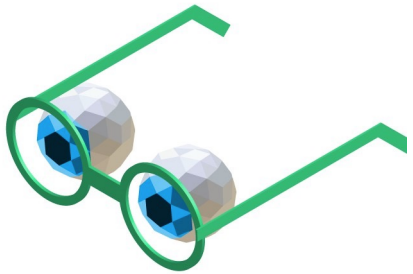

Virtual and Augmented Reality

VR-AR devices

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VR devices

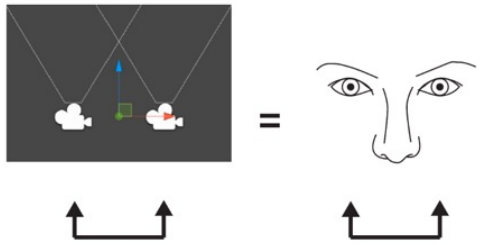
Virtual Reality devices (Head-Mounted Displays, HMDs) can be divided into several categories:

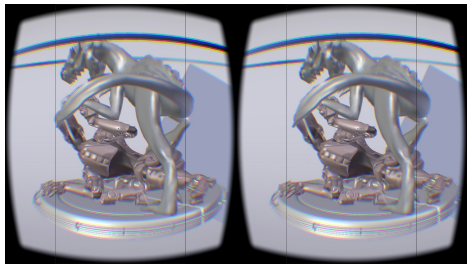
- **Tethered / Stand-alone**, depending if the generation of the images for each eye is carried out by an external device or not. The final performance depends on this, as well as the user's flexibility.
- **3DoF or 6DoF**, depending is the position of the user is tracked or not. When it is tracked, this position can be obtained using external devices or inside-out tracking (cameras in the HMD and position calculated processing the changes detected on these cameras ~ SLAM)
- **Tracking of external control devices**, such as controllers. Normally either one or two (one per hand), and generally 6DoF, and a collection of control buttons

VR devices

Other characteristics and possible differences between HMDs (also AR devices):

- **Resolution per eye**, as the screen resolution of the two displays and essential to avoid the 'screen door' effect (when user can see the pixels and the gaps between them)
- **Field of view**, and the angle/s of vision covered by the device. Essential for a full immersive experience. Quite high in VR and very limited in AR.
- **Latency**, as the time required to change user's view as a result of a change in their orientation or position. It's one of the critical elements of **'VR/AR sickness**' as this latency could be detected by our vestibular/optical system, producing an asynchrony between both systems that can produce even nauseas. Locomotion control (management of movement of the user in the space) is the other element linked to sickness.
- **Optics**, each manufacturer uses a specific optics that combined with image deformation when the image is rendered in the display, creates the desired stereoscopic effect in the user





VR devices

Valve Index (the best experience)

- Tethered (Windows, Valve Linux)
- Tracking using external devices (6DoF)
- High FOV and resolution
- Low latency
- Dual 1440x1600 RGB LCDs, 120Hz
- Two frontal cameras for CV

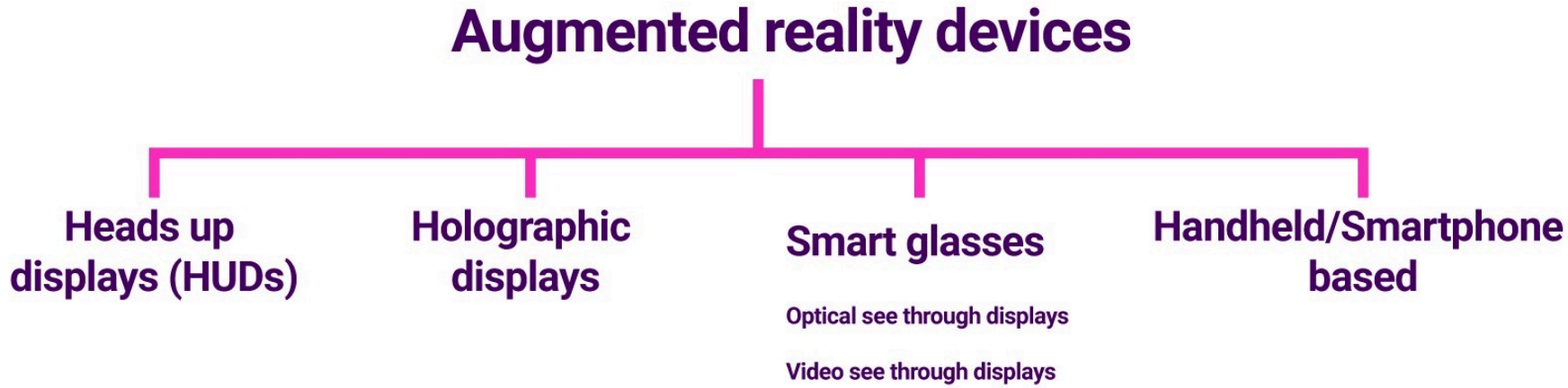
VR devices

Oculus Quest 2 (the most flexible)

