Mansoura University
Faculty of Computers and Information
First Semester- 2022-2023

COMPUTER GRAPHICS

Grade: 2ND YEAR (GENERAL –BIO)

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AR-VR-MR introduction

1- Augmented reality (AR)

adds **digital elements** to a **live view** often by using the camera on a smartphone.

https://www.fi.edu/difference-between-ar-vr-and-mr

2-Virtual reality (VR)

implies a **complete immersion experience** that **replaces** the physical world.

3-Mixed Reality

Mixed Reality (MR) experience, which **combines** elements of both **AR and VR**, real-world and digital objects interact.

Microsoft's HoloLens one of the most notable early mixed reality

4-Extended Reality (XR)

It includes technologies :

- Virtual Reality (VR)
- Augmented Reality (AR)
- Mixed Reality (MR).

https://www.fi.edu/difference-between-ar-vr-and-mr

Augmented Reality types

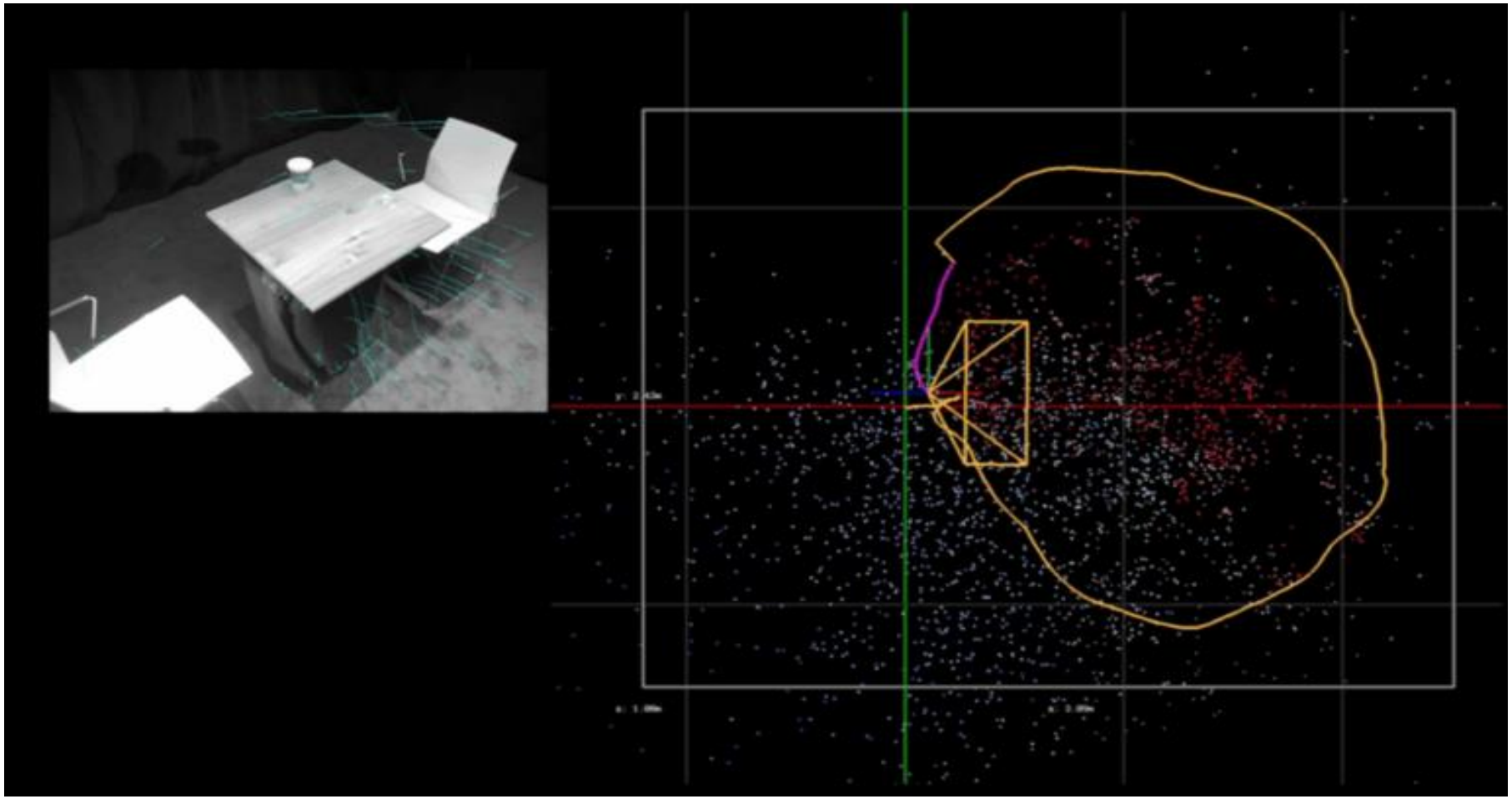
- The Augmented Reality technology can work using one of the following approaches:
  1. SLAM
  2. Recognition based
  3. Location Based
  4. Projection Based Augmented Reality

1-SLAM

- SLAM (Simultaneous Localization and Mapping) is the most effective way to render virtual images over real-world objects.
- SLAM simultaneously localizes sensors with respect to their surroundings, while at the same time mapping the structure of the environment.
- The SLAM system is a set of algorithms aimed at solving simultaneous localization and mapping problem.
- Example :

https://youtu.be/ufvPS5wJAx0

SLAM(3)



https://www.andreasjakl.com/basics-of-ar-slam-simultaneous-localization-and-mapping/

2. Recognition based (marker-based)

- **Recognition (or marker) based augmented reality uses a camera to identify visual markers or objects, such as:**
  - **QR code**
  - **Bar code**
  - **or natural feature tracking (NFT) markers صور طبيعية يمكن استخلاص خصائص مميزة لها,**

3. Location Based (Markerless)

- Contrary to recognition based, location-based AR relies on a **GPS**, **digital compass, velocity meter, or accelerometer** to provide data about the location and the augmented reality visualizations are activated based on these inputs.
- It is also known as **markerless** augmented reality.

ARCore Geospatial API

The **ARCore Geospatial API** enables you to remotely attach content to any area covered by Google Street View and create AR experiences on a global scale.

It uses device sensor and GPS data to detect the device's environment, then matches the recognizable parts of that environment to a localization model provided by Google's Visual Positioning System (VPS) to determine the precise location of a user's device.

The API also takes care of merging the user's local coordinates with the geographic coordinates from VPS so that you can work within a single coordinate system.

https://developers.google.com/ar/develop/geospatial

Global localization with VPS

Street View images from Google Maps, which have been captured around the globe for more than 15 years, are the foundation of VPS.

Deep neural networks identify and describe parts of the images that are likely to be recognizable over long periods of time. Those parts are then combined across tens of billions of images to compute a 3D point cloud of the global environment. This localization model consists of trillions of points and spans nearly all countries, with future coverage.

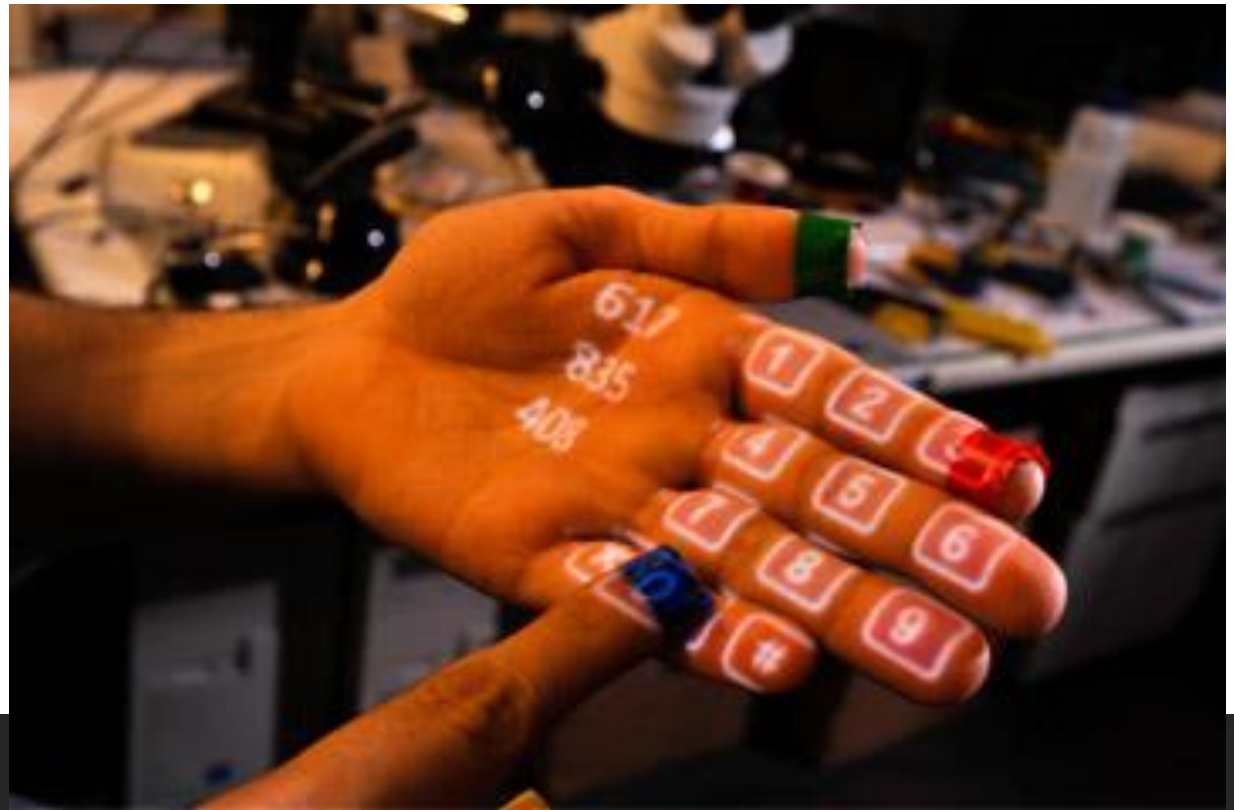
When the user's device makes a request to the Geospatial API, a neural network processes the pixels to find recognizable parts of the user's environment and matches them to the VPS localization model.

