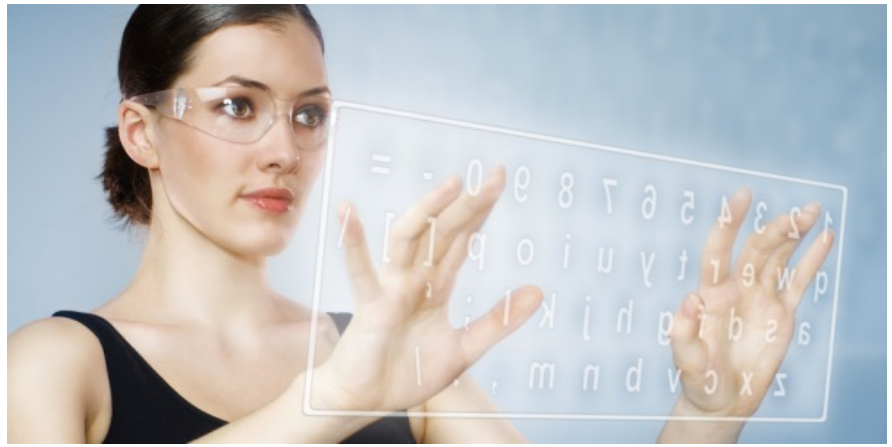

Virtual and Augmented Reality

Introduction to VR and AR

Jordi Linares Pellicer

Juan Jesús Izquierdo Doménech

Jorge Orta López

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Classical interaction paradigms

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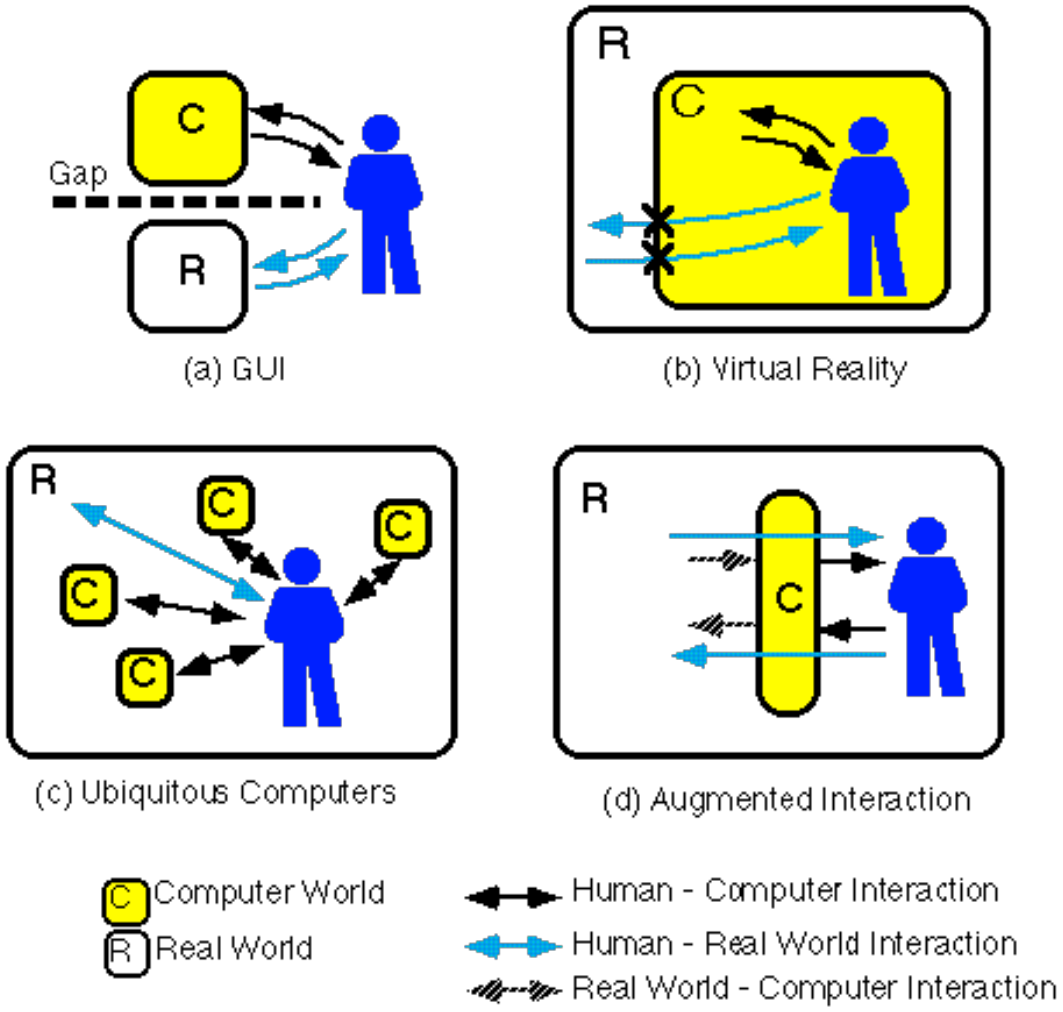
Classical human-computer interaction paradigms



Basic concepts: Augmented Reality

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In 1997 AR pioneer **Ronald Azuma** succinctly explained "AR allows the user to see the real world with virtual objects superimposed or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it."

Azuma's definition states that **AR systems have the following three characteristics**:

- Combines real and virtual
- Interactive in real time
- Registered in three dimensions (3-D)

Registration, the third characteristic, is about seamlessly aligning virtual objects into 3-D space in the real world. Without an accurate registration, the illusion of virtual objects existing in the physical world is compromised; the believability is broken.

Mixed Reality

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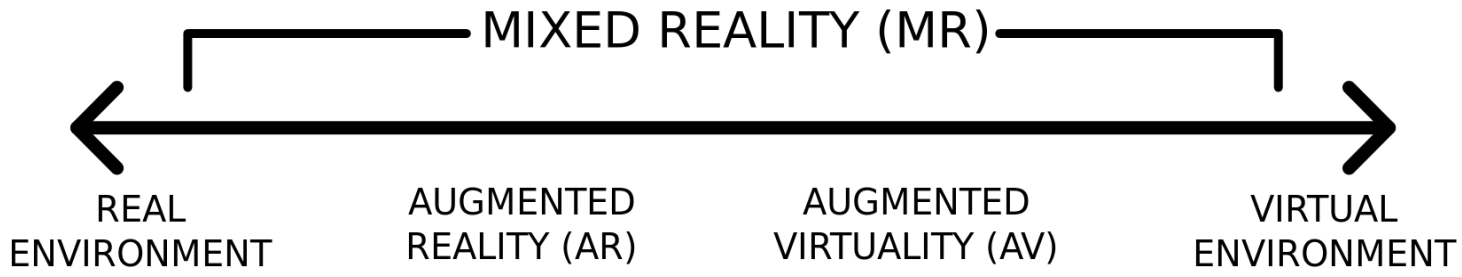
The merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time (**Milgram & Kishino 1994**)



Mediated Reality

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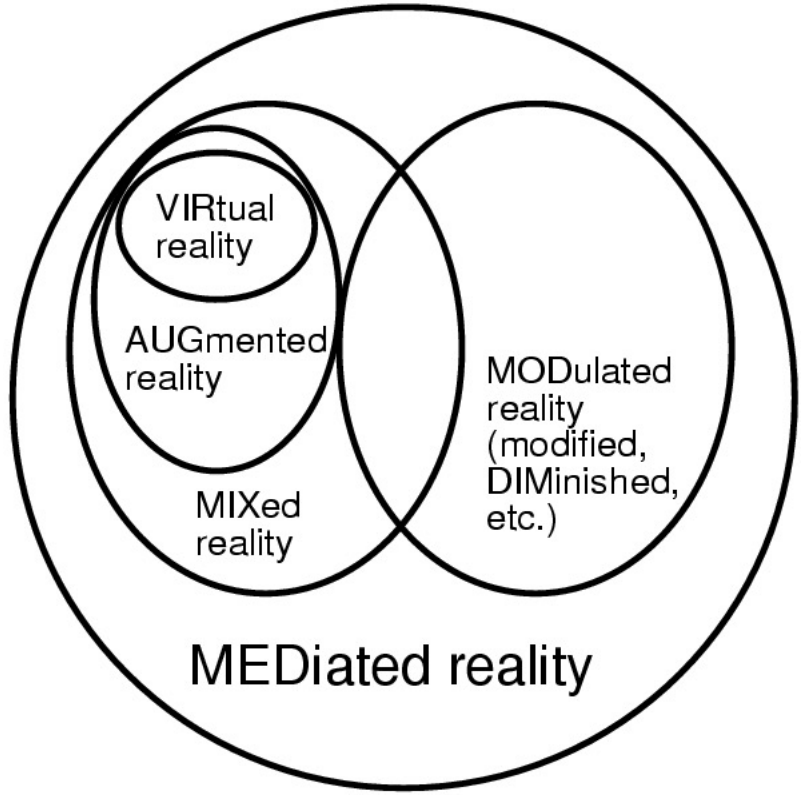
Mediated reality

-The ability to add to, subtract information from, or otherwise manipulate one's perception of reality through the use of a wearable computer or hand-held device

- Steve Mann, as a "general framework

for artificial modification of human perception by way of devices for augmenting, deliberately diminishing, and more generally, for otherwise altering sensory input."



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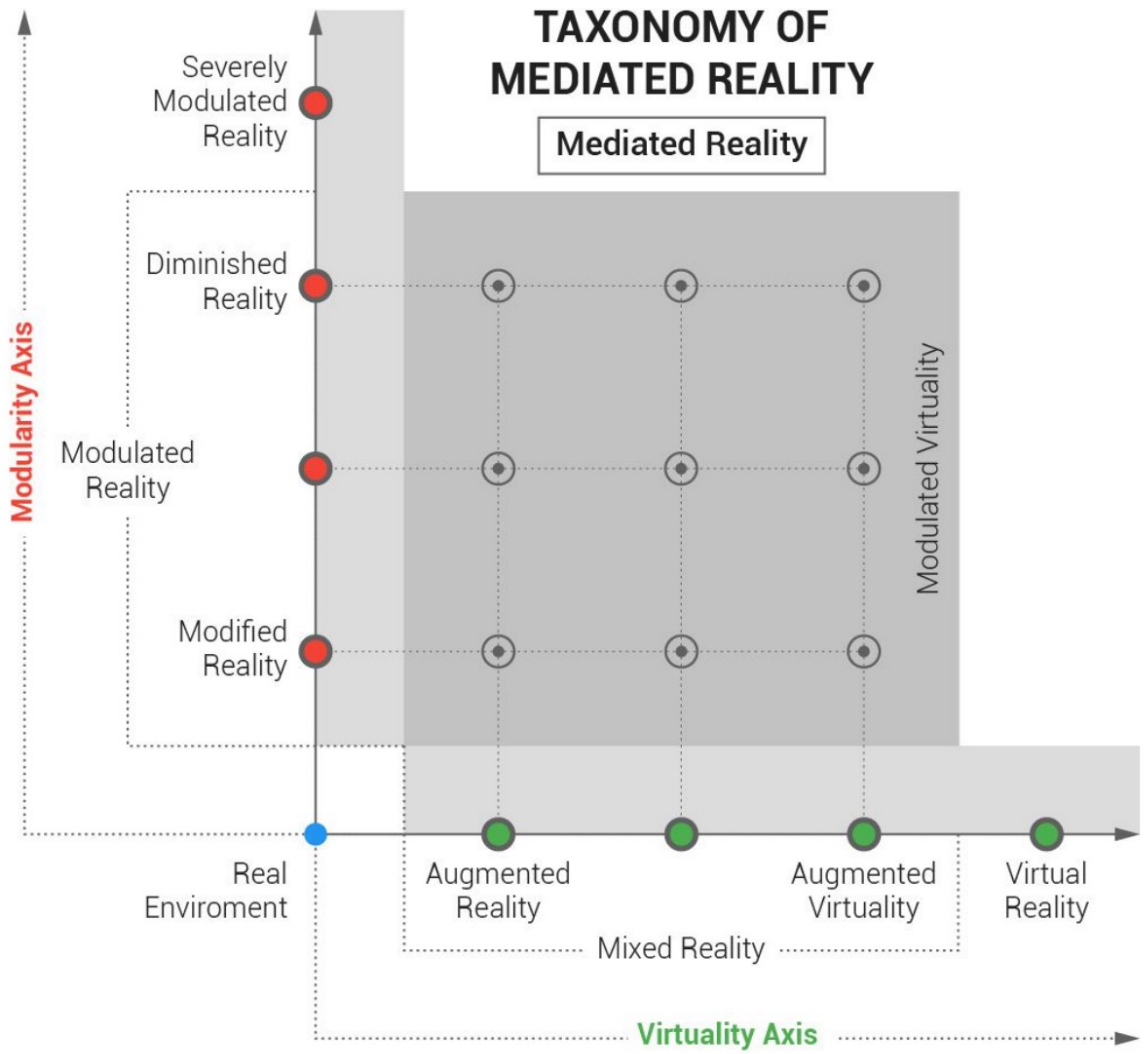
Mediated reality



VR vs AR

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Focusing on VR and VR:

"VR replaces your experience, AR amplifies it"

Virtual/Augmented Reality near future

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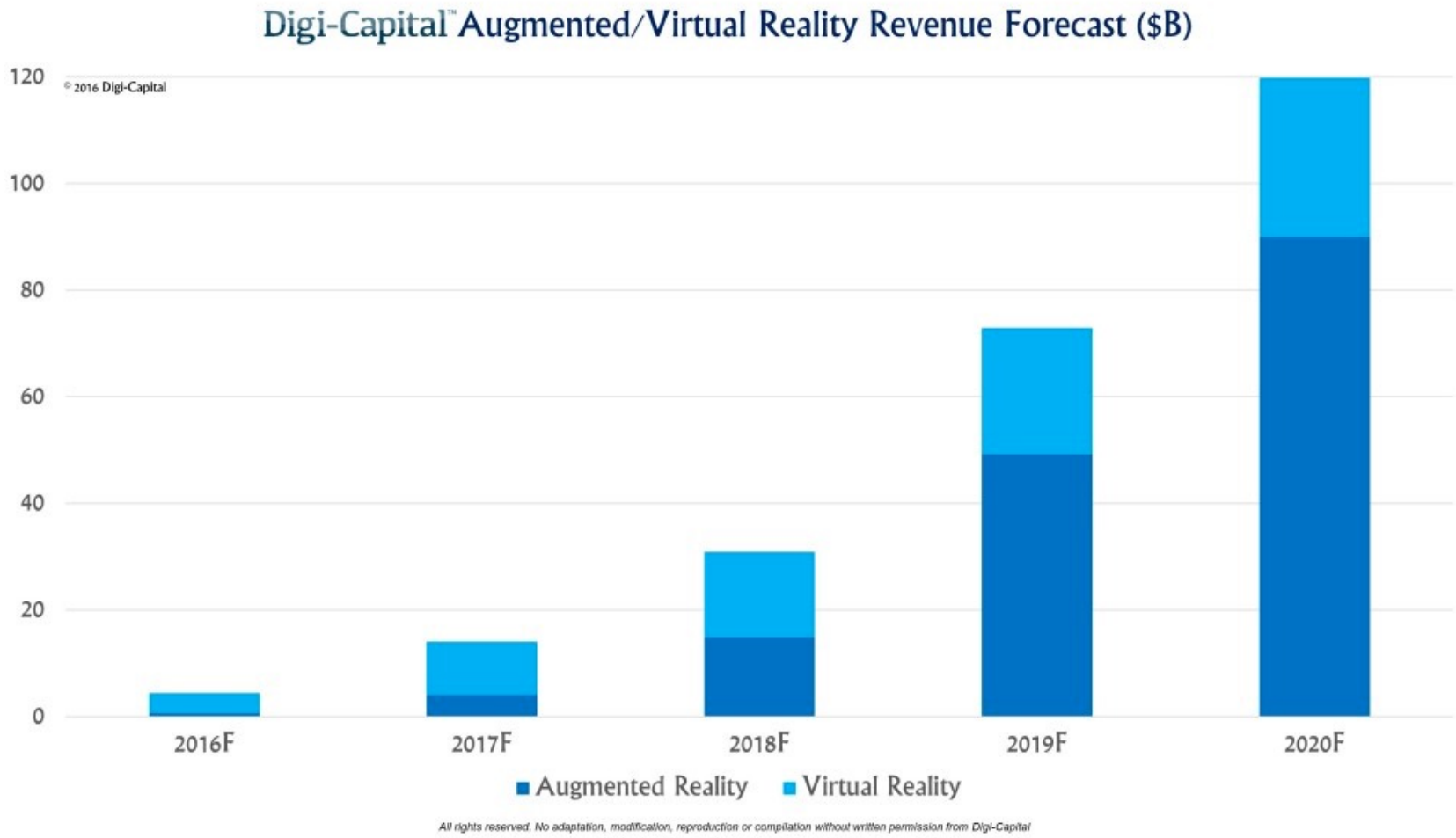

