of which take advantage of its relatively complex controls.
- **They cost more than your average mobile game, the 5€ to 10€ price tag isn't bad**.

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PC BASED AND STANDALONE VR DEVICES:
DESIGN (High end)

- **The absolute best-quality VR experiences can't be powered by a mobile phone.**
- The Oculus Rift, Valve and HTC's Vive, and Sony PlayStation VR all run off external computers or game consoles.
- **They can offer motion tracking, high-resolution screens, and the best graphics possible**.
- They're more **comfortable**, better at blocking outside light, and less prone to inducing motion sickness.
- But for now, they're **expensive** and intended mostly for early adopters.

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PC BASED AND STAND ALONE VR DEVICES:
UP-FRONT PRICE and HIDDEN PRICES (High end)

- High-end headsets **cost a *lot.*** The Oculus Rift is almost 500€ and The HTC Vive pro is more than 1000€.
- Computers that don't meet the Rift and Vive's recommended specs might still be able to run some VR games and videos.
- But **to get a guaranteed good experience, expect to spend around 900€ if you're buying a new desktop** — maybe a little less if you buy a combined headset and PC bundle.

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PC BASED AND STAND ALONE VR DEVICES:
SPACE NEEDS (High end)

- One of the big features is the ability to **move or even walk through space.**
- The standard way to do this is to put LEDs or some other set of markers on the headset, then track them with an external camera.
- HTC's Vive uses a **laser tracking** system that lets you walk around a 15 x 15-foot room. It's by far the most freedom you'll get from any headset. **That also means you'll need to install a high-powered computer next to a totally clear patch of**

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PC BASED AND STAND ALONE VR DEVICES:
CONTROLLERS (High end)

- What really sets these high-end headsets apart is their **motion controllers**
- **They let you do everything from play realistic virtual ping-pong to paint in three dimensions.**

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PC BASED AND STAND ALONE VR DEVICES:
AVAILABILITY (High end)

- As an example, **Sony** introduced around **17 launch games last year**.
- Oculus and Valve have both lined up several dozen titles for the Rift and Vive
- If you wait, the hardware needed to run these high-end headsets will only get cheaper.

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TRACKING SYSTEMS

- Positional tracking **detects the precise position** of the head-mounted displays, controllers, other objects or body parts.
- The purpose of VR is to **emulate perceptions** of reality.
- Several methods of tracking the position and orientation of the display and any associated objects or devices have been developed to achieve this.
- They use **sensors** which repeatedly record signals from transmitters on or near the tracked object(s), and then send that data to the computer in order to maintain an approximation of their physical locations.

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TRACKING SYSTEMS

- The simplest tracking systems can detect the movement of your head with the use of your Smartphone and more robust systems can detect the movement of your entire body.

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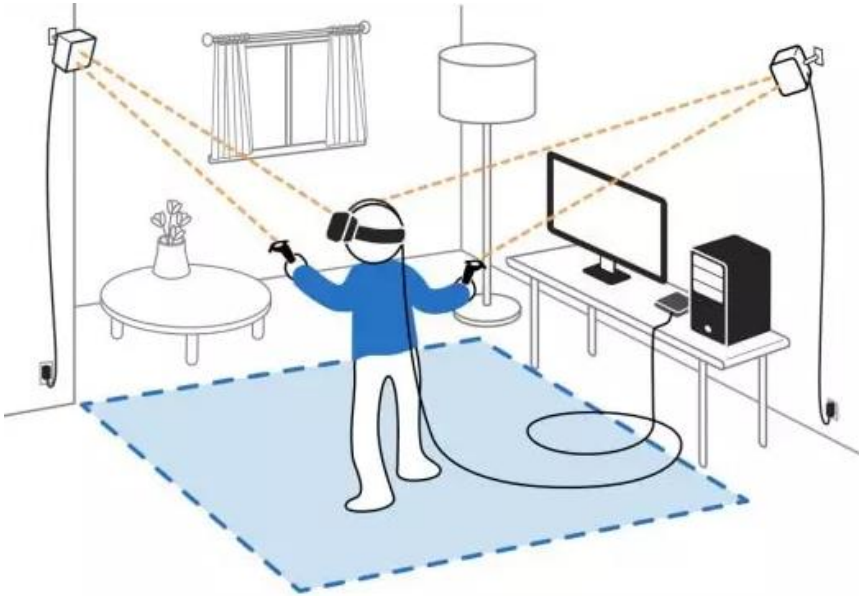
TRACKING SYSTEMS

- Wireless tracking
- Optical tracking
- Outside-in tracking
- Inside-out tracking
- Inertial tracking
- Sensor fusion
- Acoustic tracking
- Magnetic tracking



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TRACKING SYSTEMS

Wireless Tracking

- Uses a set of anchors that are placed around the perimeter of the tracking space and one or more tags that are tracked.
- This system is similar in concept to GPS, but works both indoors and outdoors.
- The tags triangulate their 3D position using the anchors placed around the perimeter.