Computer vision algorithms then compute the position and orientation of the device, offering a location that is much more accurate than what was previously possible with GPS alone.

Global localization with VPS

4- Projection Based Augmented Reality

- Projection based augmented reality works by projecting artificial light onto real world surfaces.
- Projection based augmented reality applications allow for human interaction by sending light onto a real world surface and then sensing the human interaction (i.e. touch) of that projected light. Detecting the user's interaction

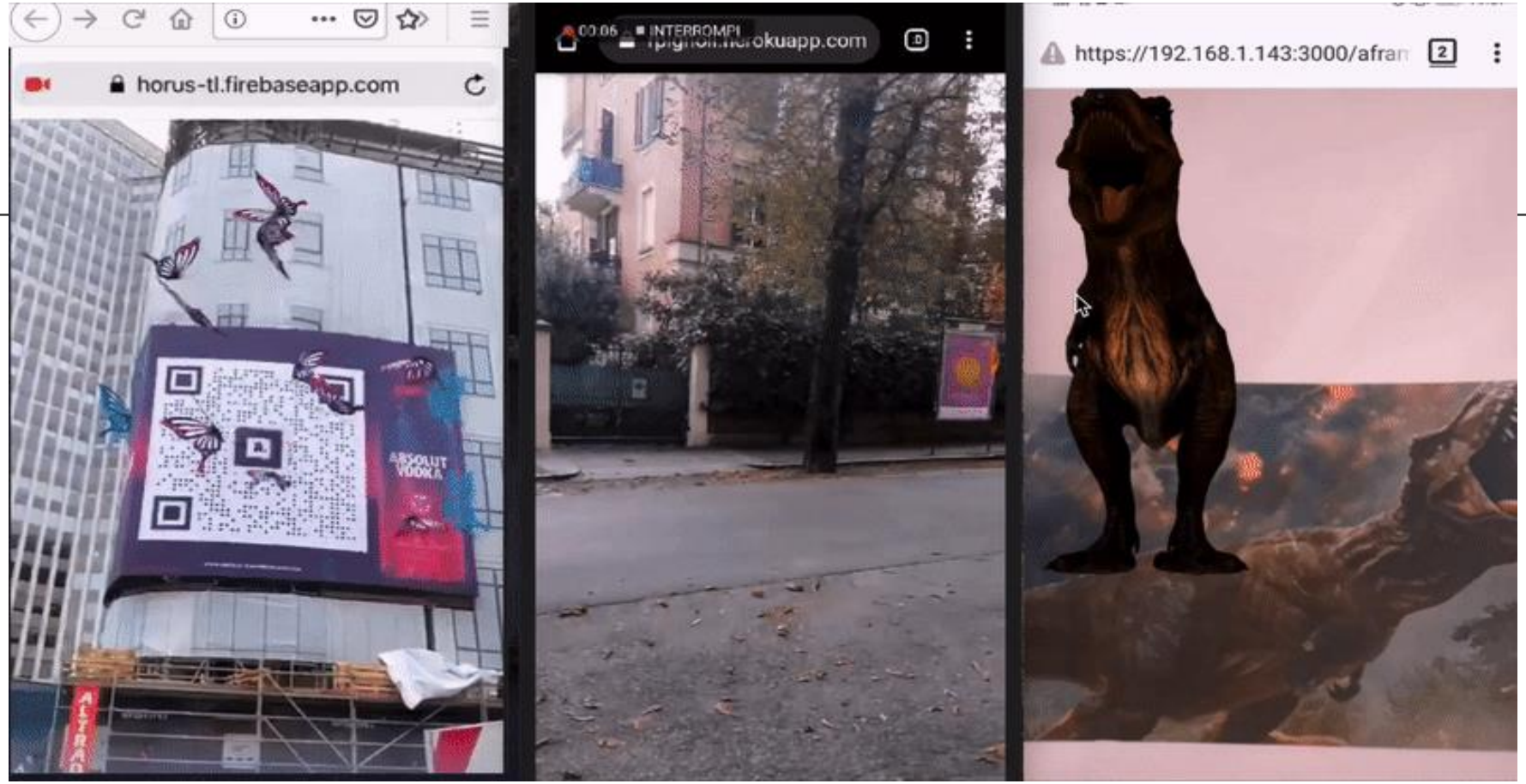


Known AR SDKs for programmers للاطلاع فقط

https://rubygarage.org/blog/best-tools-for-building-augmented-reality-mobile-apps

	Vuforia	Wikitude	EasyAR	Kudan	ARToolKit	Maxst	Apple ARKit	XZIMG
Licence	Free, Commercial	Commercial	Free, Commercial	Free, Commercial	Free Open Source	Free, Commercial	Free	Free, Commercial
Supported platforms	Android, iOS, UWP	Android, iOS	Android, iOS, UWP, macOS	Android, iOS	Android, iOS, Linux, Windows, macOS	Android, iOS, Windows, macOS	iOS	Android, iOS, Windows
Smart glasses support	+	+	-	-	+	+	+	-
Unity support	+	+	+	+	+	+	+	+
Cloud recognition	+	+	+	-	-	-	+	-
3D recognition	+	+	+	+	-	+	+	-
Geolocation	+	+	-	-	+	-	+	-
SLAM	-	+	+	+	-	+	+	-

Augmented Reality on the Web



AR.js is one of the javascript libraries for web AR

https://ar-js-org.github.io/AR.js-Docs/

Virtual reality types

Types of Virtual Reality
[Virtual Reality (VR) Categories]

- Several categories of virtual reality technologies exist, with more likely to emerge as this technology progresses. The various types of virtual reality differ in their levels of immersion درجة الاندماج
- Below, we explore a few of the different categories of virtual reality:
  1. **Non-immersive simulations**
  2. **Semi-immersive simulations**
  3. **Fully-immersive simulations**