Virtual/Augmented Reality near future

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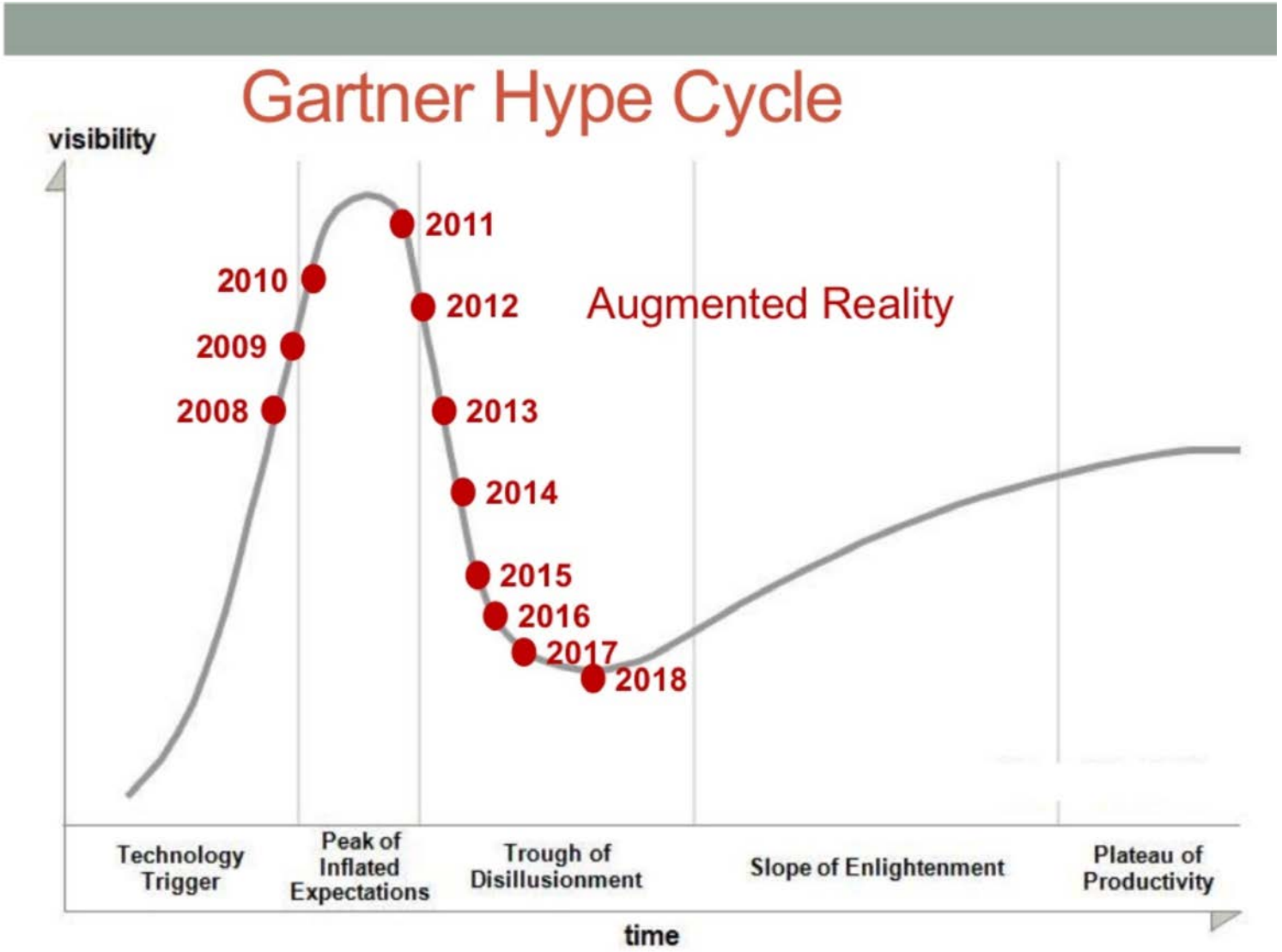

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Immersive, interactive experience generated by a device

HMD + walk platform

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Is it 360º video real Virtual Reality ?

Oxford dictionary definition: "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"

For many, not really, because:

- 360º video and photos can be considered immerse multimedia content, since they have no interaction (or very limited)
- Real VR means you can move around, and interact with scene elements, with implies that you have to model, animate and render the scenes (that's why we need so much performance)

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Is it 360º video real Virtual Reality ?

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Hey !!!! Mono spherical VR is not the same of Stereo 3D VR !!

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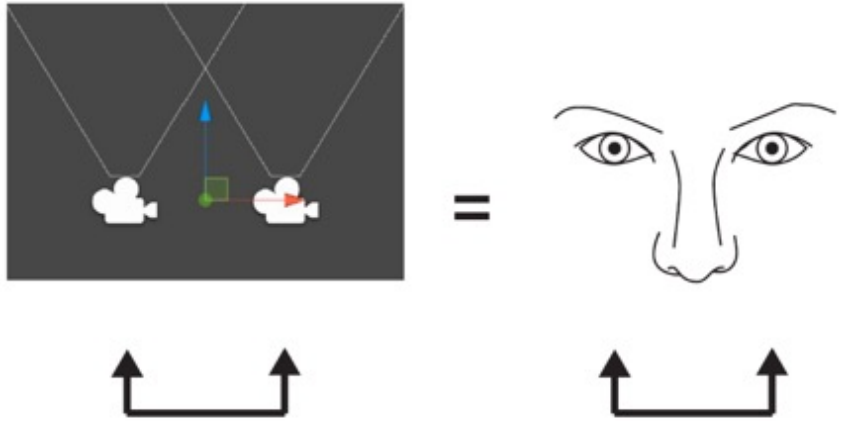
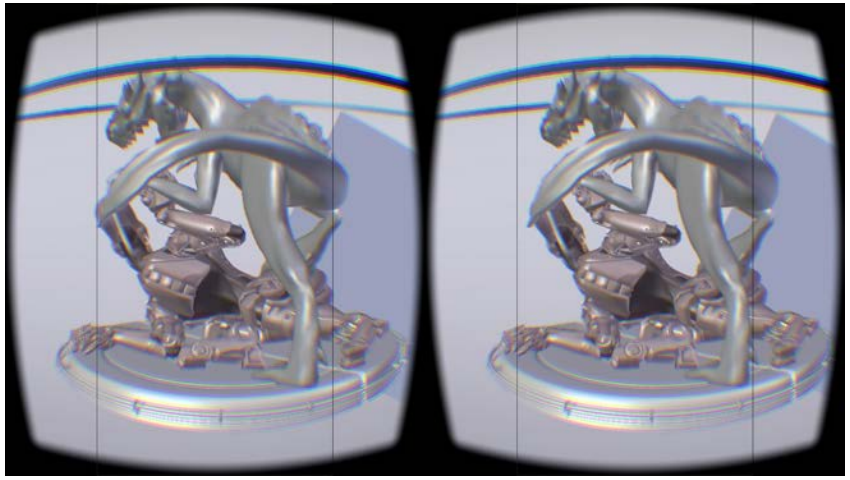
Stereo vision is produced by generating an image per eye





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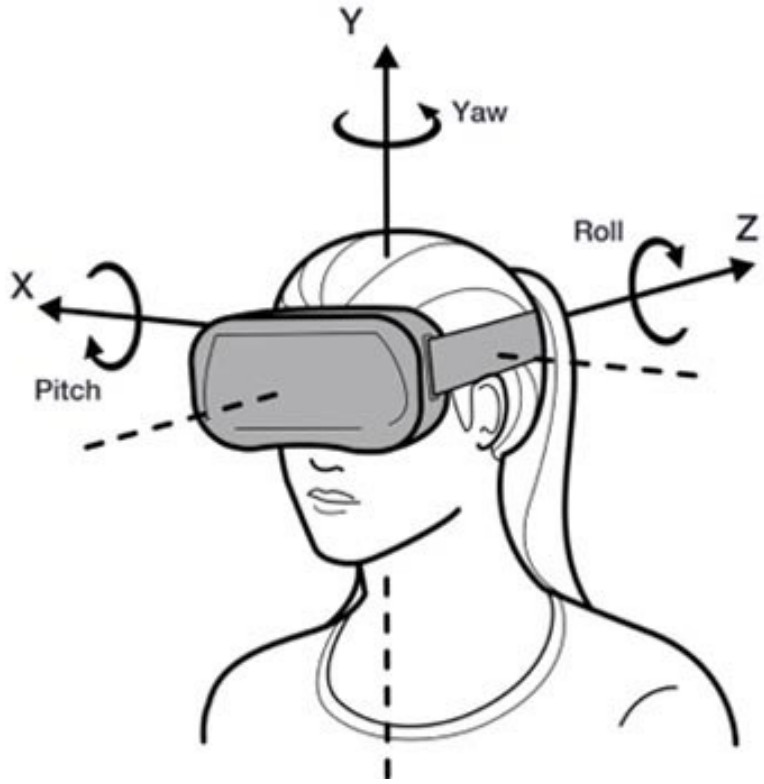
In an AR or VR application it is interesting to have, if we can, 6 degrees-of-freedom (6DoF):

- Where the user is (3 degrees)
  - Several possibilities, with additional devices in the space or with the use of cameras and vision techniques (inside-out tracking such as Oculus Quest)
- Where is he/she looking at (3 degrees)
  - Using generally the IMU (Accelerometers, gyroscopes and magnetometer)



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3 degrees of freedom (3-DoF)

6 degrees of freedom (6-DoF)

In AR/VR we get the best experience if, somehow, we can have 6DoF

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The very first desktop solutions:

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Oculus Rift (the very first successful one)

Oculus has a proximity camera

Oculus Touch

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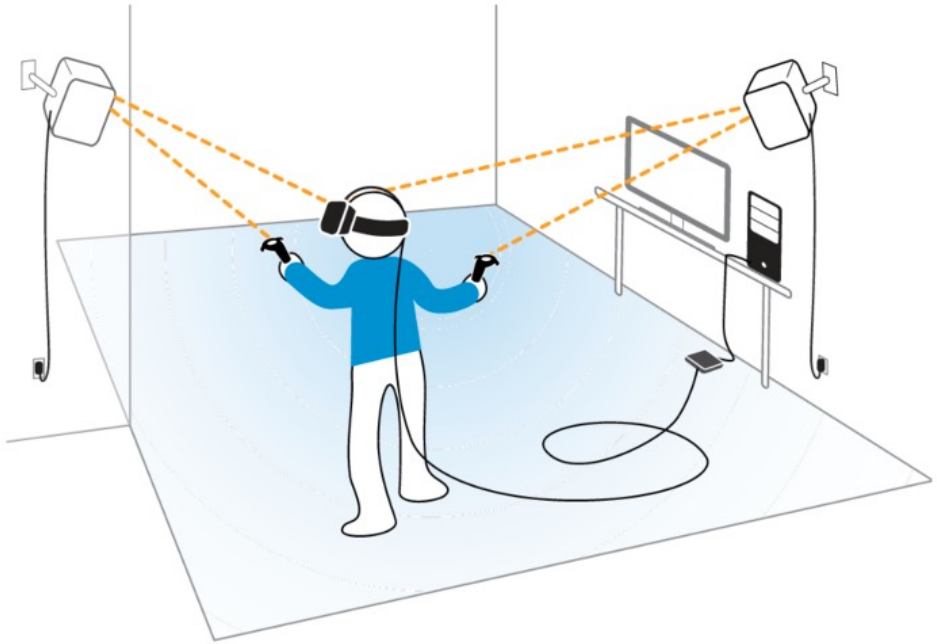
HTC Vive (with Room Scale VR) or tracking with external devices:



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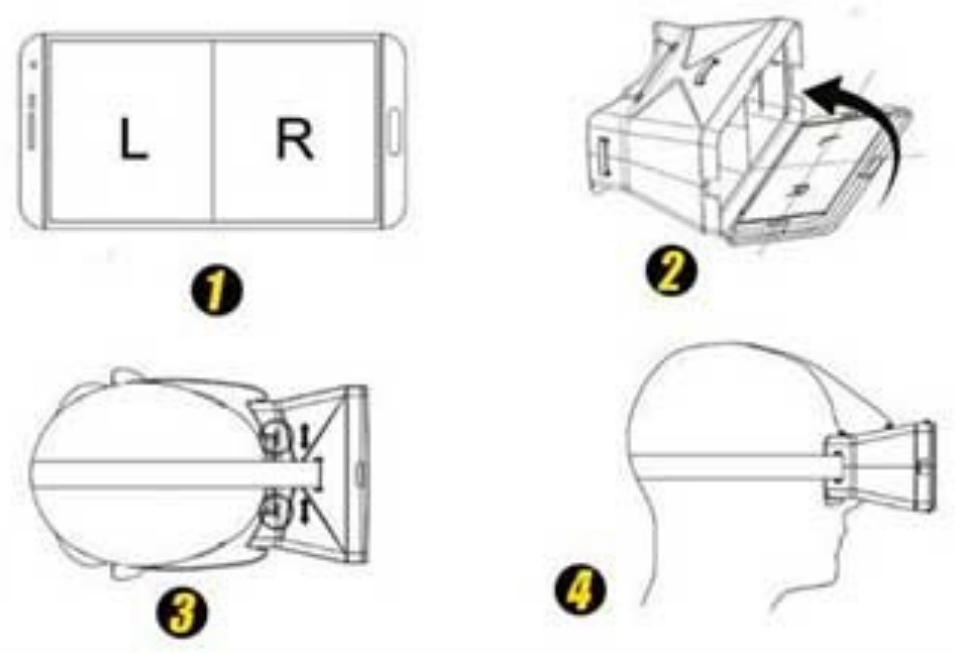
Google Carboard make VR very popular:



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Google Carboard make VR very popular:

Google Cardboard

Google Daydream (discontinued)

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Samsung Gear VR (additional hardware)

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Standalone devices – Oculus Go (not available now)

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Oculus Quest (and 2)

The foundation of Oculus Insight's **inside-out tracking** is simultaneous localization and mapping, or SLAM, which uses computer vision CV algorithms to essentially fuse incoming data from multiple sensors in order to fix the position of an object within a constantly updated digital map

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Some complements

Leap Motion

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Some complements

Manus VR

Virtuix Omni

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Some complements

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Augmented Reality (AR) is a real-time direct or indirect view of a physical real world environment that is enhanced or augmented by adding virtual computer-generated information to it.