- Stand-alone (allows to be used tethered as well)
- ARM SnapDragon XR2, Android based
- Inside-out tracking, 6DoF
- 1832x1920px per eye
- Four cameras for inside-out tracking, controller tracking, and hand-tracking

AR devices

Augmented reality devices can be broadly categorized into four types:



AR devices

Head up displays (HUD)

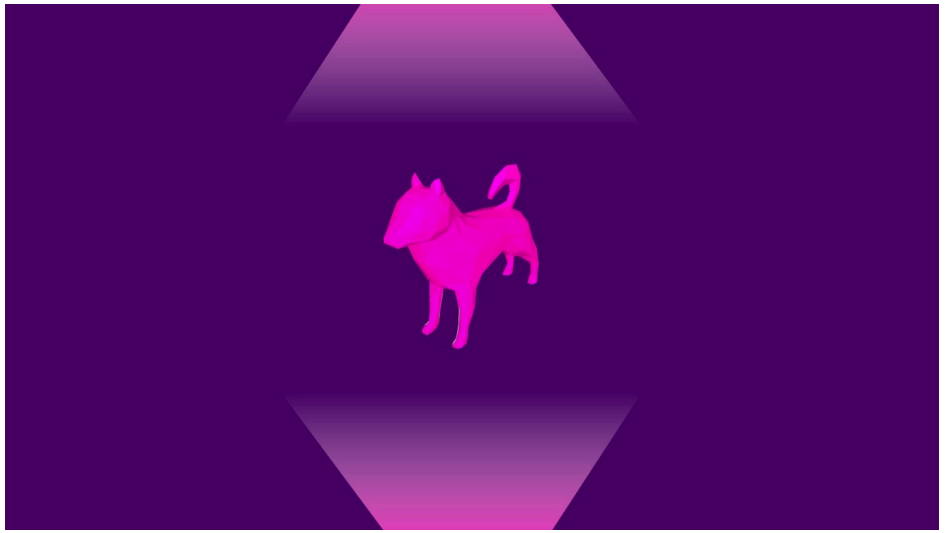
- Heads up displays were mainly invented for mission critical applications like flight controllers and weapons system dashboards.
- Critical information is projected on transparent screens mounted in front of the pilot (this enables pilots to look forward outside rather than looking down inside the cockpit)
- HUDs try to solve the problem of shifting focus by using a type of collimating projector
- The information projected is collimated (parallel light rays) focused on infinity so that the pilot's eyes do not need to refocus to view outside the cockpit
- A regular HUD contains three main components: a projector unity, a viewing glass (combiner) and a computer (symbol generator)

AR devices

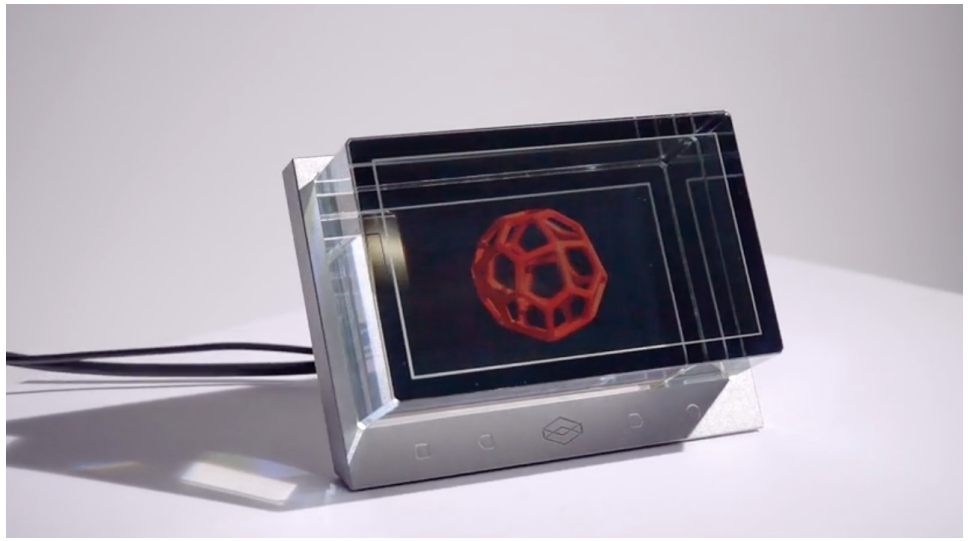
AR devices

Holographic displays

- These devices idea is to use light diffraction to generated three dimensional forms of objects in real space
- Still under hard research and development, with many problems to be able to create them with the 'air' as vehicular element