1. **Non-immersive simulations**

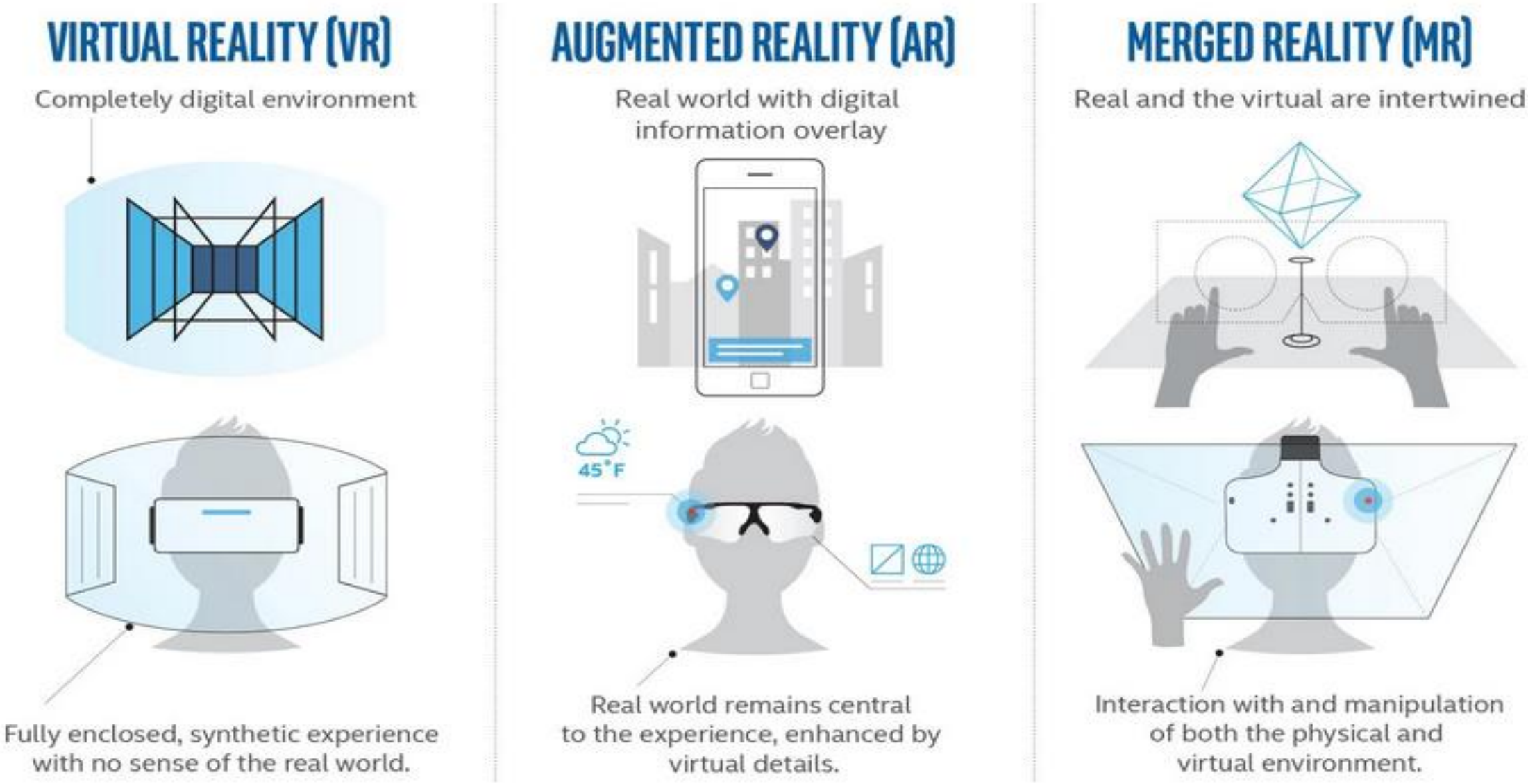
- **Non-immersive simulations**
  - The ***least*** immersive implementation of virtual reality technology.
  - In a non-immersive simulation, only a **subset** of the user's **senses** are stimulated, allowing for peripheral awareness of the reality outside the virtual reality simulation.
  - Users enter into these three-dimensional virtual environments through a **portal or window** by utilising standard high **resolution monitors** powered by processing power typically found on conventional desktop workstations.

2. **Semi-immersive simulations**

- **Semi-immersive simulations** provide a *more* immersive experience, in which the user is **partly** but not **fully immersed** in a virtual environment.
- Semi-immersive simulations are powered by **high performance graphical computing systems**, which are often then coupled with **large screen projector** systems or **multiple television projection** systems to properly stimulate the user's visuals.

3. **Fully-immersive simulations**

- **Fully-immersive simulations** provide the *most* immersive implementation of virtual reality technology. In a fully-immersive simulation, hardware such as **head-mounted displays** and **motion detecting devices** are used to stimulate all of a user's senses.
- Fully immersive simulations are able to provide very realistic user experiences by delivering a wide **field of view**, high **resolutions**, increased update rates (also called refresh rate), and high levels of contrast into a **user's head-mounted display (HMD).نظار الواقع الافتراضي**



Reality roadmap according to Intel, which prefers "merged reality" to mixed reality. (Courtesy ExtremeTech)

360 Video

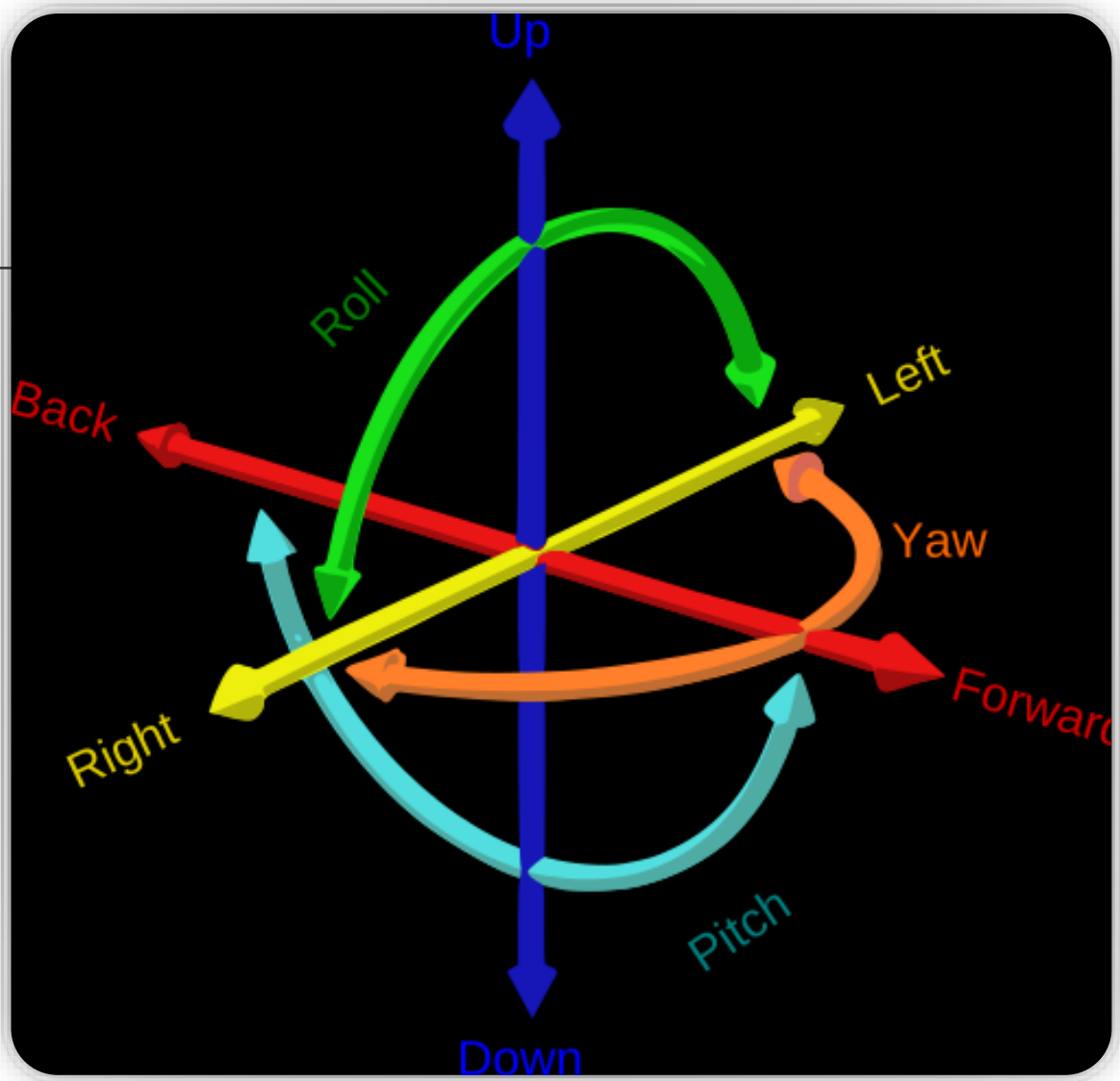
What is 360 Video?

Essentially, 360-degree photos or videos are visuals in which the view in every direction is captured and presented simultaneously.

https://pressbooks.library.torontomu.ca/360essentials/chapter/chapter-1

Degrees of freedom

Three degrees of freedom correspond to rotational movements around x, y and z axes, also referred to as “pitch, yaw and roll.” In other words, if you use a VR headset that offers **3DoF** (three degrees of freedom), you can look forwards and backwards, side to side and shoulder to shoulder (fig. 11)– basically wherever your head can rotate. You may be able to use your hand controllers to manipulate some objects or perform certain actions, but 3DoF VR essentially limits you to be tethered in one spot, why is why it’s often called **standing VR**.