Augmented Reality - Definition

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An AR solution (following Azuma's definition):

- combines real and virtual objects in a real environment
- aligns real and virtual objects with each other so that as the view to a real object changes, the augmented object connected to it changes accordingly -> registered in 3D
- runs interactively, in three dimensions, and in real time

So, AR requires:

- Position and orientation of the user (as with VR)
- Environment awareness

Augmented Reality – Environment awareness

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Environment awareness is important when it comes to placing object (holograms) in the virtual world – don't ruin the illusion

The most effective way for environment awareness is environment 3D scanning (Microsoft Hololens, Magic Leap) and computer vision (e.g. face recognition)

Augmented Reality – Main approaches

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Currently we have 2 approaches to AR:

- Video see-through (e.g. by using a mobile device)
- Optical see-through (Hololens, Magic Leap)

Environment awareness can be solved:

- 3D scanning (Hololens)
- Optical (vision-based) AR (by using a marker or SLAM)
- Geographical (sensor-based) AR (GPS + accelerometers + magnetometer)

Common ways today with a mobile device

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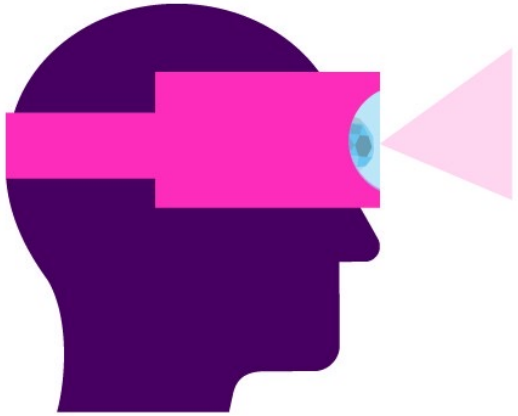
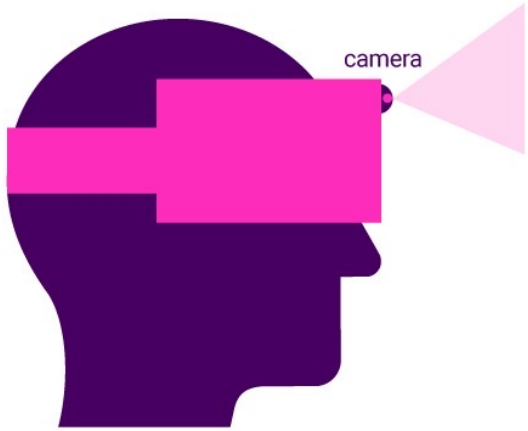


Optical see through displays



Video see through displays

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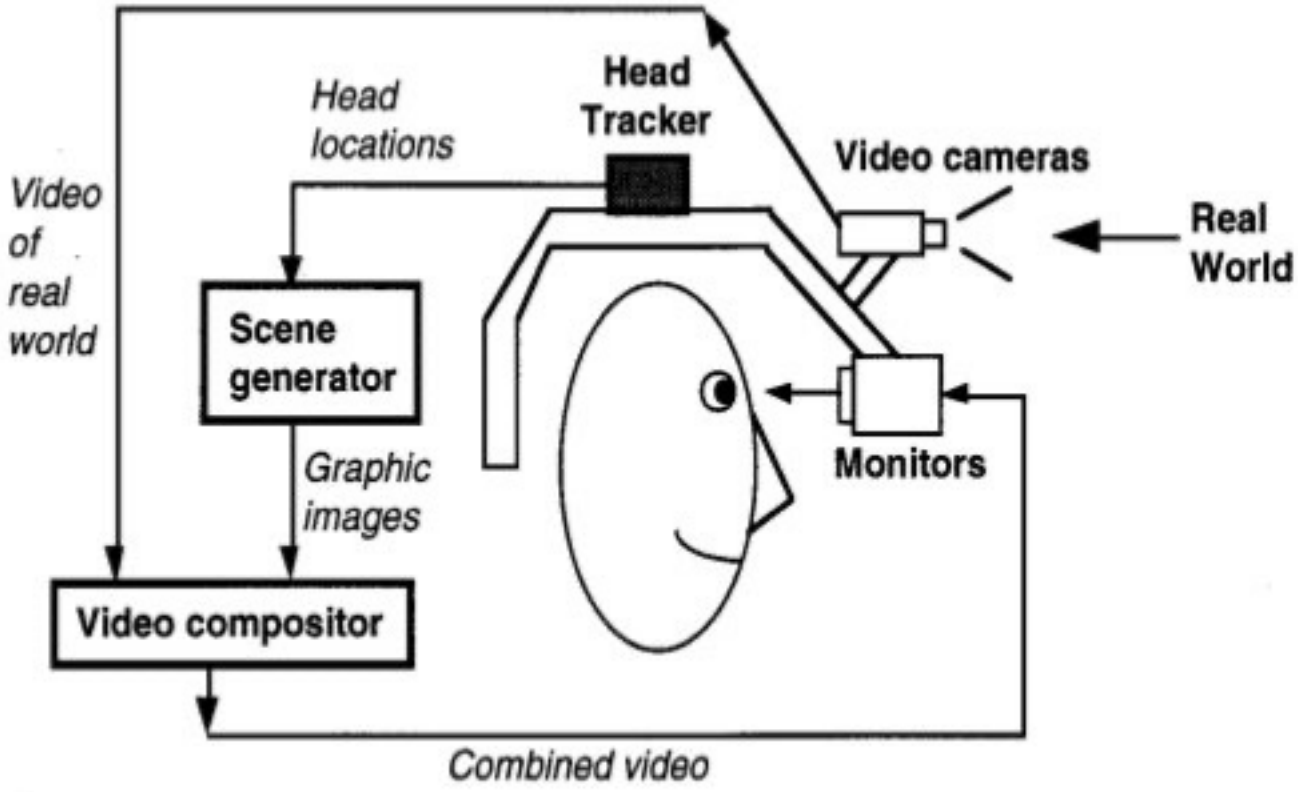
Video see-through



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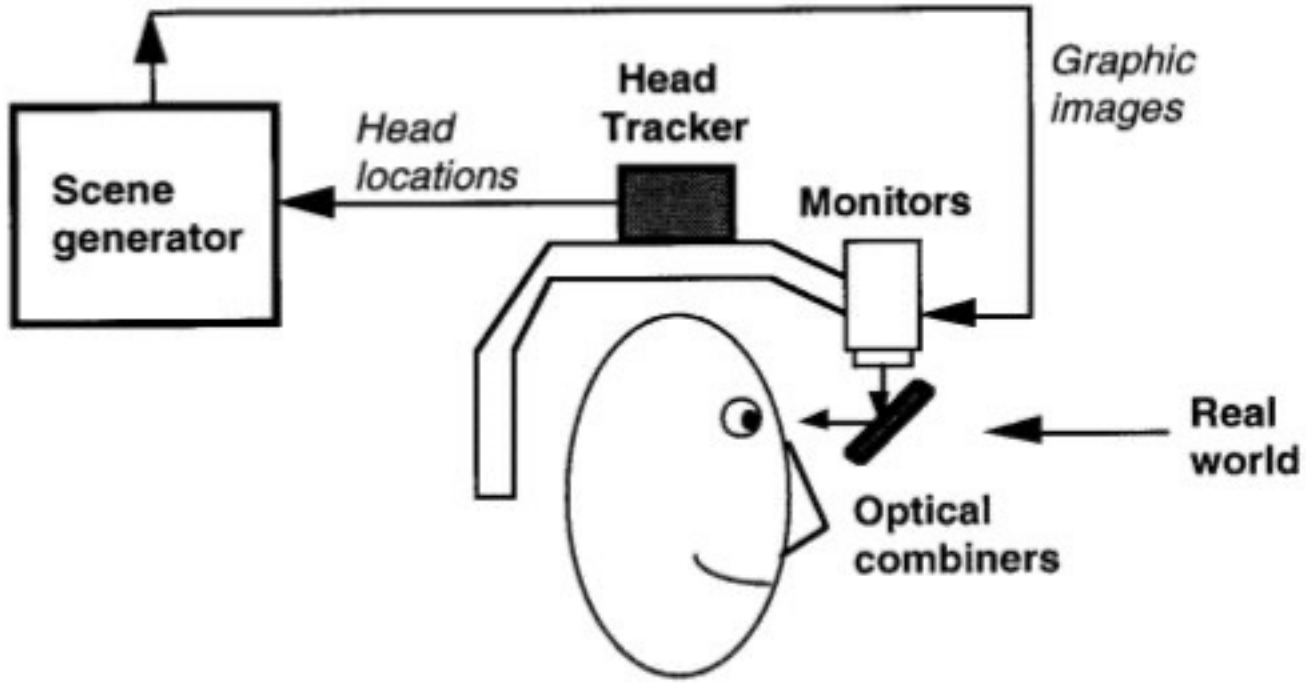
Optical see-through



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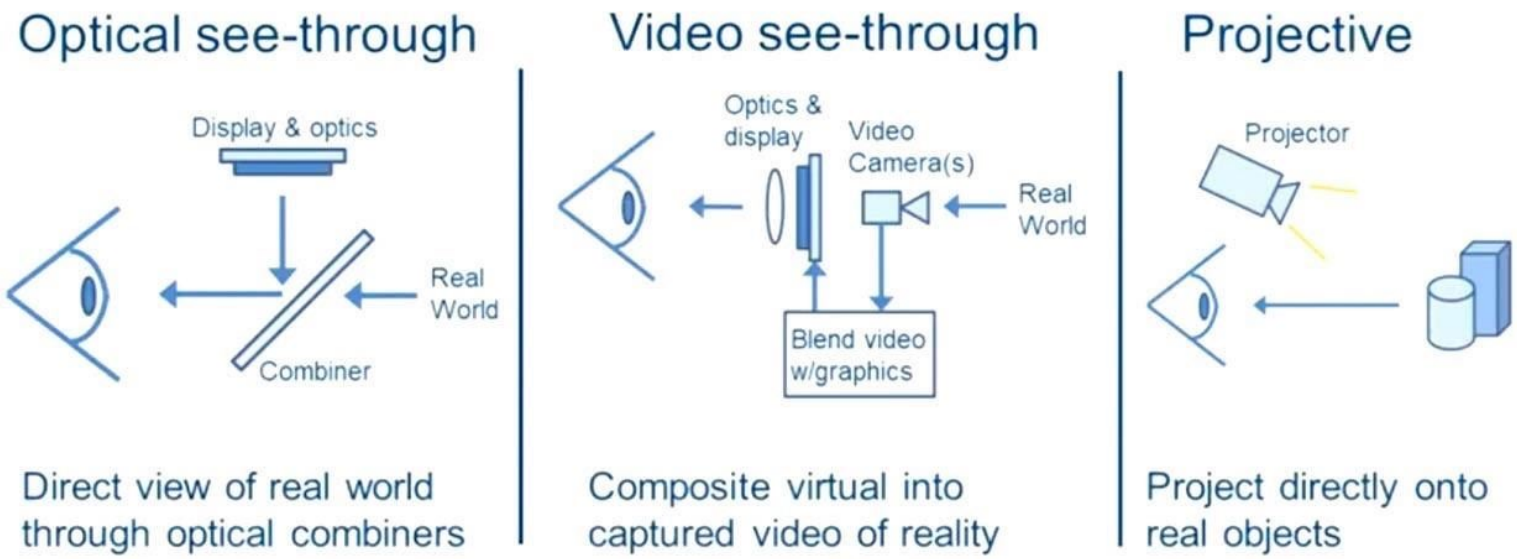

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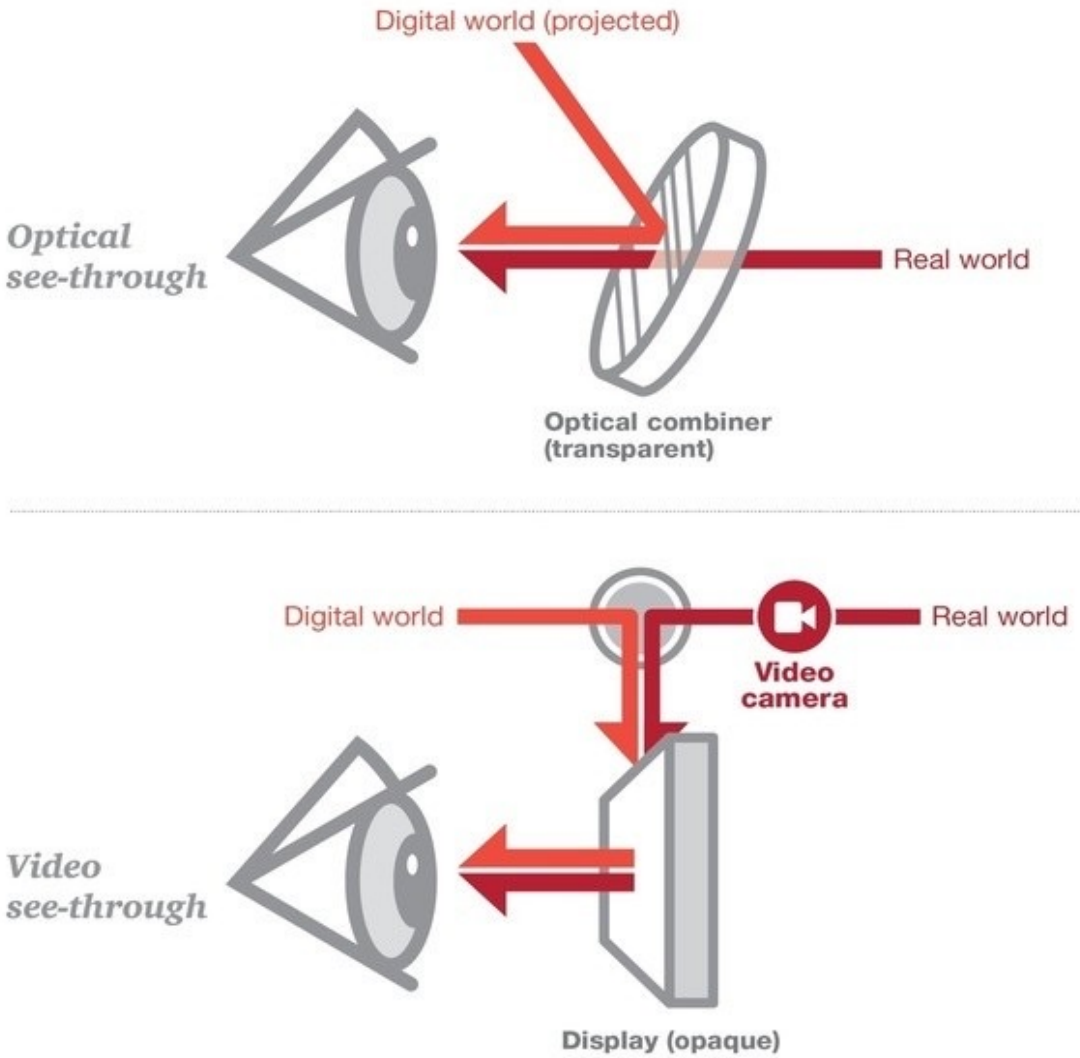