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TRACKING SYSTEMS

PROS	CONS
User experiences unconstrained movement / Allows wider range of motion	Low sampling rate can decrease accuracy / Low latency (define) rate relative to other sensors

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TRACKING SYSTEMS

Optical Tracking

Optical tracking uses cameras placed on or around the headset to determine position and orientation based on computer vision algorithms.

- This method is based on the same principle as human vision. When a person looks at an object, he/she is able to define approximately at what distance the object is placed due to the difference in perspective between the two eyes.
- In optical tracking, cameras are calibrated to determine the distance to the object and its position in space.

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TRACKING SYSTEMS

Optical Tracking

- Optical tracking can be done either with or without markers.
- Tracking with markers involves targets with known patterns to serve as reference points, and cameras constantly seek these markers and then use various algorithms to extract the position of the object.
    - Markers can be visible, such as printed **QR codes**, but many use **infrared (IR) light** that can only be picked up by cameras.
    - Markerless tracking does not require any pre-placed targets, instead using the natural features of the surrounding environment to determine position and orientation.

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TRACKING SYSTEMS

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TRACKING SYSTEMS

Outside-in tracking

- In this method, cameras are placed in stationary locations in the environment to track the position of markers on the tracked device, such as a head mounted display or controllers.

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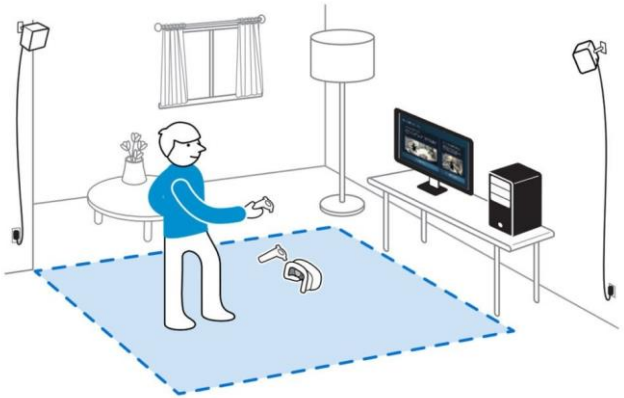
TRACKING SYSTEMS

Outside-in tracking

- Having multiple cameras:
  - Allows for different views of the same markers
  - This overlap, allows for accurate readings of the device position.
- The original Oculus Rift utilizes this technique, with external cameras in the environment to read their positions.
- This method is the most mature but it is space-limited, needing external sensors in constant view of the device.



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TRACKING SYSTEMS

Outside-in tracking

PROS	CONS
More accurate readings, can be improved by adding more cameras / Lower latency than inside-out tracking	Occlusion, cameras need direct line of sight or else tracking will not work / Necessity of outside sensors means limited play space area

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TRACKING SYSTEMS

Inside-out tracking

- The camera is placed on the tracked device and looks outward to determine its location in the environment.
- Headsets that use this tech have multiple cameras facing different directions to get views of its entire surroundings. The Lighthouse system used by the HTC Vive is an example of active markers.
- Each external Lighthouse module contains IR LEDs as well as a laser array that sweeps in horizontal and vertical directions, and sensors on the headset and controllers can detect these sweeps and use the timings to determine position.

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TRACKING SYSTEMS

Inside-out tracking

- Markerless tracking, such as on the Oculus Quest, does not require anything mounted in the outside environment. It uses cameras on the headset, or simultaneous localization and mapping, where a 3D map of the environment is generated in real time.
- This tech allows high-end headsets like the Microsoft HoloLens to be self-contained, but it also opens the door for cheaper mobile headsets without the need of tethering to external computers or sensors.

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TRACKING SYSTEMS

Inside-out tracking

PROS	CONS
Freedom! With inside-out you're not restricted to a play space, so mobility is increased and the virtual feels a bit more… real.	• Accuracy and latency. Inside-out tracking requires good computer vision, and this technology is a little further behind outside-in solutions, but it's getting there. • All computational work must be done by the headset itself.

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TRACKING SYSTEMS

Inertial Tracking

- Inertial tracking use data from accelerometers and gyroscopes.
  - Accelerometers measure linear acceleration.
  - Gyroscopes measure angular velocity.
    - Angular velocity can be integrated as well to determine angular position relatively to the initial point. Modern inertial measurement units systems allows to track the orientation (roll, pitch, yaw) in space with high update rates and minimal latency.