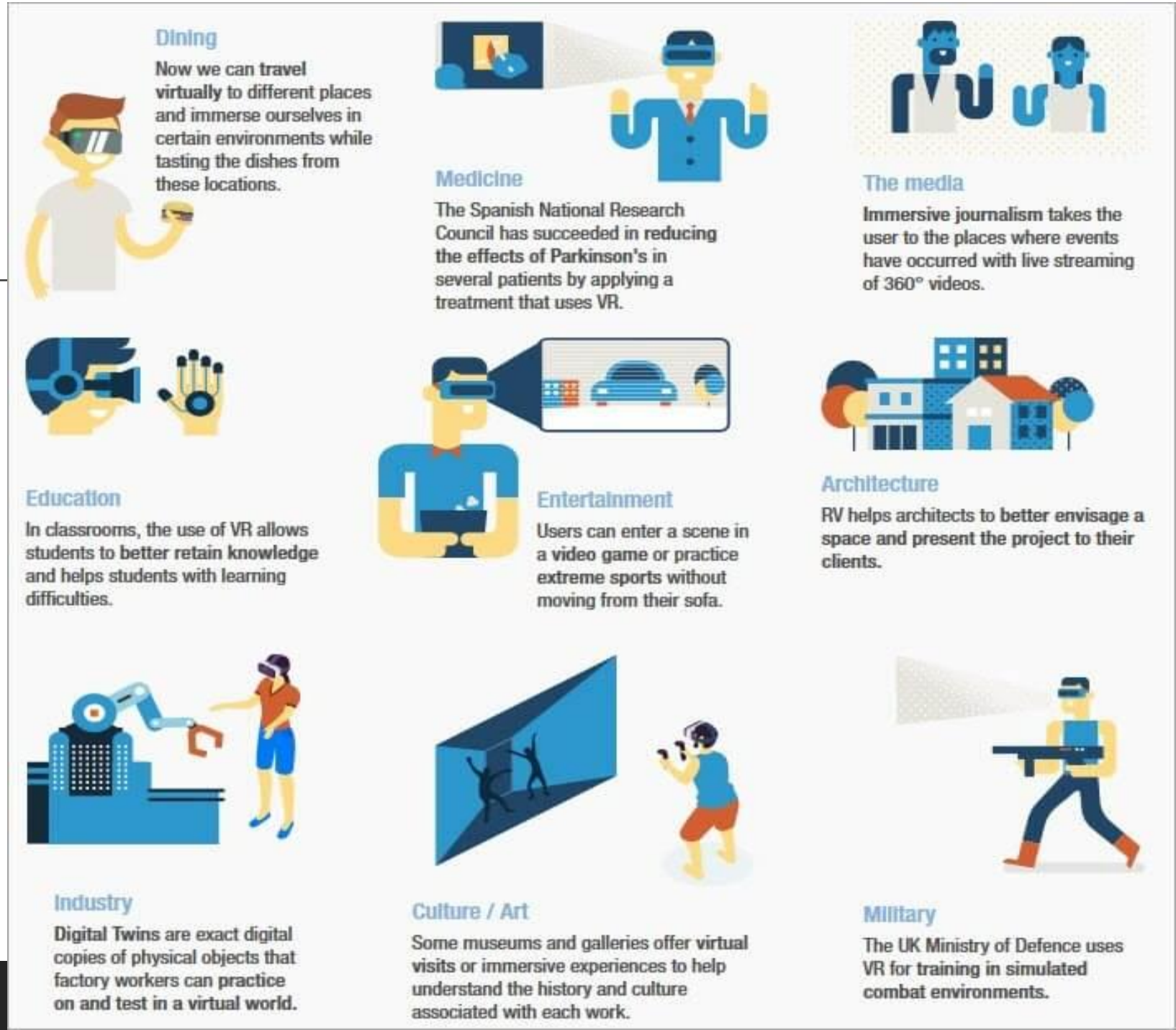


3DoF and 6DoF

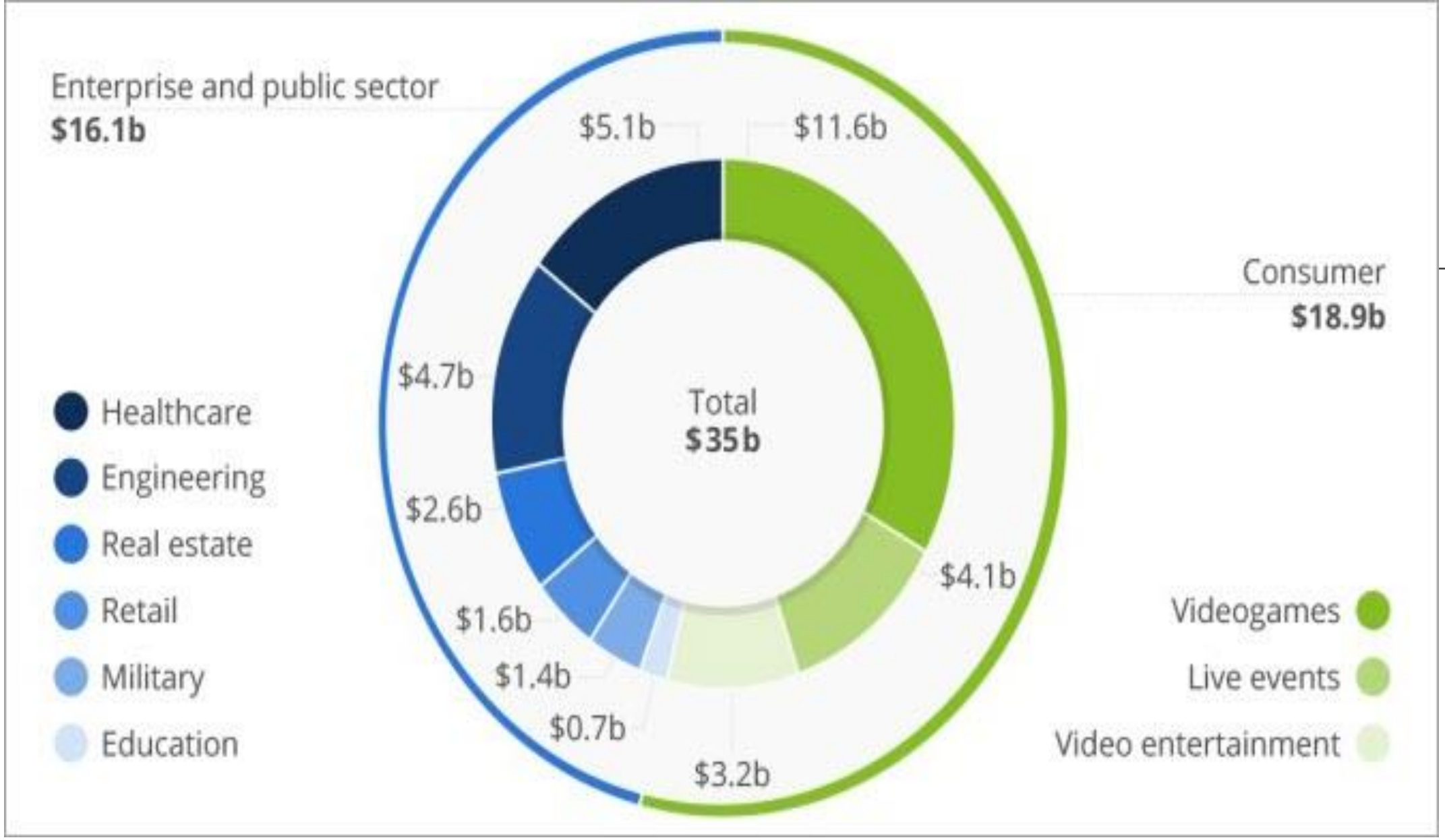
- **3DoF** refers to three degrees of freedom (ability to move (rotate) your head around while experiencing content).
- **6DoF** refers to six degrees of freedom (ability to move your head and body position while experiencing content).