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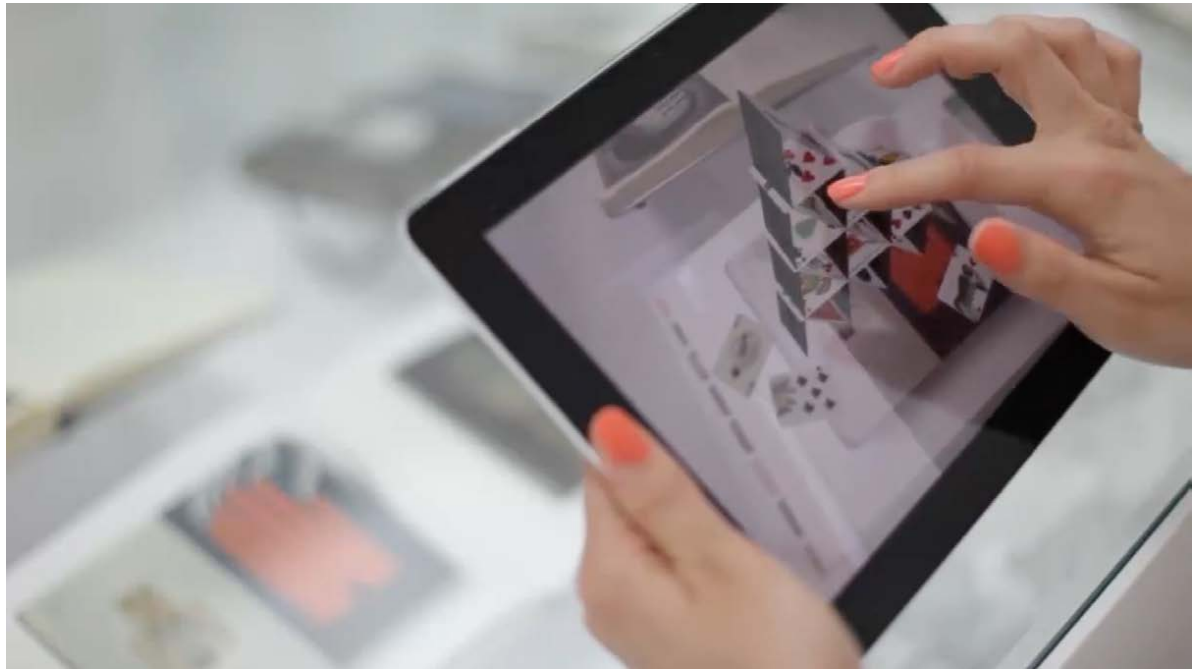
Optical AR (vision-based) by using visual markers, such as fiducial or images (video see-through)

- The system using CV techniques finds the mark and calculates the geometrical position of the mark relative to the camera; after that it can place 3D objects on the marker to provide the alignment between real and virtual elements



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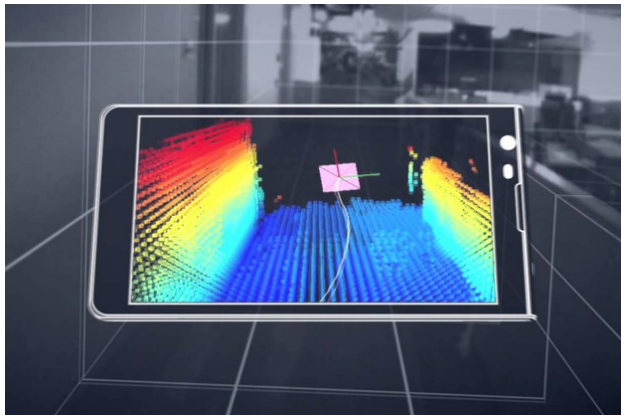
Project Tango from Google (discontinued) and iPhone/iPad Lidar – Video see-through with 3D Scanning



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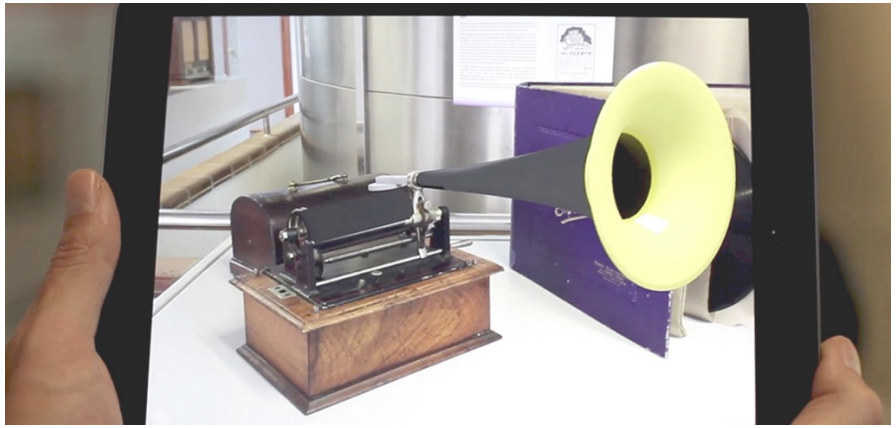
It is possible to use an object instead of an image (the object is identified using a set of images of it from any angle)



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Geographical or sensor-based AR (video see-through)

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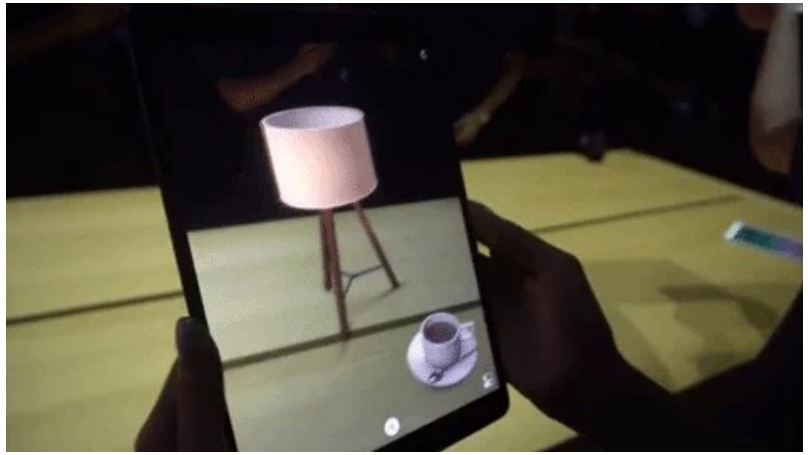
Markerless SLAM based AR (instant tracking)

The AR experience is triggered by arbitrary environments. **SLAM** technology (**Simultaneous Localization and Mapping**) allows users to scan previously mapped environments to view and interact with AR content.

ARCore from Google and ARKit from Apple are SDKs based on this technology using just a camera, by detecting planes and light estimation

We will talk about SLAM later.



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Microsoft Hololens, Magic Leap, Varjo (video see-through), Rokid, etc. have as objective a true alignment of virtual and real elements

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Quality of the holograms, battery, weight, and especially **field-of-view** are the main drawbacks of the current best AR solutions (Hololens, Magic Leap etc.)

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Smart glasses not considered as full AR

- They are generally provided with a frontal camera
- They project a synthetic image with a translucid crystal or a little opaque display
- The synthetic content is NOT aligned with the real world
- The information displayed can be triggered by the environment using the camera and other internal sensors
- Google Glasses, Vuzix Blade, Vuzix M-300, Epson Moverio etc.

Augmented Reality - Layers

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The Layers of AR

- AR can be seen as a stack of **two main layers**:
- **The physical layer**, which it is focused on the main problem of AR: the alignment of digital elements and the real world.
- In order to do that, the system has, somehow, to recognize elements of the real world, such as patterns, images or 3D information (e.g. 3D point clouds). Synthetic elements must be anchored into these elements of the real world, and, finally, the AR system must be able to make a real-time composition of reality and synthetic elements.
- Beyond the physical layer of forms, there is the **semantic layer** which gives meaning or semantics to the things we see (for example, using neural networks, so machines can understand the world as we do)

Augmented Reality – Physical Layer – Marker-based

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We can have different possibilities in providing a solution to the **physical layer** of an AR system, mainly depending on the sensors and technology available:

- **Using just a camera (marker-based)**

It is possible to solve the physical layer using just a single camera. A traditional approach has been using image (or markers) recognition.

Using computer vision techniques, the system can try to recognize a specific image and, what it is also essential, what is the 3D relative position of the image detected related to the camera.

With this 3D relation, the AR system can put a synthetic 3D object following the position, scale and orientation of the image, generating a true AR composition.

At the beginning, only specific markers with a well-defined set of properties were possible, but currently it is possible to use any image, as far as the image can be recognized (it contains a minimum set of 'singular' points, normally with high gradient variations)

Augmented Reality – Physical Layer – Marker-based

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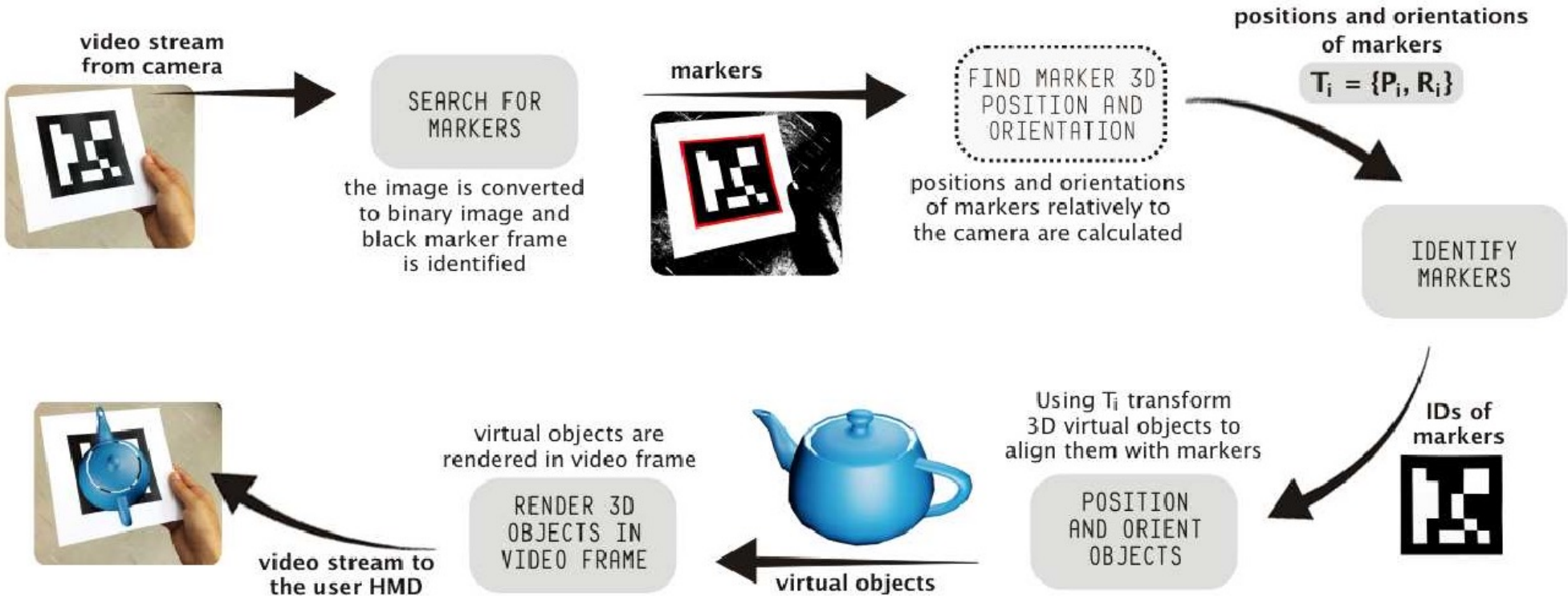

Augmented Reality – Physical Layer – Marker-based

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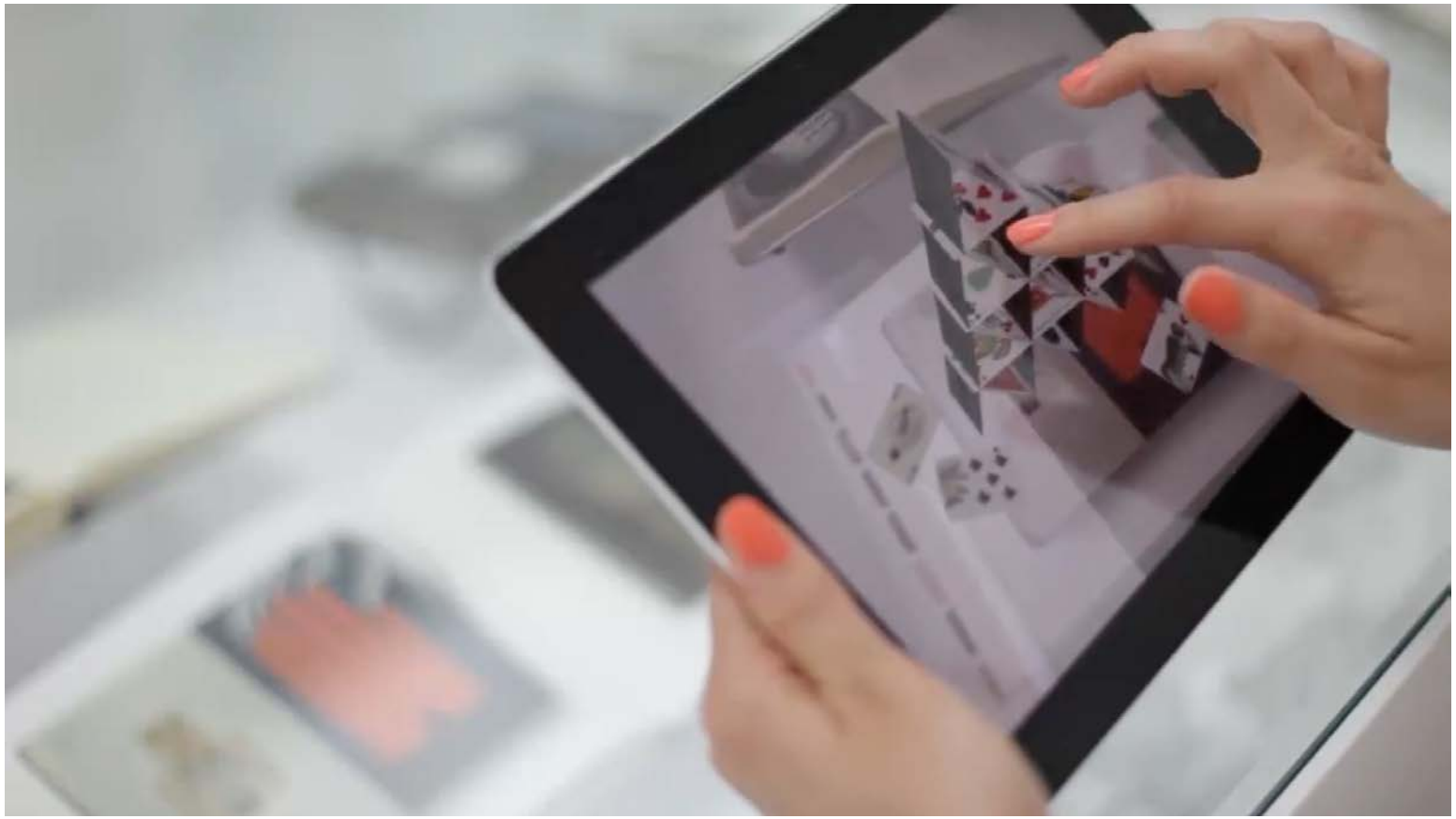

Augmented Reality – Physical Layer - Markerless

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- **Markerless-based solutions (geo-AR and SLAM)**

Using markers or images we can provide solution to many AR applications. It is even possible to put markers into different areas of a space and have as a result that different virtual elements will appear into different areas, depending where the user is looking at.