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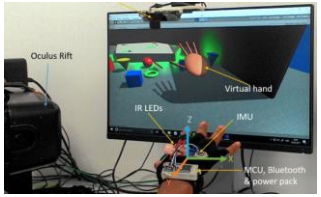
TRACKING SYSTEMS



Inertial Tracking

- Inertial sensors are not only capable of tracking rotational movement (roll, pitch, yaw), but also translational movement.
- These two types of movement together are known as the Six degrees of freedom.
- Many applications of virtual reality need to not only track the users' head rotations, but also how their bodies move with them (left/right, back/forth, up/down).
    - Six degrees of freedom capability is not necessary for all VR experiences, but it is useful when the user needs to move things other than their head.

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TRACKING SYSTEMS

Inertial Tracking

PROS	CONS
Can track fast movements well relative to other sensors, and especially well when combined with other sensors Capable of high update rates	Prone to errors, which accumulate quickly, due to dead reckoning Any delay or when determining position can lead to symptoms in the user such as nausea May not be able to keep up with a user who is moving too fast Inertial sensors can typically only be used in indoor and laboratory environments, so outdoor applications are limited

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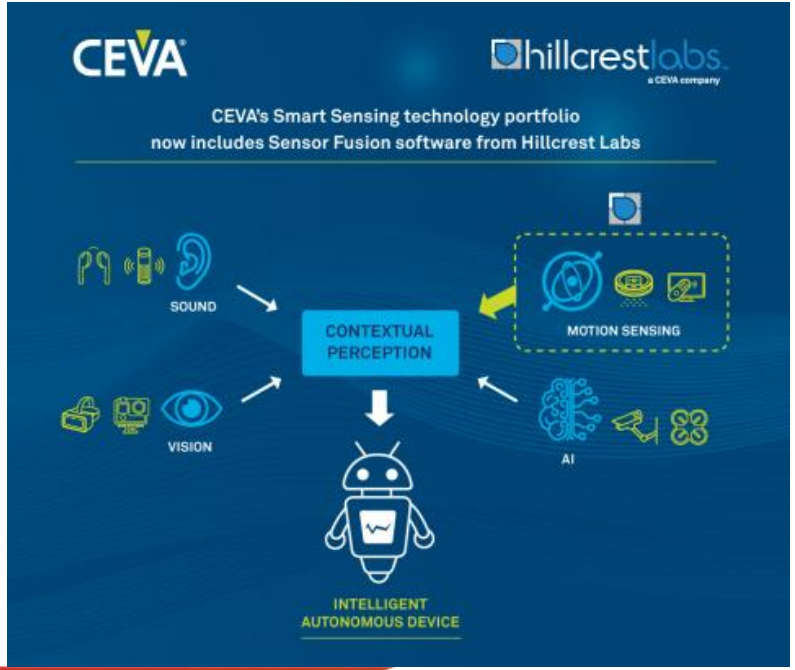
TRACKING SYSTEMS

Sensor fusion

- Sensor fusion combines data from several tracking algorithms and can yield better outputs than only one technology.
- One of the variants of sensor fusion is to merge inertial and optical tracking.
- These two techniques are often used together because while inertial sensors are optimal for tracking fast movements they also accumulate errors quickly, and optical sensors offer absolute references to compensate for inertial weaknesses.



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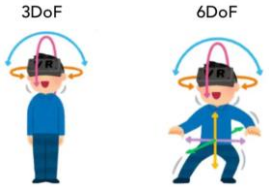
TRACKING SYSTEMS



Acoustic tracking

- Use techniques for identifying an object or device's position similar to those found naturally in animals that use echolocation.
- Analogous to bats locating objects using differences in soundwave return times to their two ears.
  - May use sets of at least three ultrasonic sensors and at least three ultrasonic transmitters on devices in order to calculate the position and orientation of an object
  - E.g. a handheld controller

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TRACKING SYSTEMS

Magnetic tracking

- This is based on the same principle as a theremin → Based on measuring the intensity of in homogenous magnetic fields with electromagnetic sensors.
  - Three magnetic fields are generated sequentially to cover all directions in the three dimensional space.
  - It is the tracking system used in fully immersive virtual reality displays → because magnetic tracking does not require a head-mounted display.
- The system works poorly near any electrically conductive material, such as metal objects and devices, that can affect an electromagnetic field.
  - Magnetic tracking worsens as the user moves away from the base emitter, and scalable area is limited and can't be bigger than 5 meters.

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TRACKING SYSTEMS

Magnetic tracking

PROS	CONS
Uses unobtrusive equipment that does not need to be worn by user	User needs to be close to base emitter
Does not interfere with the virtual reality experience	Tracking worsens near metals or objects that interfere with the electromagnetic field
Suitable for fully immersive virtual reality displays	Tend to have a lot of error and jitter due to frequent calibration requirements

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IMMERSION IN VR

- Is the possibility of interacting with elements of the virtual environment, such us → movement, manipulation of objects, making decisions, being part of the story that is being told etc.

- Reality → Evoke the sensation of being physically present in the virtual world

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