Applications

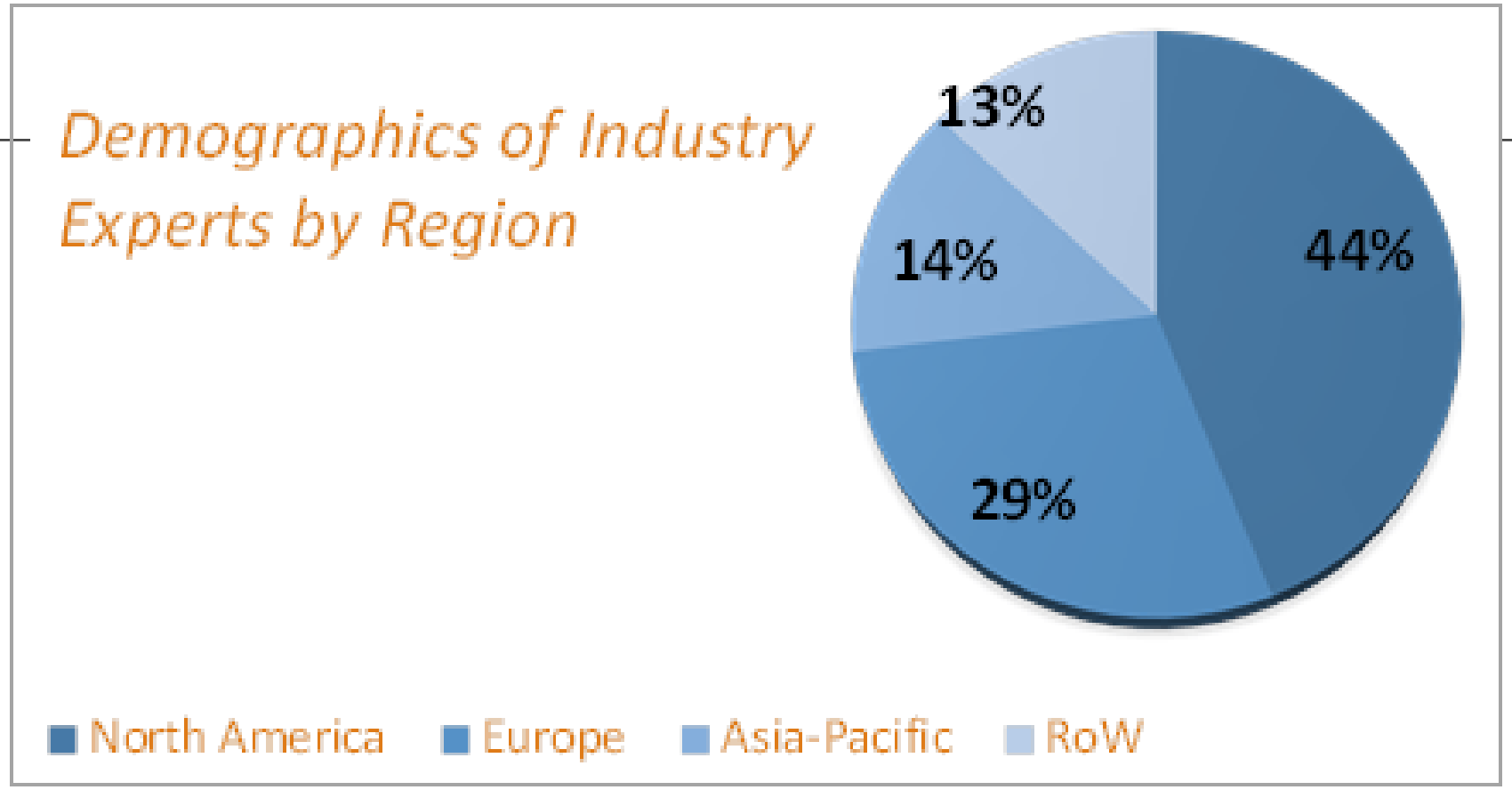
- Educational and training
- Medical and healthcare
- Art and tourism
- Marketing and sales
- Military and aerospace
- Social sciences and psychology
- Engineering and design



https://www.softwaretestinghelp.com/future-of-virtual-reality/



https://www.softwaretestinghelp.com/future-of-virtual-reality/



https://www.softwaretestinghelp.com/future-of-virtual-reality/

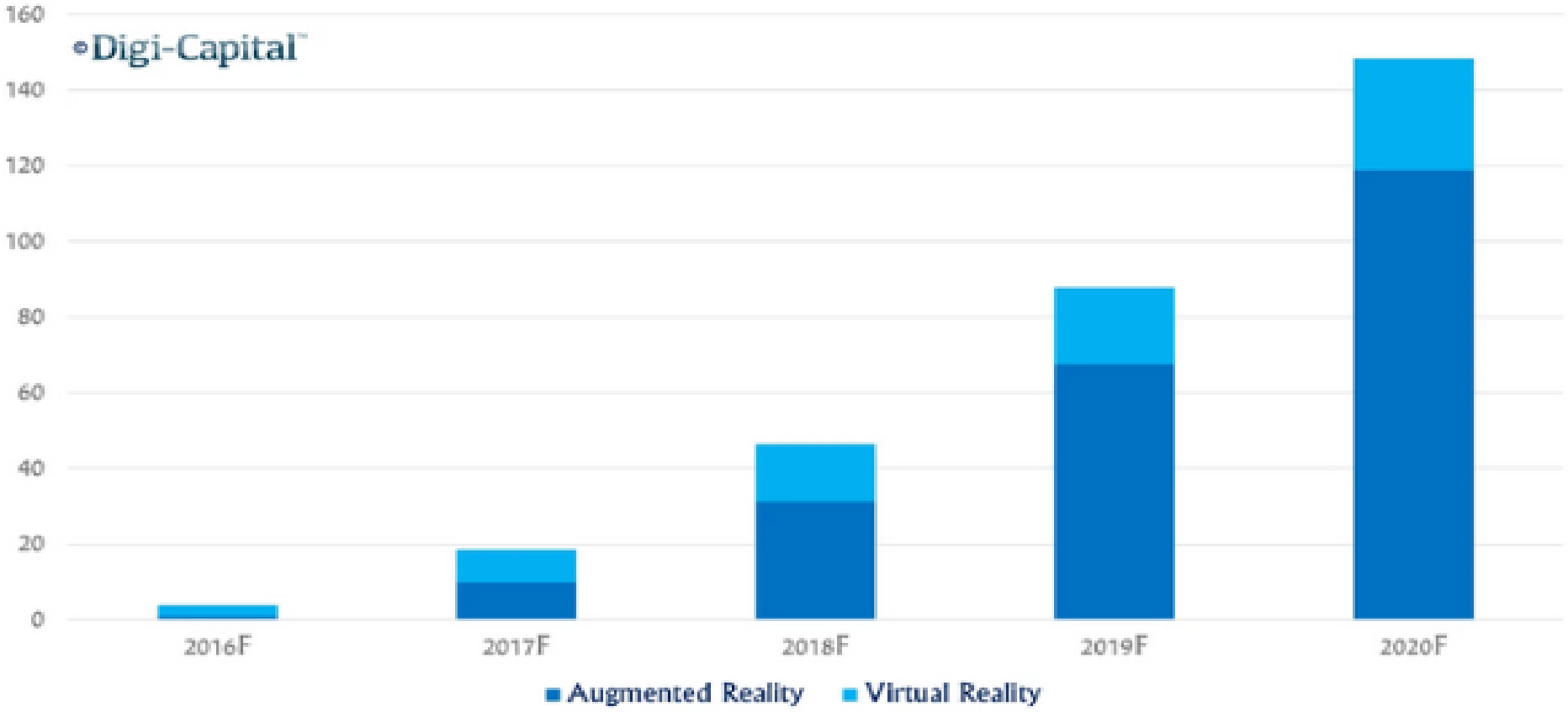
Virtual Fairs (Hyperfair.com example)

https://apkpure.com/hyperfair-enterprise-vr/com.Hyperfair.Mobile

VR applications

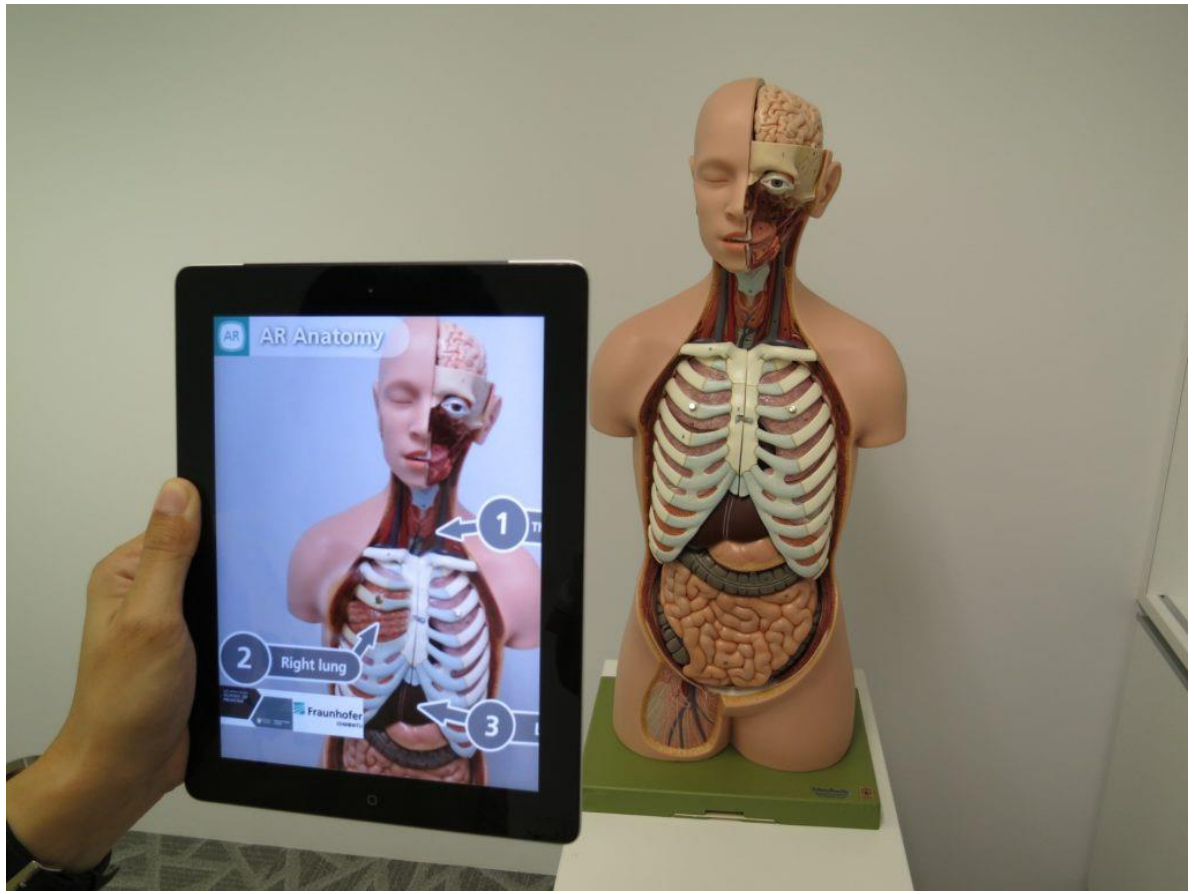
https://touchstoneresearch.com/the-top-10-companies-working-on-education-in-virtual-reality-and-augmented-reality-rebooted/