Another possibility is available if our device has an **IMU** (Inertial Measurement Unit). IMU is the integration of accelerometers, gyroscopes and magnetometer that finally can figure out device 3D orientation and the angle to magnetic north. IMU is available in almost all mobile device.

With **camera + IMU + GPS** is possible to implement geographical AR solutions, such as Pokemon Go famous game, although, due to the GPS, with an important degree of error and with many problems to implement occlusion (when the digital element is hidden by a real element, situation where the digital element is not generally occluded).

With **camera + IMU + GPS** we can get the required 6 degrees-of-freedom for actual AR.

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SLAM (Simultaneous Localization and Mapping)

- SLAM is a new step that allows, using at least a camera and allowing additional sensors, to get a spatial mapping of the environment (mapping) and, at the same time, to localize the user regarding the environment; allowing in this way an outstanding solution to the physical layer and even giving the user the possibility of dynamically put 3D objects into the environment in real-time
- SLAM refers to the broader system that allows your device to construct and update a map of an unknown environment while simultaneously keep track of its location within the map
- With tight integration between hardware and software, your device now has the ability to understand where it is in the world and track itself within its environment
- SLAM is a more general and potentially more accurate than GPS, that gives us only a rough estimation of latitude and longitude and does not work indoor

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SLAM - > **Localization (where the device is in the world)**

- Localization is solved using Visual Inertial Odometry (VIO), with no GPS
- VIO is made out of two parts:
  - The Optical System (at least one RGB camera, although additional cameras or depth cameras can be used if available)
  - The Inertial Measurement Unit (IMU)
- The optical system is comprised of a camera stack which includes the lens, shutter and image sensors. The inertial system is made up of accelerometers, which measures acceleration and a gyroscopes, which measures orientation. Together, they help the device determine its position (x,y,z) and orientation (pitch, yaw, roll), 6-degrees-of-freedom (6DoF)

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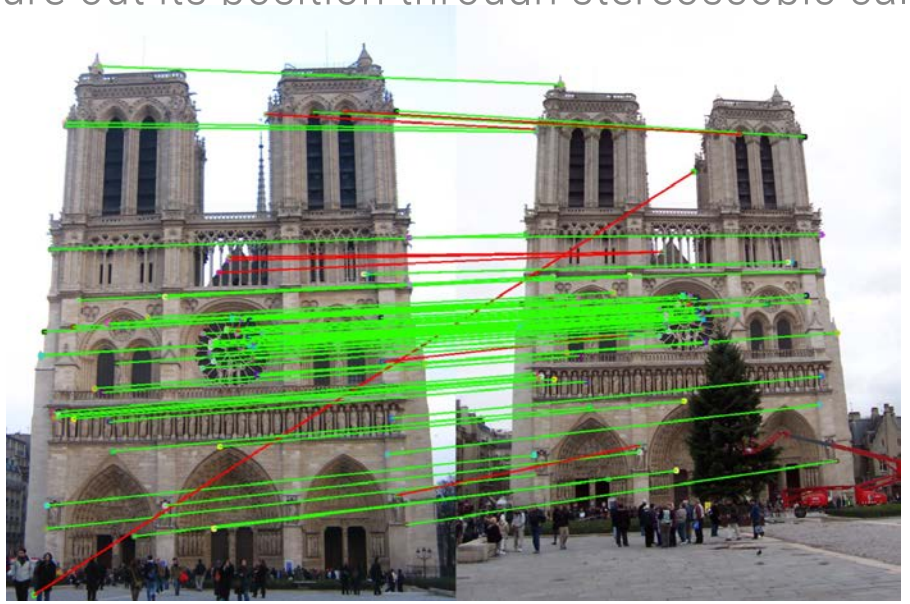
- As moving the device to look at AR content, the device is essentially **capturing many photos** of the environment and comparing them to figure out its position.
- For each photo it captures, it is also identifying **key features** in the environment that are visually unique and interesting in nature such as the edges, corners, ridges of unique objects in the scene.
- By comparing two images and their respective key features and using the sensor data from the device's IMU, the device can figure out its position through stereoscopic calculation.



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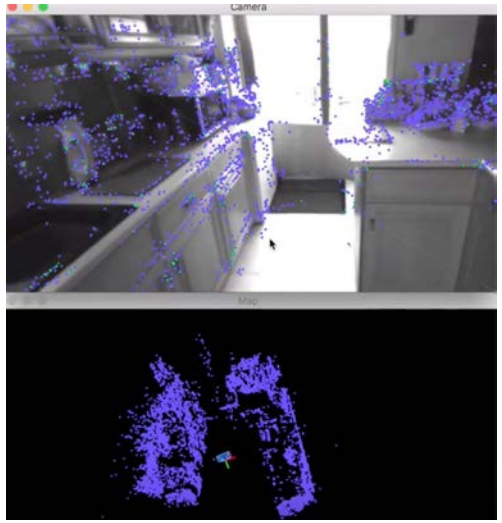
SLAM - > **Mapping**

- In the previous process, the set of points identified in several frames with their changes in positions and IMU values can generate a 3D point cloud of the environment (spatial mapping or 3D scanning)
- This cloud of points can be converted into a 3D mesh, stored, and used as a preprocess for anchoring 3D objects in an external editing environment



https://www.youtube.com/watch?v=RbOcpOmEbiI&t=15s

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- This point cloud or mapping is very important for the device to relocalize itself when it loses tracking
- The relocalization process starts when your device looks at the scene again and identifies the key features of the scene. It then compares those features with the features on the map it previously memorized. When a match has been found, it will be able to find its spatial position again.

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- With the current technology and SLAM techniques, now it is possible to map the environment spatially (3D reconstruction), this means the device can understand the shape or structure of real objects in the scene, making occlusion and collision possible
- **Occlusion** is the ability for virtual objects to hide behind real-world objects
- **Collision** is the ability for virtual objects to collide with real-world objects
- When virtual objects respond to real-world physics as if they are real, this makes the AR experience so much more believable
- So, even using a monocular RGB camera, we are starting to get the power of a depth sensor. It is possible to scan the environment and capture a dense point cloud, which is later converted into a mesh through computational geometry.
- If a depth camera is available, the SLAM technique can achieve a greater degree of accuracy in getting the 3D map of the environment and knowing the position of the user related to it.
- With SLAM, the physical layer part of an AR system can be fully solved

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- **ToF (Time of Flight)** cameras started to be used in different AR related devices (Kinect, Hololens, Magic Leap…)
- ToF cameras are used to precisely measure the distance to an object by projecting an infrared light beam onto it. When the light strikes the surface of the object, part of it is reflected back to the camera in the opposite direction to that in which it was initially propagated. Then it calculates the time that has elapsed since it emitted the light pulse until it receives it, once it has been reflected from the object. The speed at which the infrared light beam propagates is well known because it is the same speed at which visible light propagates in the same medium (light in a vacuum propagates at about 300,000 km/s, and in air a little slower)
- The use of ToF and a camera, what it is know as RGB-D, improves the accuracy of SLAM and the final AR solution

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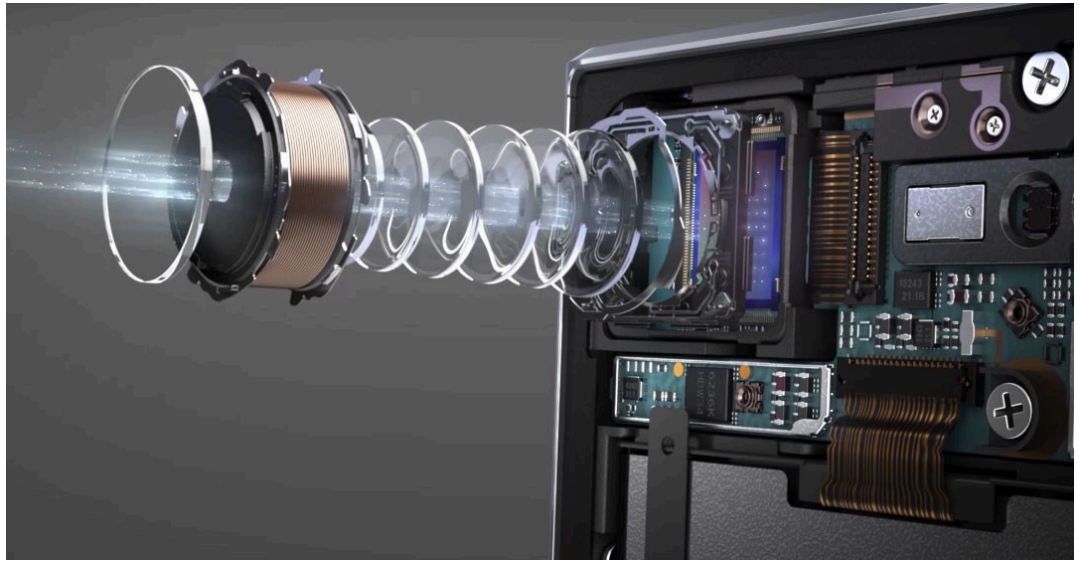

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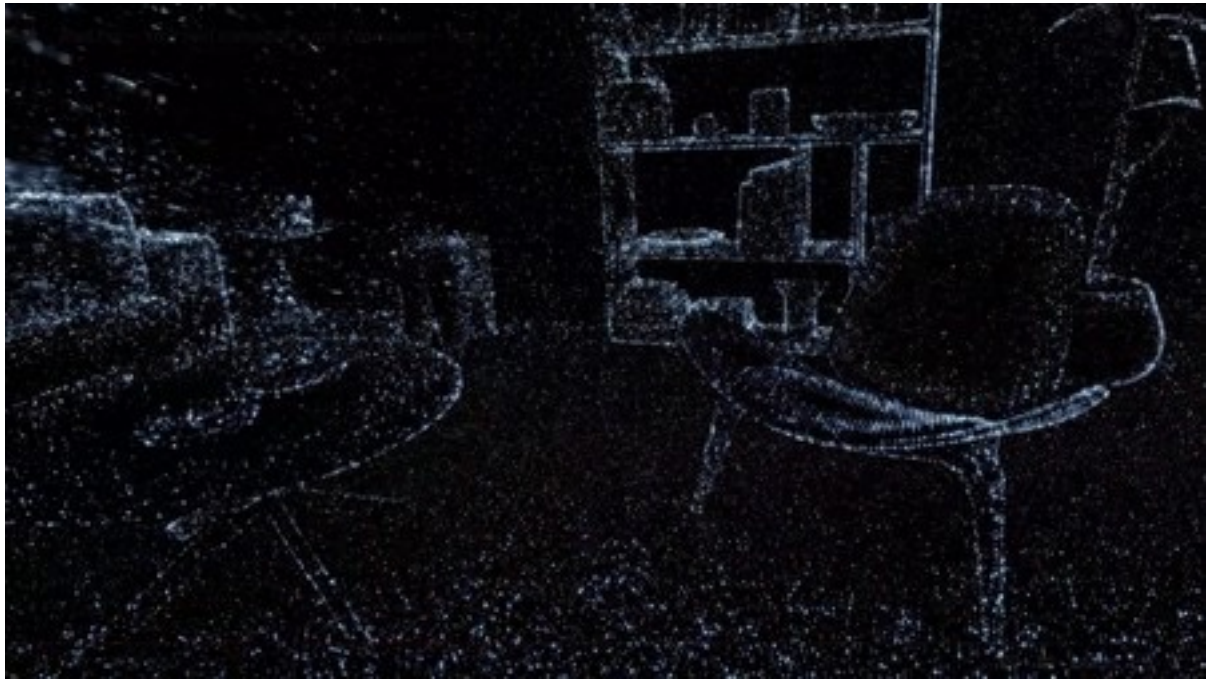
- The new Apple devices have started to integrate LIDAR (Light Detection And Ranging), a kind of ToF camera based on infrared laser.



https://www.youtube.com/watch?v=wpRcGN3RyTE

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SLAM based AR solutions allows two possibilities:

- We can use SLAM mapping possibilities to carry out, in a first stage, a spatial mapping of the whole environment we want to augment. This means that we first, using the device, scan all the environment as a pre-process (it can take quite a while). The generated map is stored and can be edited with an external tool, where we can add any kind of virtual elements anchored in the desired positions. This can be saved, so, when the final user starts the AR final solution, the device will do the same thing: use SLAM to scan what it is in front of him/her. Now, the device will compare the cloud of points obtained with the map previously stored in order to localize the user and add the synthetic elements that were anchored.
- Besides the previous case, SLAM allows also to dynamically anchor new 3D elements into the map obtained. This is the case of apps such as IKEA that allows you to place furniture in AR in a environment without the need of a preliminary scanning.

Augmented Reality – Physical Layer - Properties

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Anchoring, Tracking, and Persistence

- 3 properties are really useful in the physical layer of an AR system: anchoring, tracking and presentence
- **Anchoring** is placing a digital object in the augmented world
- **Tracking** is maintaining consistency of the augmented world as the camera moves
- **Persistence** works in SLAM by saving (serializing) the map that we obtained from the point cloud of the world, this means we can reload the saved map and don't need to perform spatial mapping again. It will fail if the environment changes. When using marker-based AR, persistence is much easy to obtain as far as the markers don't change. Persistence is quite challenging, since it means that if a user anchor a virtual object in a specific position, he/she wants to watch it again in the future by him/her or other users. What happens if the world changes (even just a bit)? How can the device be sure of the proper location of the user? This is a basic achievement in order to reach what we call AR Cloud.