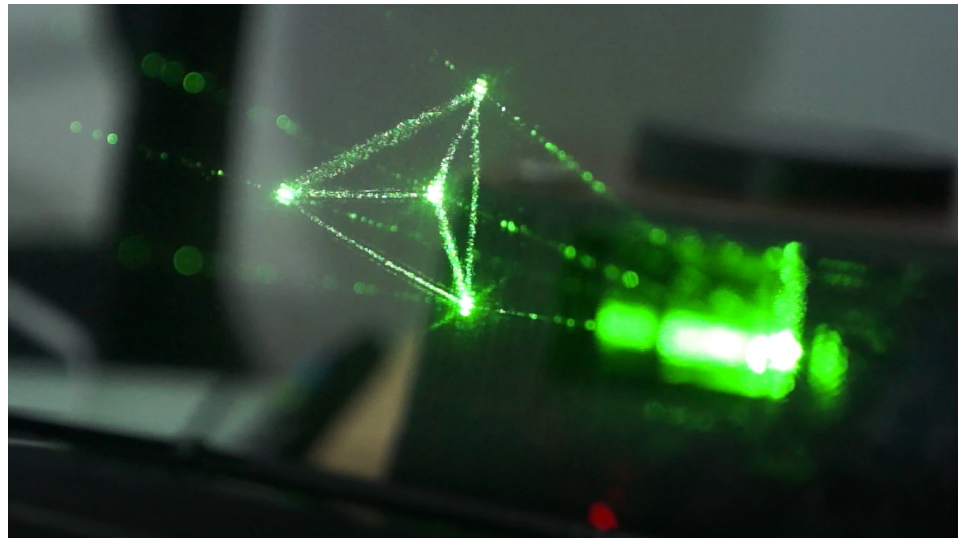


AR devices



https://lookingglassfactory.com

https://www.youtube.com/watch?v=EMUdmE0lKIU



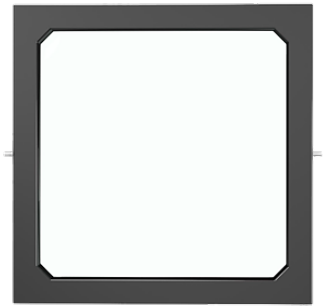
https://www.youtube.com/watch?v=kPW7ffUr81g

(the project failed)

AR devices

https://www.youtube.com/watch?v=jOnxr9Ez_Kc

AR devices



RealFiction – DeepFrame

https://www.youtube.com/watch?v=YCrJcsr2lzg&t=1s

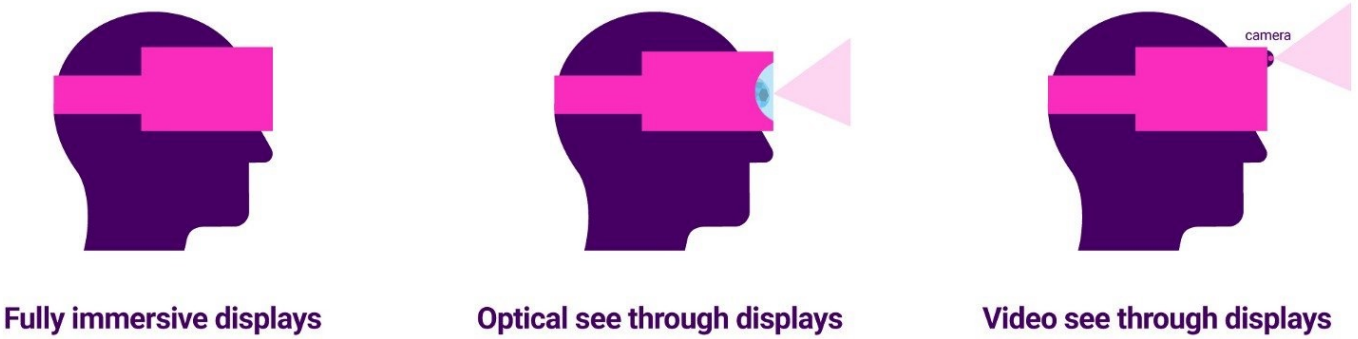
RealFiction – DREAMOC

https://www.youtube.com/watch?v=YCrJcsr2lzg&t=1s

AR devices

Smart glasses

- Smart glasses have become one of the most popular types of augmented reality devices
- They are of two types:
  - **Optical see through.** The user views reality directly through optical elements such as holographic wave guides and other systems that enable graphical overlay on the real world. Microsoft's Hololens, Magic Leap One.
  - **Video see through.** The user views reality that is first captured by one or two cameras mounted on the display. These camera views are then combined with computer generated imagery for the user to see. A good example: https://varjo.com/products/xr-3/