AR/VR market shares comparison



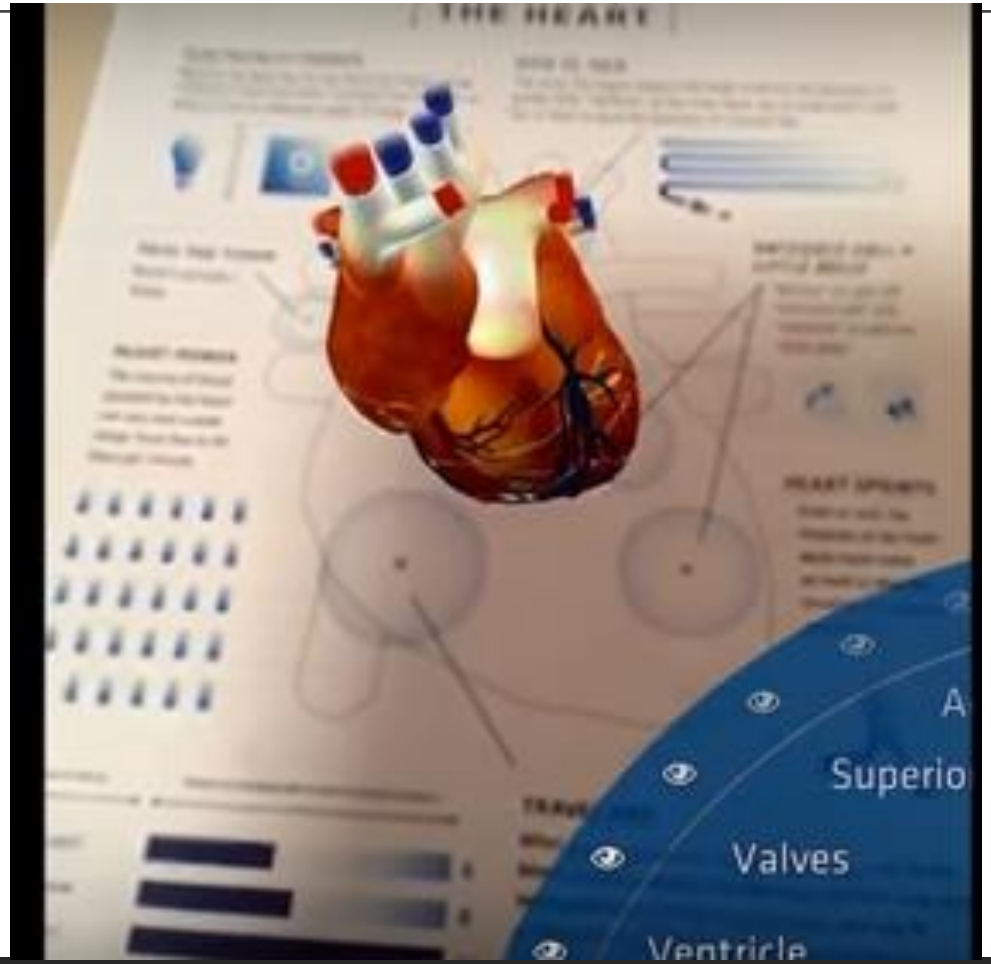
https://techcrunch.com/2015/04/06/augmented-and-virtual-reality-to-hit-150-billion-by-2020/

AR: Augmented Reality example



https://www.emergingedtech.com/2018/08/multiple-uses-of-augmented-reality-in-education/

AR example 2: Anatomy 4D



AR for home interior design

https://dmexco.com/stories/augmented-reality-in-marketing-8-current-examples-2/

AR in sports / shopping

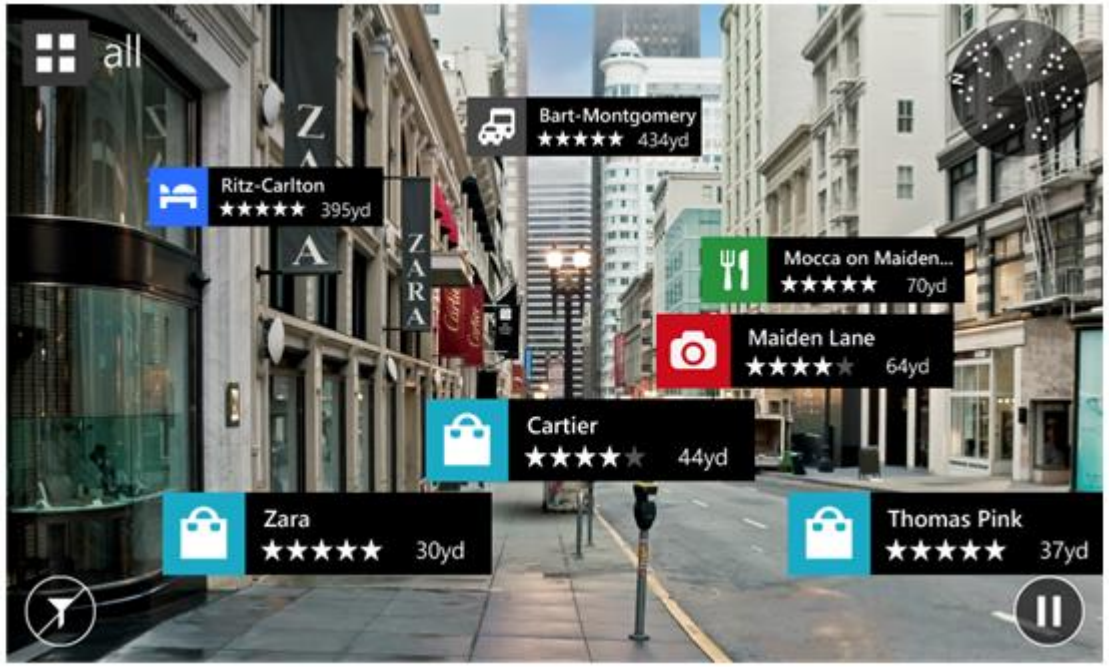
With AR fans will be able to get statistics and see the ball trajectory and its speed right at the stadium.

Imagine walking around the shop with a smartphone in your hands, and seeing the price and characteristics of the products, along with special offers and discounts for them.

https://www.information-age.com/12-hot-augmented-reality-ideas-for-your-business-123471817/

AR Landscaping/Tourism

you'll be able to place objects outside before you build anything there.



Showing more information from **maps** on camera. Also can be done in **museums**

https://www.information-age.com/12-hot-augmented-reality-ideas-for-your-business-123471817/

VR companies

https://www.toptal.com/designers/ui/augmented-reality-vs-virtual-reality-vs-mixed-reality

HMD (head-mounted display) types-1

1. physically connected to a computer by cables, such as HDMI and/or USB.

- Already own a powerful PC or have a big budget
- Require a truly immersive experience
- Examples:
  - Oculus Rift
  - HTC VIVE Pro
  - Sony PlayStation VR (PSVR)

HMD (head-mounted display) types-2

2-Standalone VR headsets (all-in-one HMDs):

standalone VR headsets have built-in processors, sensors, batteries, storage memory, and displays

they don't require a connection to a PC or a smartphone.

wireless,

users don't have to limit themselves to their living rooms

Examples:

- Oculus Quest 2
- Pico Neo
- HTC VIVE Focus
- Lenovo Mirage Solo

HMD (head-mounted display) types-3

3-Smartphone (Mobile) VR headsets

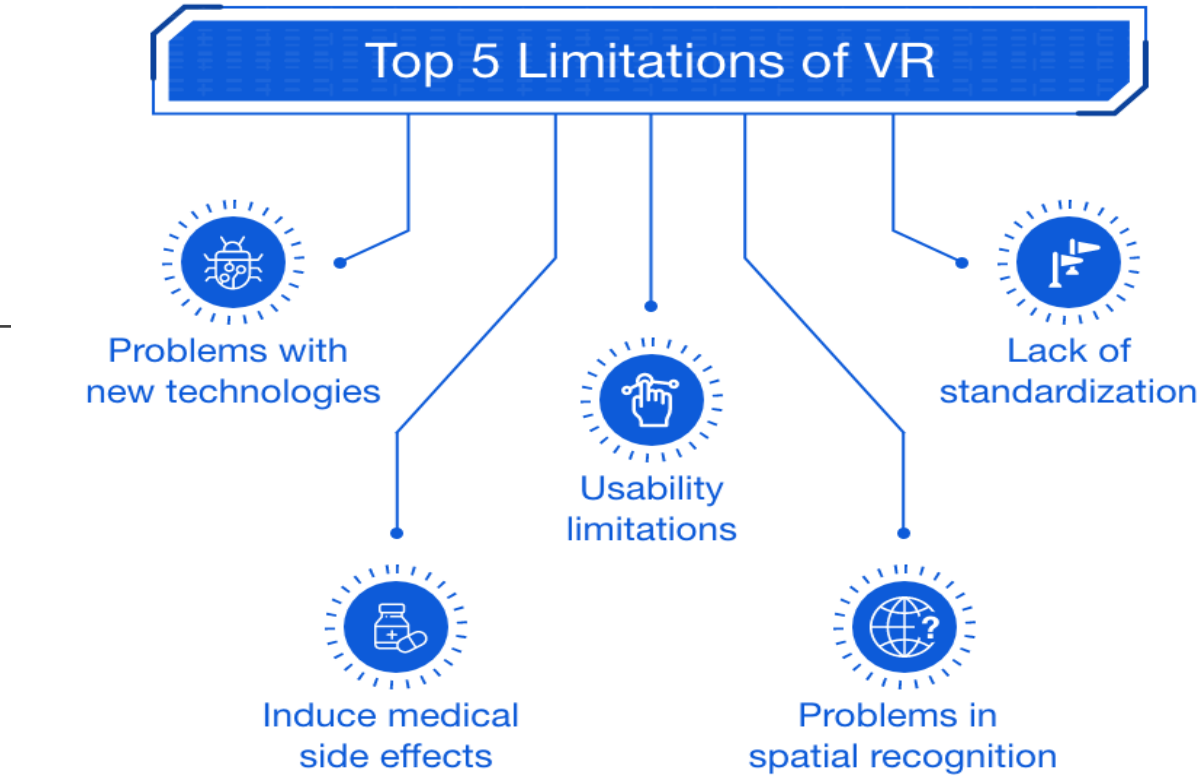
simply slide their smartphones into the headset

Examples:

- Samsung Gear VR
- Google Daydream View 2
- Google Cardboard

Challenges to VR

1. Cost of VR devices
2. Size of VR software :
   Application size is large in most cases
3. Locomotion Sickness
   VR successfully mimics the illusion of reality by placing it close to your visual space but it is also the exact thing that can break the illusion that VR is trying to create. The weight of VR devices
   Most VR devices are quite heavy and extended use can cause headaches and neck pain.
4. Lack of the vision of the surroundings
5. Potential Addiction
6. Graphical limits
7. Potential Eye Damage and Vergence conflict



https://www.appypie.com/virtual-reality-limitations

Mobile VR limitations

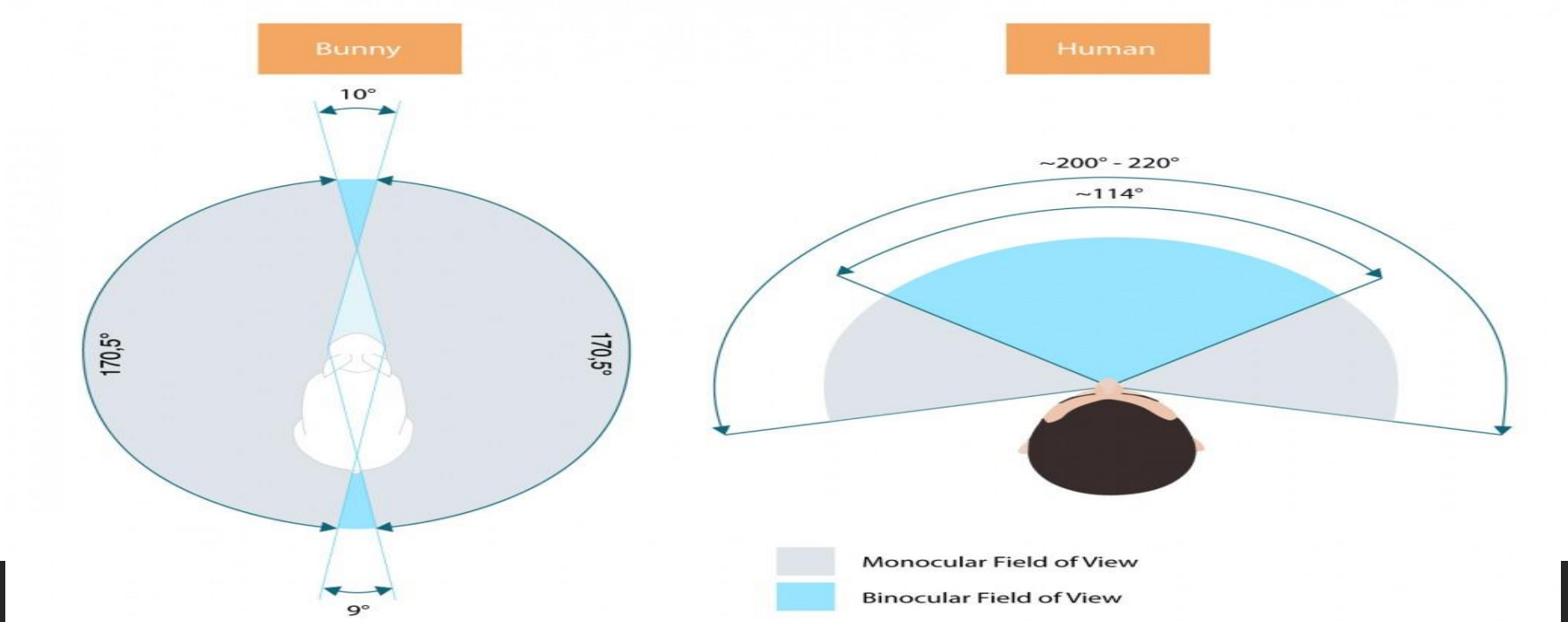
1. Limited power budget
2. Low latency
3. Audio and sensors

Read more: https://www.androidauthority.com/challenges-facing-mobile-vr-771609/

Concepts to Understand How Virtual Reality Headsets Work

1-Field of View

- Field of view, or the extent of the observable environment at any given time, is one of the more important aspects of virtual reality. The wider the field of view, the more present the user is likely to feel in the experience. There are two types of FOV that work together to form human vision.
- field of view refers to how wide the picture is. Field of view is measured based on the degree of display (e.g. 360°). Most high-end headsets make do with 100° or 110° field of view which is sufficient for most virtual reality content.



Concepts to Understand How Virtual Reality Headsets Work (2)

2-Frame Rate

- Frame rate refers to the frequency (rate) at which the display screen shows consecutive images, which are also called frames.
- Television shows run at 30 frames per second (fps) and some game consoles run at 60 frames per second (fps). In virtual reality, a minimum frame rate of approximately 60 frames per second is needed to avoid content stuttering or cause of simulation sickness.
- The Oculus Rift runs at 90 fps, providing Oculus Rift users with a very lifelike experience. Future Frame rates for virtual reality headsets are set to inevitably continue getting faster, providing for a more realistic experience.

Concepts to Understand How Virtual Reality Headsets Work (3)

3- Latency

- Latency refers to the amount of time it takes for an image displayed in a user's headset to catch up to their changing head position. Latency can also the thought of as a delay, and is measured in milliseconds (ms). In order for an experience to feel real, latency usually needs to be in the range of 20 milliseconds (ms) or less.
- **Low latency**, or very little delay, is **needed** to make the human brain accept the virtual environment as real.
- The **lower the latency, the better**.
- The higher the latency, a noticeable and unnatural **lag** may set in, consequently causing simulation sickness for the user.

4- Audio

- Virtual reality audio may not be as technically-complex as the visual components, however, it is an equally important component to stimulate a user's senses and achieve immersion.

Gaze Control

Gaze control, on the other hand, allows players to select an item from a menu or interact with the environment with minimal neck and head gestures.