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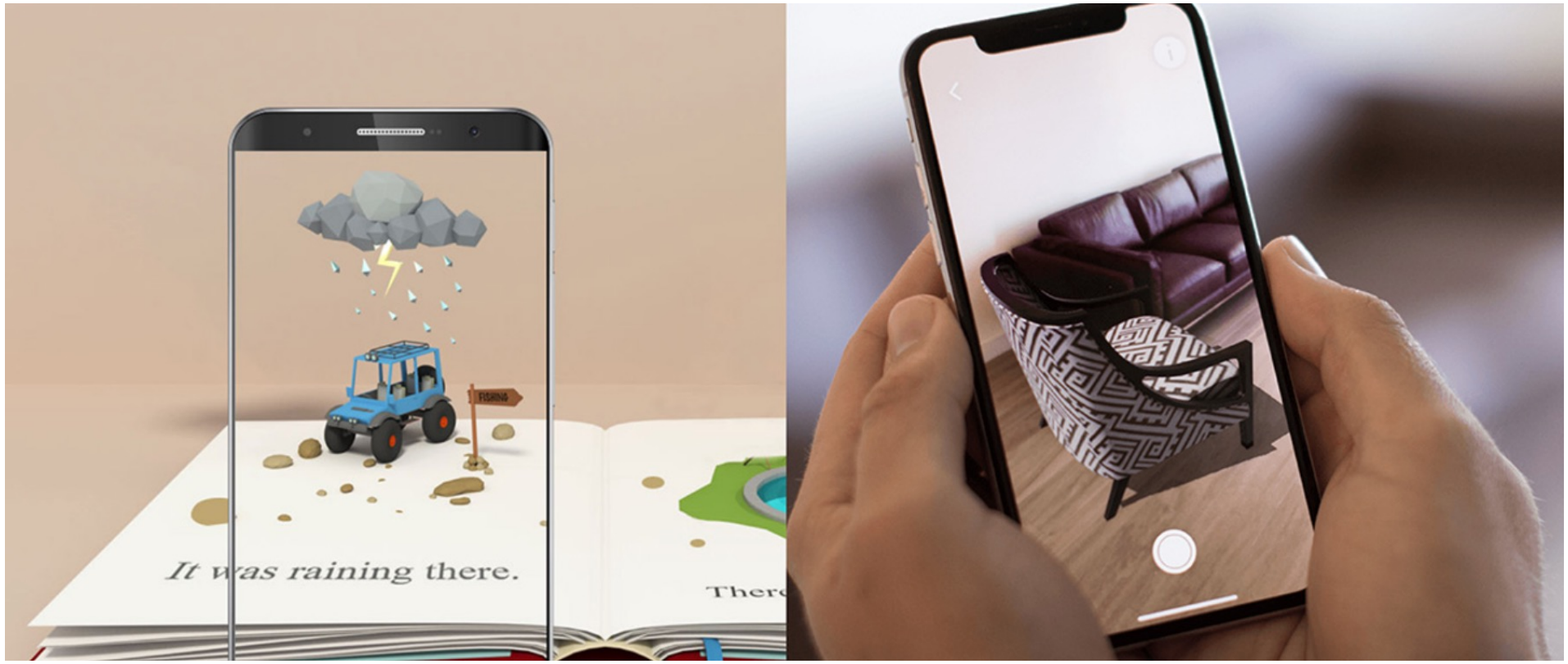

Marker-based vs. marker-less (SLAM)

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Google Maps AR mode uses everything: IMU + GPS and image recognition using the street view maps Google servers store. This gives the maximum degree of quality in a standard mobile device

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- With just one camera (6D.AI)

https://www.youtube.com/watch?v=7VeZ6Ciy-uo

https://www.youtube.com/watch?v=OsZvBEkJ6Vg

- With 2K Stereo Camera (ZED, from StereoLabs)

https://www.youtube.com/watch?v=HnXnBKaCqpU

- Google is also improving its AR CORE wit Depth AI

https://www.youtube.com/watch?v=VOVhCTb-1io

- Immersal

https://www.youtube.com/watch?v=cpQEMvvARI8

Augmented Reality- Semantic Layer

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For the **semantic layer** it will be necessary many elements:

- Technology able to interpret the information capture by the sensors (currently, deep learning)
- Know the user profile, context and necessities
- Seamlessly integrate cloud + sensors + IoT + IA + Human

More details on this semantic layer will be covered in the next units with AI techniques (deep learning).

Augmented Human

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The concept of **Augmented Human**

- Don't focus only in 'augmenting' the visual experience
- Augmented audio, or even adding new senses and possibilities (by adding new sensors to our devices able to capture new sources and make them available to us)
- Especially interesting for impaired people

Augmented Human

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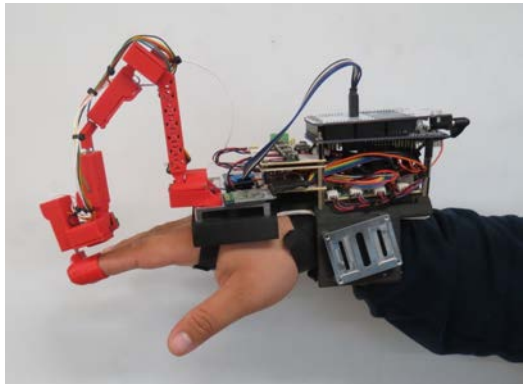
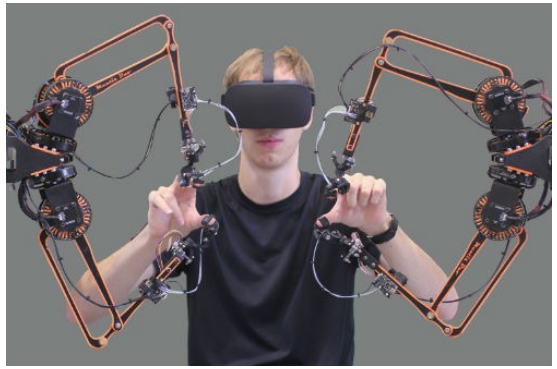
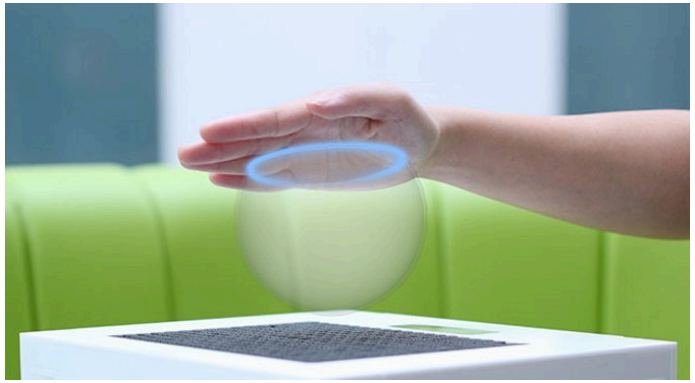
The concept of **Augmented Human**

- Haptic devices (feel that you grasp things), haptic suits, tasting devices, smell devices etc.







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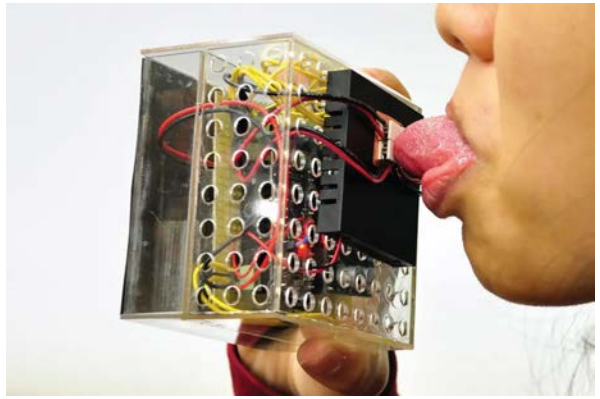

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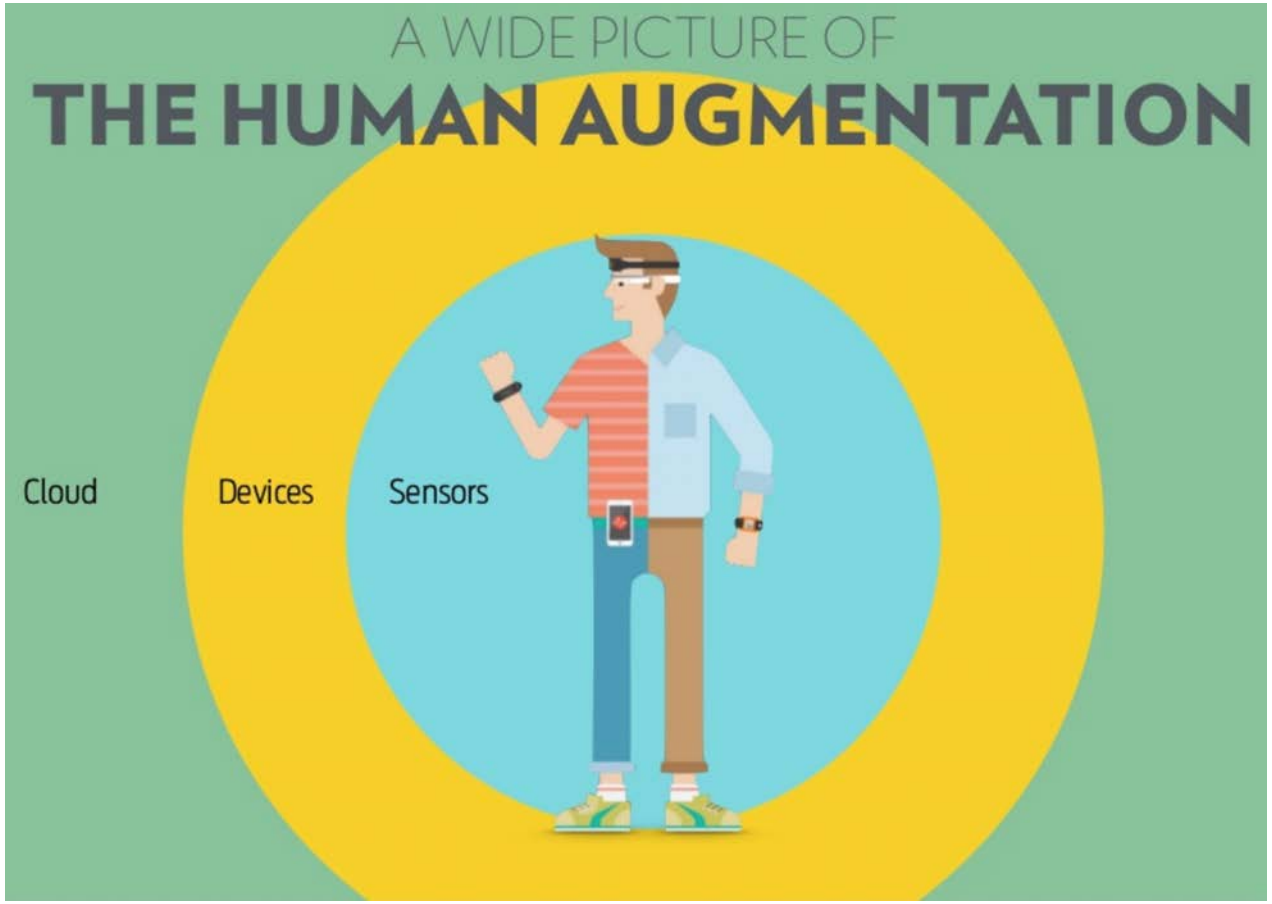
The concept of **Augmented Human**

- Adding new senses to humans
- Perceiving what it is not directly sense by our human senses
- Adding/modifying/removing what it is interesting by the user
- 'Context' and 'user profile' become essential to be able to provide a new experience and adapted to the user



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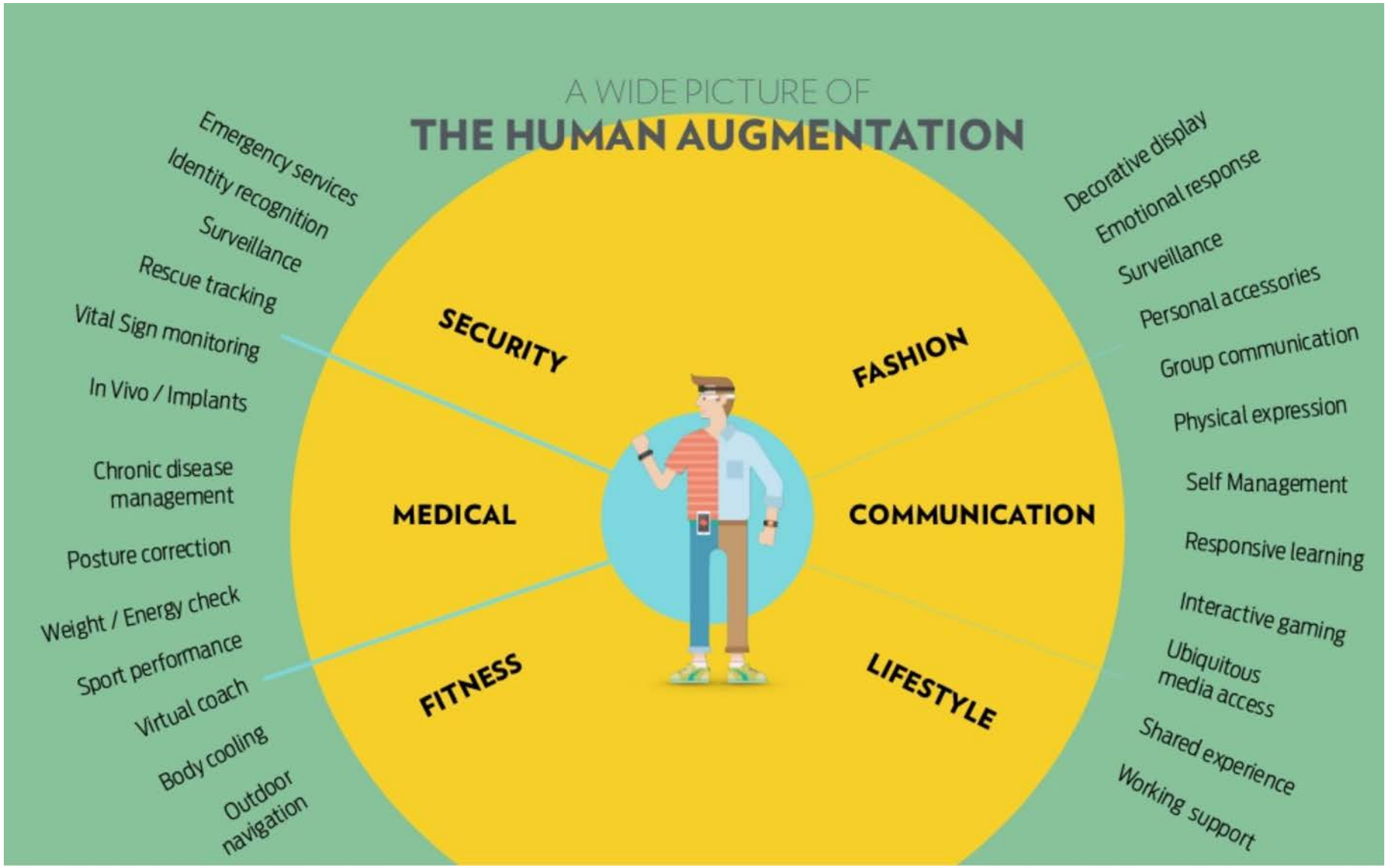

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"The internet will disappear to become part of our presence all the time."