التفاعل مع الأشياء الموجودة في المشهد عن طريقة حركة الرأس

Used a lot in Mobile VR headsets

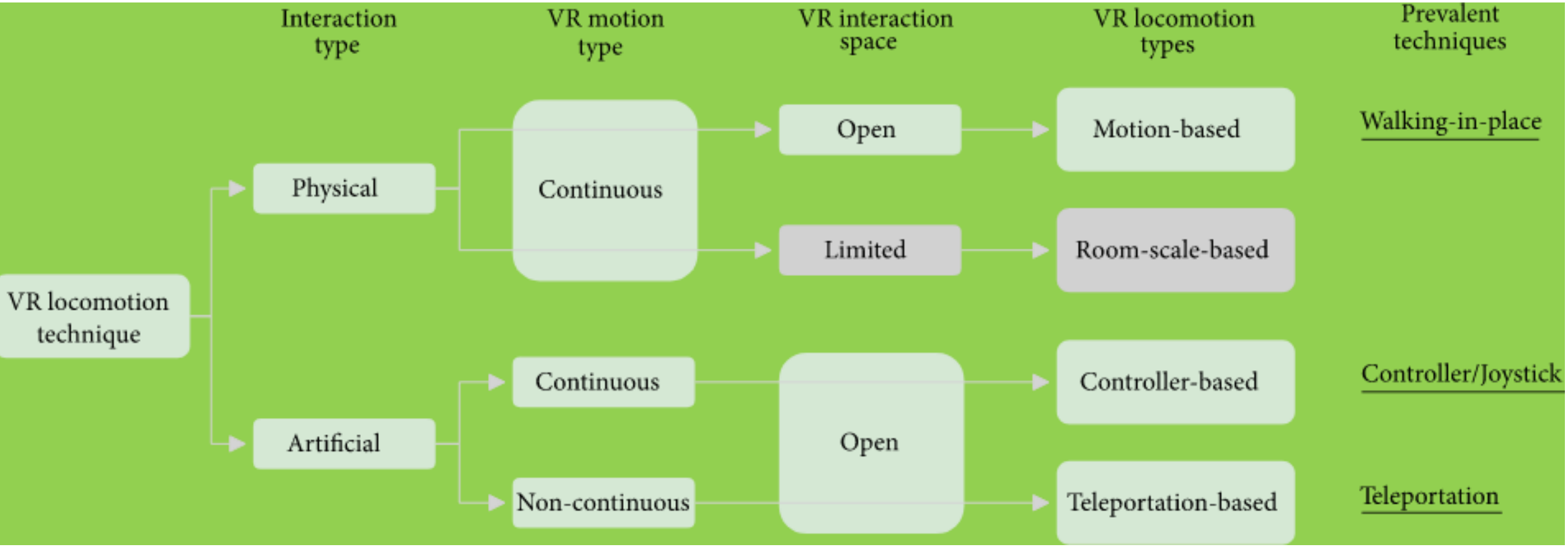
VR Locomotion
التحرك

By definition locomotion is the ability to move from one place to another in physical space.

The virtual reality locomotion is the technology that enables movement of the avatar or user (in this case you in first person) through the entire virtual world, using only a small real-world space. Locomotion is one of the pillars of great VR experience.

https://www.circuitstream.com/blog/vr-locomotion

VR Locomotion Techniques
للاطلاع فقط



1- Room-Scale Based Locomotion

This approach utilizes only the player's physical movement on the real-world space, and so, the applications must be designed around this constraint.

2- Motion-Based locomotion

This technique uses some external sensors, that for now aren't included with the major headsets, to detect some kind of physical movement, and translate it into VR movement.

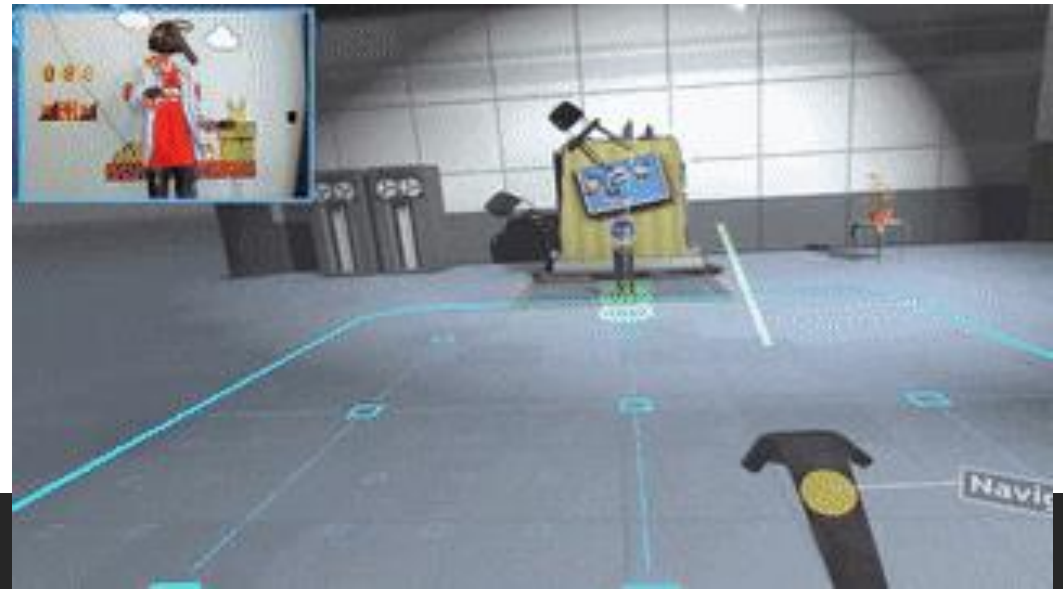
3- Teleportation Based locomotion
انتقال لحظي (فجأة)

This is the only non-continuous locomotion technique, meaning when the player teleports, they are instantaneously repositioned to the target location, with no in-betweens. The target location is selected by the player by aiming with the controller, and sometimes they can also select a facing direction for the teleport.

4- Blink locomotion

In this variation, upon selecting the target position, the player view fades out اعتام المشهد, they are relocated in the virtual world, and finally, the vision fades back in. Almost as if the player blinked and voilà! They are in a new location.

Blink Locomotion is The Most used technique



5-Dash
انتقال بسرعة عالية وليس فجأة

Although The blink locomotion is by far the most used, but it can hinder the player immersion, and for that, there is the dash variation. In this version, instead of blinking into a different location, the player is rushed there at super speed.

Virtual Reality Sickness

اعياء (تعب) بسبب عدم تناسب طريقة العرض مع الحركة الفعلية

Virtual reality sickness, also known as simulator sickness or cybersickness, is hypothesized to be due to a sensory conflict between what your eyes see and how your brain interprets it, versus what your body is doing.

Possible causes:

- lower resolution
- lower framerate
- Movement speed
- Long simulation duration

VR sdk Comparison (1) https://thinkmobiles.com/blog/best-vr-sdk/

Product	HTC Vive	Sony PlayStation VR	Oculus Rift	Samsung Gear VR	Google Daydream View	Google Cardboard
Headset type	PC	Console	PC	Mobile	Mobile	Mobile
Connections	HDMI, USB 3.0	HDMI, USB 2.0	USB 3.0	USB 2.0, USB 3.0	None	None
Resolution (per eye)	1080×1200	960×1080	1080×1200	Native to phone	Native to phone	Native to phone
Field of view	110°	100°	110°	101°	100°	90°
Refresh rate (Hz)	90	120	90	Native to phone	Native to phone	Native to phone
Sensors	Motion, camera, external motion tracking	Motion, external visual positioning	Motion, external visual positioning	Motion	Motion	Motion
Controls	HTC Vive motion controllers	DualShock 4, PlayStation Move	Oculus Touch, Xbox One gamepad	Handheld remote, touchpad on headset	Handheld remote	Handheld remote

Headset comparison

	Google Cardboard 2.0	Oculus Rift	HTC Vive	Samsung HMD Odyssey (WMR)	HoloLens
					
Company name	Google	Facebook	HTC	Samsung	Microsoft
Initial cost	$15	$399	$499	$499	$3,000
Type	With Mobile Phone	Headset with a PC	Headset with a PC	Headset with a PC	Standalone
Platform	Android, iOS	Oculus Home	SteamVR, VivePort	Windows Mixed Reality	Windows 10
Resolution	Smartphone Resolution	2160 x 1200	2160 x 1200	2880 x 1600	1268x720
Display type	Smartphone Display	OLED	OLED	AMOLED	See-through holographic lenses
Field of view	90°	110 °	110 °	110°	35°
Sense of immersion	Medium	Medium-High	Medium-High	Medium-High	Low
Multiple concurrent users	No	Yes	Yes	Yes	Yes
Controller	Magnet	Oculus Touch, Xbox One	Vive controller, PC compatible gamepad	Samsung HMD Odyssey	Gaze, Gesture, Voice
Head tracking	No (Stereo Panorama)	Outside-In Tracking	Outside-In Tracking	Inside-Out Tracking	Inside-Out Tracking
Primary input device	No	Controllers	Controllers	Controllers	Gaze & Gesture
Portability and setup	Easy	Medium	Hard	Medium	Easy

https://www.sitepoint.com/there-are-more-virtual-reality-headsets-than-you-realize/

Tools

Unity

Unreal Engine

ARCore

ARKit

Vuforia

Learning Resource

https://learn.unity.com/course/create-with-vr

Udemy.com

Udacity.com

Coursera.com

Youtube.com

Google….etc

THANKS