Eric Schmidt

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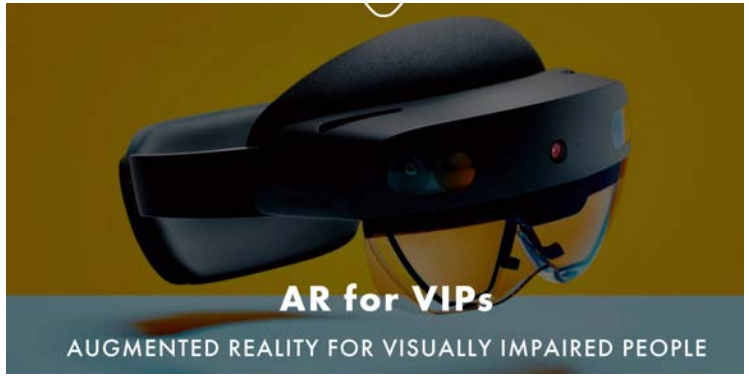
AR and related technologies can be a before and after for disabled people:

aira

https://www.youtube.com/watch?v=p816oUJzJvg

AI technology will enhanced this in the future



https://www.youtube.com/watch?v=tqpFkU4fnIE

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Many possibilities in AR, mainly using a mobile devices and smart glasses.

AR has more potential possibilities than even VR

Some possibilities next (from https://www.cbinsights.com/research/ar-vr-industries-disrupted-beyond-gaming/)

Applications of VR/AR

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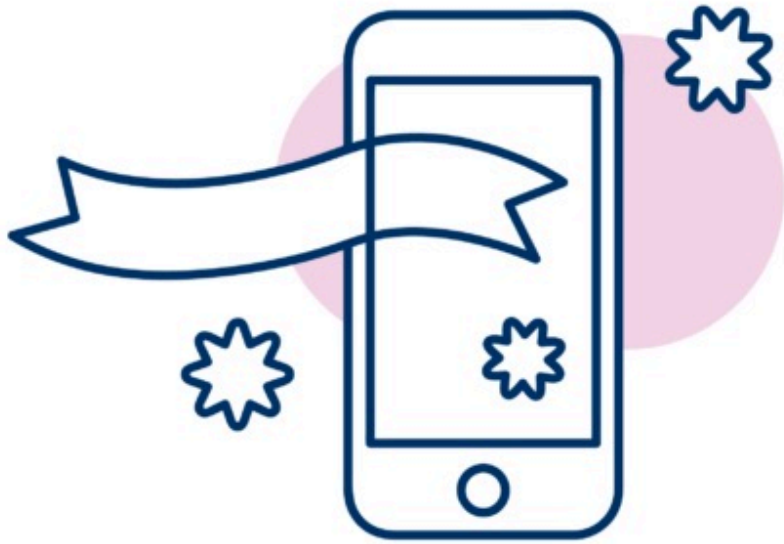
Marketing & Advertising

As consumer adoption of headsets increases, VR/AR will evolve to become less of a promotional novelty and more of a standard channel for experiential marketing and advertising.



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Law Enforcement

The technologies enable police forces to escalate or de-escalate trainees' simulated interactions with individuals inside the virtual training environments, helping learners practice making judgment calls and critical decisions under stress.

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Recruiting, Talent Management & HR

Once consumer adoption of VR devices reaches critical mass, VR-driven HR may benefit candidates just as much as companies.

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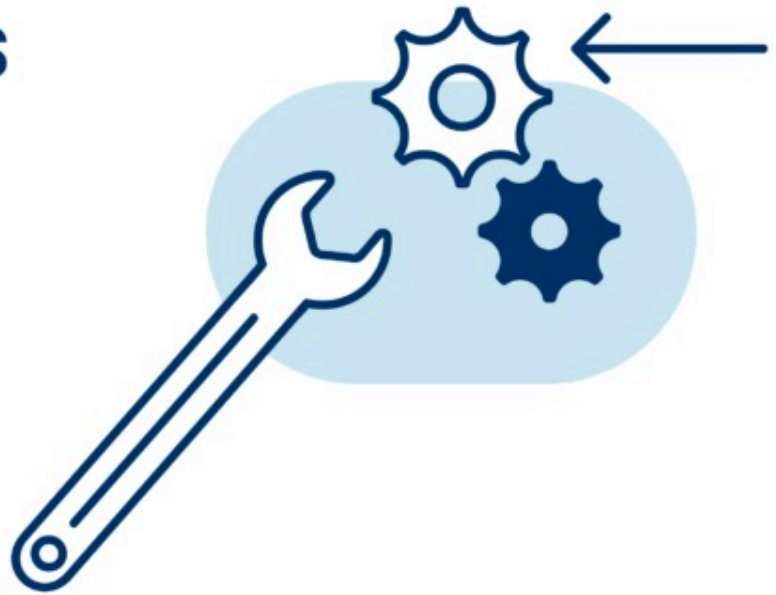
Manufacturing & Logistics

AR can superimpose holographic images — "objects" — and instructions atop an individual's real-world perspective, which can be immensely valuable for educating workers to use large machinery or specialized devices.



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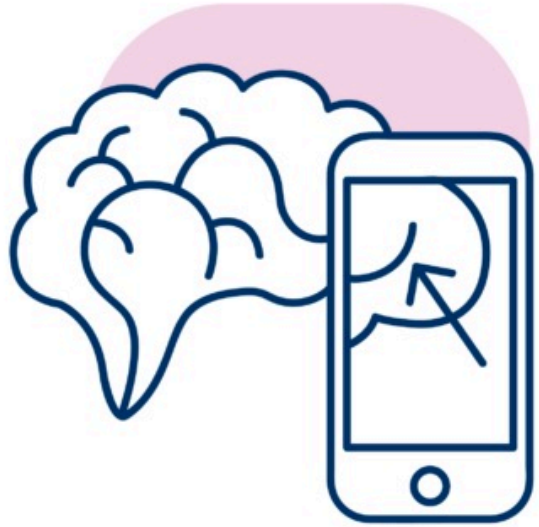
8. References

Healthcare & Medicine

Many companies are looking to provide hospitals with customizable apps for visualizing patient health information in augmented reality (imagine AR replicas of smokers' lungs or runners' knees).



Applications of VR/AR

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Journalism & Media Dissemination

Plenty of media outlets are looking to use VR to place audiences "inside" their stories. The New York Times is already a leader in VR-powered storytelling, releasing new visual stories through the NYTVR app.

Applications of VR/AR

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Film & Entertainment

Deploying VR in entertainment eliminates the boundary between a story and its audience, allowing filmmakers to experiment with space and point of view.

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Construction & Real Estate

Architects are excited about AR's potential for digital modeling — tools from startups like Augment can be used to overlay building plans, marketing materials, and other 2D collateral into 3D models.

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Automotive

VR is an obvious fit for immersive car tours and experiential test drives. Consumers can experience the Volvo XC90, for example, using the Volvo Reality app entertainment.

Applications of VR/AR

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8. References

Space Exploration

The use of VR is increasing NASA's effectiveness in space exploration: Researchers were reportedly "two times more accurate at determining distances and three times more accurate at determining angles between specific Martian locations" using VR than with traditional plotting methods.

Applications of VR/AR

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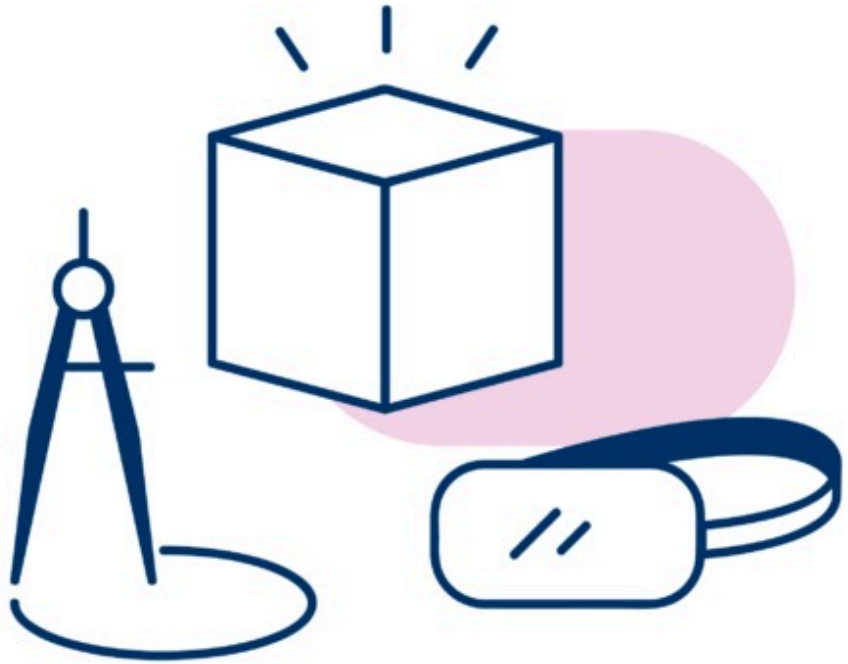
Engineering

Engineers would be able to make changes to a product using a given software, and then see the results on a virtual reality display.



Applications of VR/AR

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Customer Service

A representative could appear to hover in front of customers to talk them through their issues, step by step.

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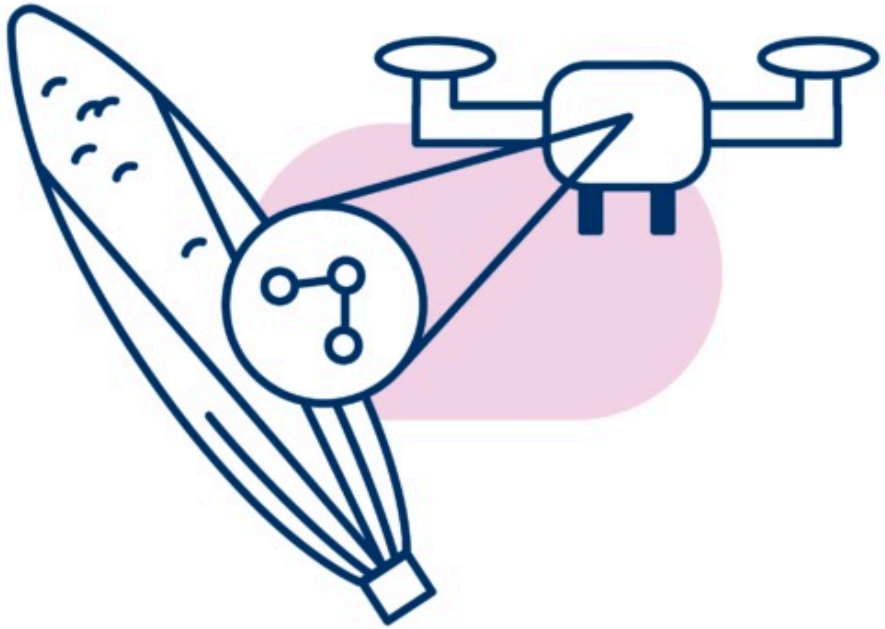
Agriculture

By caring for crops at the granular level that VR and crop data allow for, farmers can increase yields, decrease disease, and improve costs.



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Sports

In the future, AR and VR will help make practice even more like gameday. In fact, some athletes already have access to this technology.

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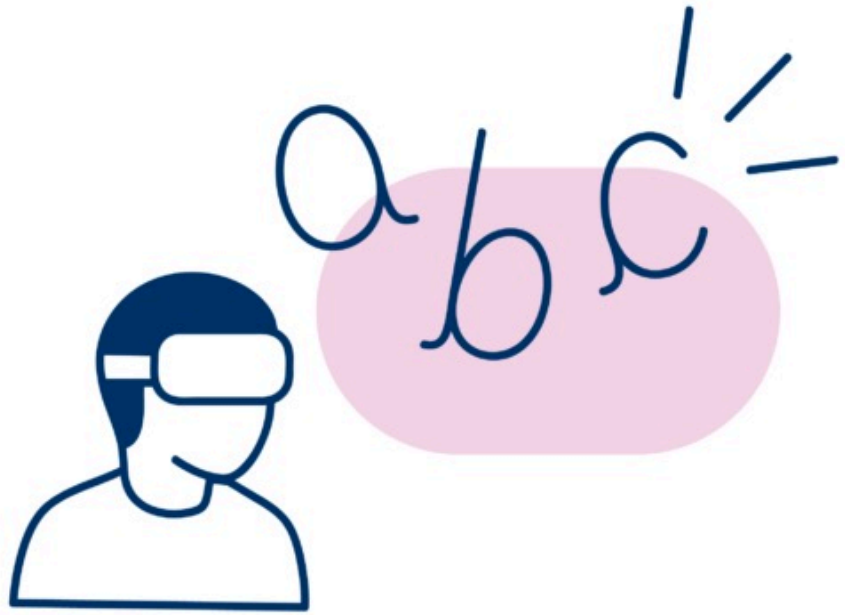
Education

The technologies could increase students' engagement across subjects, enabling them to comprehend concepts faster and foster community learning.



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Energy

AR/VR can help scientists determine where to locate and test drilling sites. The technologies can also help them monitor operations of pumps and motors from a remote setting, among other things.

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VR in entertainment

Applications of VR/AR

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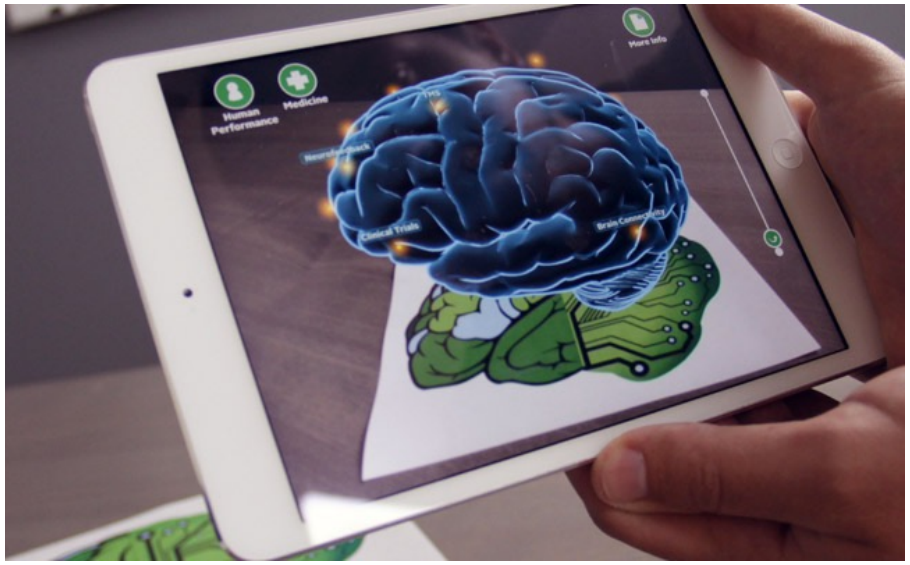
Education



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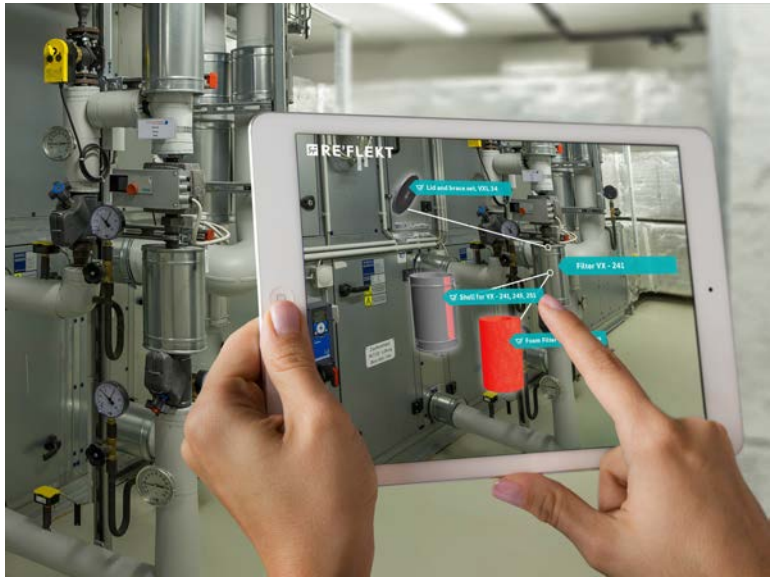
Training and industry



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VR in healthcare

Applications of VR/AR

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VR in product visualization

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VR in supermarkets

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AR in catalogues and brochures

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AR in business cards

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AR in books

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AR in stickers

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AR in t-shirts

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AR in billboards

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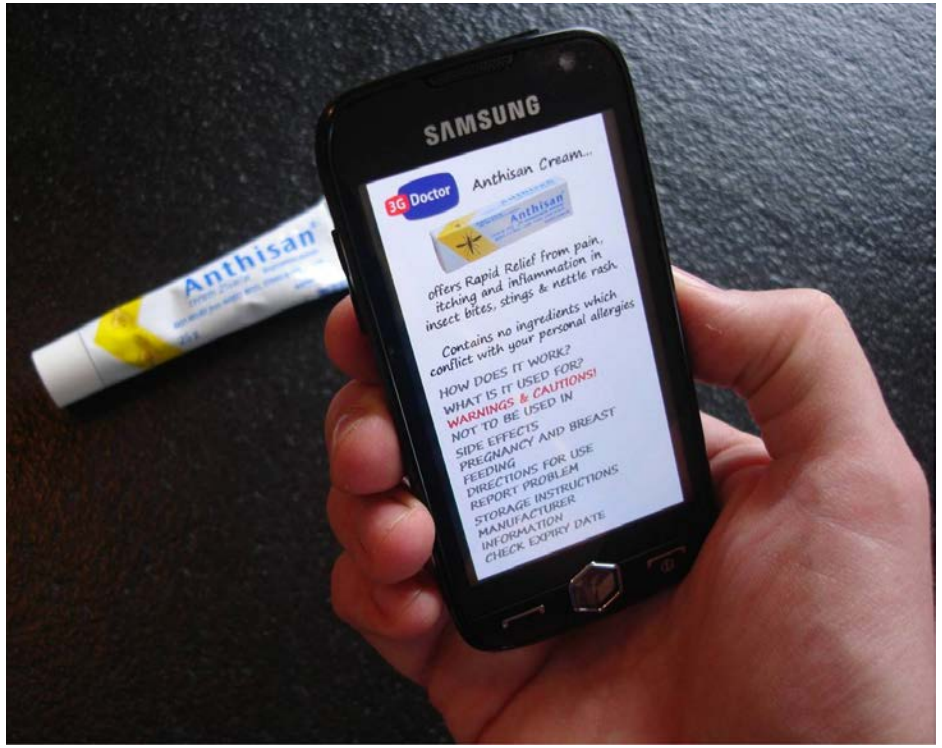
AR in medication and healthcare



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AR in restaurants

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AR in photocalls

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AR in operating instructions

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AR in home textiles

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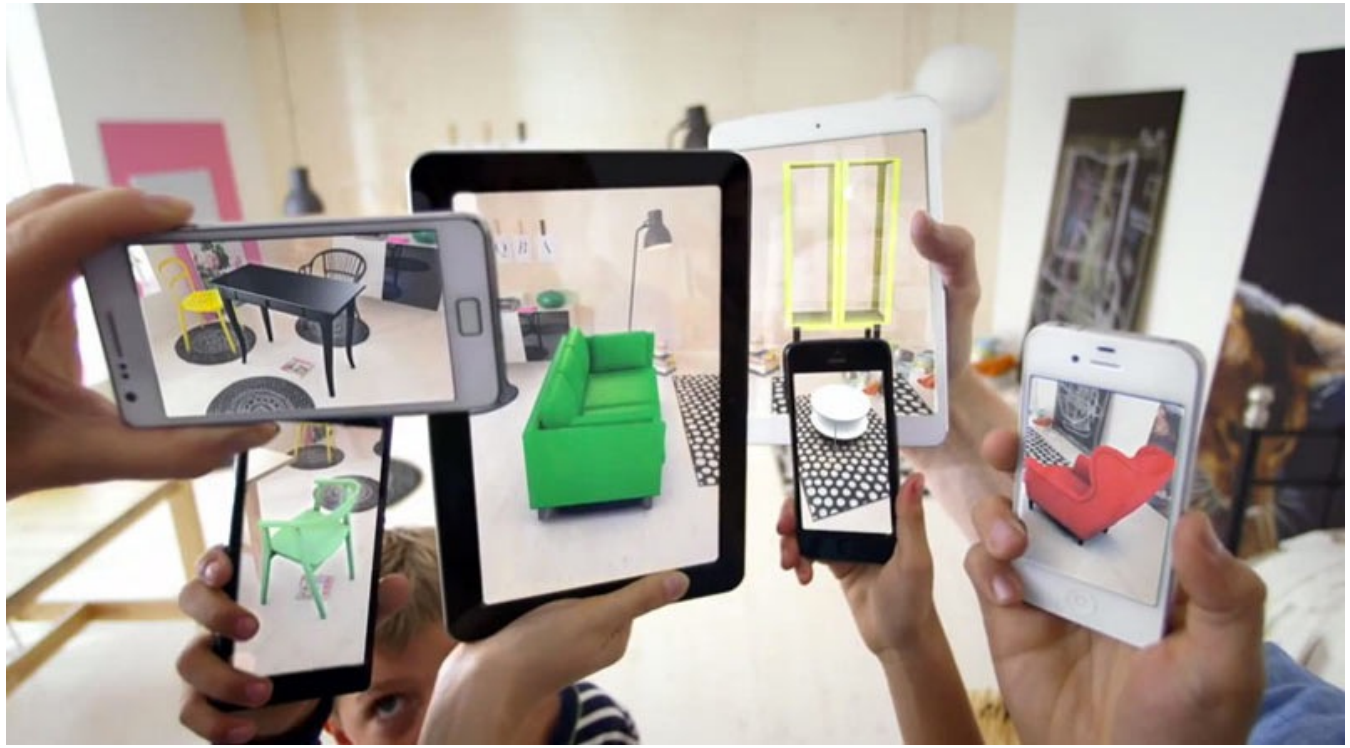
AR in decoration



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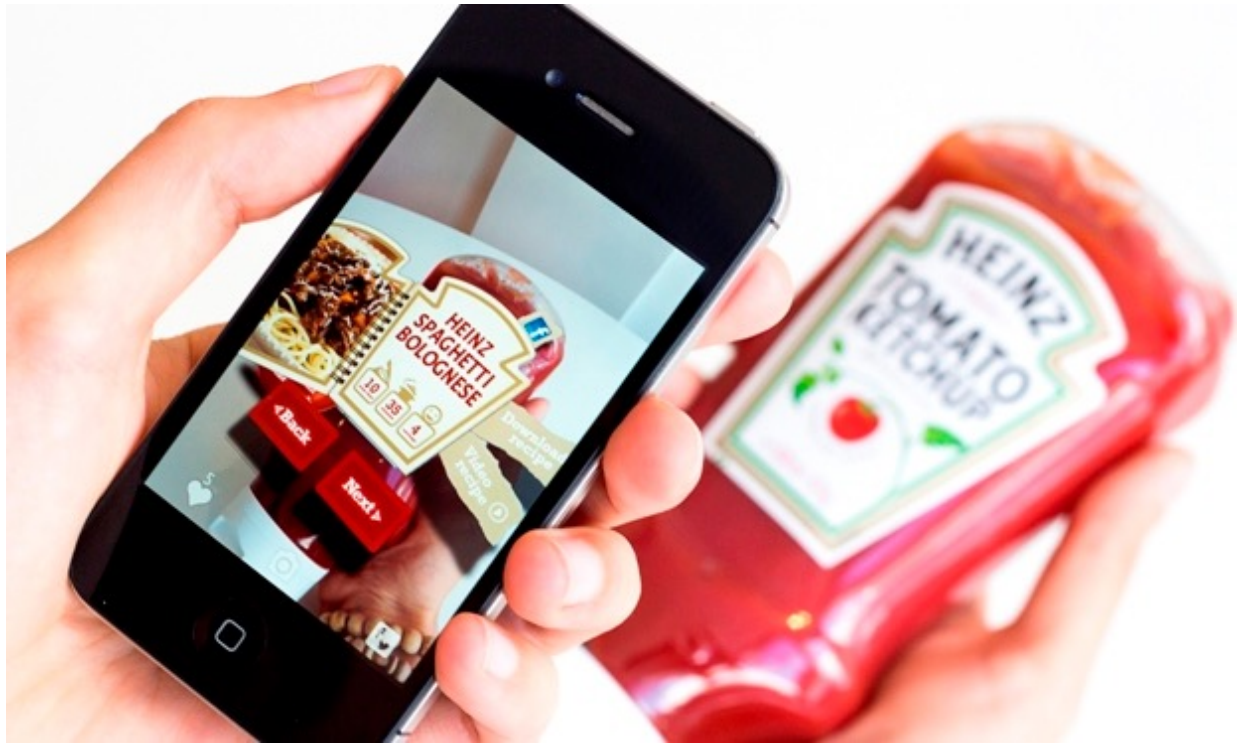
AR in packaging



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AR in a supermarket

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Holoportation

Applications of VR/AR

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We will cover in a specific unit what can be done in Industry 4.0

Metaverse– A near future

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Metaverse

- The metaverse is the digital world, where anything we can imagine can exist
- It is generally conceptualized as an immersive experience (VR)
- Eventually, we'll be connected to the metaverse all the time, extending our senses of sight, sound, and touch, blending digital items into the physical world, or popping into fully immersive 3D environments whenever we want
- In his 1992 book, "Snowcrash", Neal Stephenson imagined an internet-like virtual reality world he called "the metaverse" where users would interact with digital forms of themselves called "avatars"
- From Snowcrash, the term "avatar" spread across popular fiction franchises, including Earnest Cline's "Ready Player One"

Metaverse– A near future

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Metaverse

- **Facebook** is trying to build its metaverse — a maximalist, interconnected set of experiences, spanning social presence, office work, and entertainment (https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview)
- **Sony and Epic Games** (Unreal engine) are also investing a lot of money in this area
- Blockchain, AI and other technologies will have also an important role for metaverse decentralized products

AR Cloud – A near future

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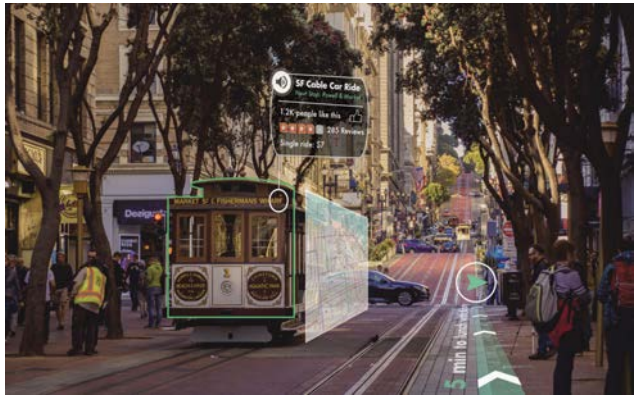

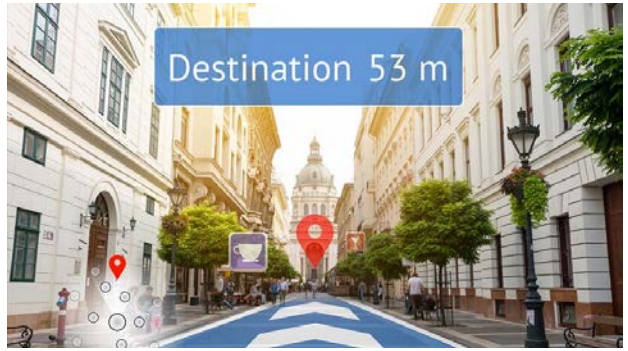

AR Cloud

- Virtual information integrated into the whole 3d world (indoors/outdoors)
- Information accessible from any device, added by anyone
- A new Internet 3.0

AR Cloud – A near future

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AR Cloud

- The promise that will finally make augmented reality go mainstream
- Do you remember how 'search' in a browser revolutionized internet 20 years ago? This is what AR Cloud is supposed to do: changing how we organize information
- Think of the AR Cloud as the evolution of search: most people look for things on the go. Instead of phrasing a request into a search engine and receiving some text back, the AR Cloud will get us the visual information we need—by putting our camera right on the spot with any device
- It's all about receiving the right information in the right context at the right time—without even asking.
- Anything is able to 'trigger' augmented content

AR Cloud – A near future

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AR Cloud

"*The world is about to be painted with data. Every place. Every person. Everything*." Charly Fink

Augmented reality – A near future?

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Future:

- Light glasses
- Environment-aware
- Voice-based interaction, hand movement recognition
- Computer vision
- Assistant technology
- Etc

https://www.youtube.com/watch?v=qj-6G2d9qPU

References

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- Azuma, R. T. (1997). A survey of augmented reality. Presence: Teleoperators & Virtual Environments, 6(4), 355-385.
- Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems, 77(12), 1321-1329.
- Hillstead, A. (2017). Simulating Psychedelic Therapy Through Mediated Reality.
- Papagiannis, H. (2017). Augmented human: How technology is shaping the new reality. " O'Reilly Media, Inc.".
- “The age of Augmented Humanity” by Antonio de Paquale
- ”Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing” by Erin Pangilinan, Steve Lukas, Vasanth Moran
- “Reality Check: The marvel of computer vision technology in today’s camera-based AR systems” by Alex Chuang
- “What is augmented reality” by Bivás Biswas
- Mann, Steve & Barfield, Woodrow. (2003). Introduction to Mediated Reality. Int. J. Hum. Comput. Interaction. 15. 205-208
- Mann, S., Furness, T., Yuan, Y., Iorio, J., & Wang, Z. (2018). All reality: Virtual, augmented, mixed (x), mediated (x, y), and multimediated reality. arXiv preprint arXiv:1804.08386.
- ”Simulating Psychedelic Therapy Through Mediate Reality” by Hillstead, Andrew