AR devices

Smart glasses

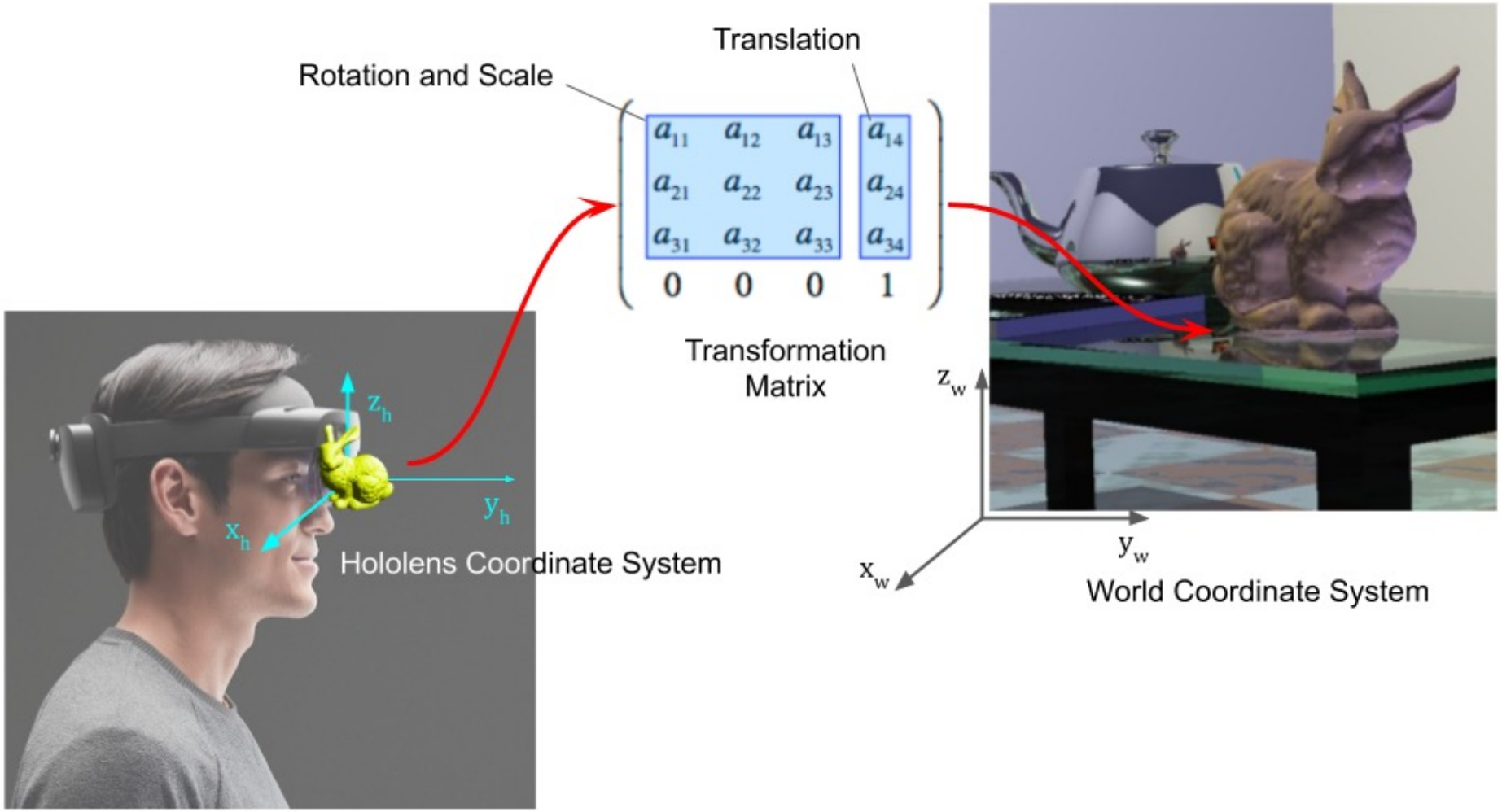
- An important difference must be highlighted regarding smart glasses:
  - Those able to really 'overlap' and 'align' synthetic and real information (Magic Leap, Hololens), so the follow **Azuma's** definition of Augmented Reality
  - Those that only offers just a head-up display experience, able also to display relevant information (even context-aware) but not aligned with the real world.

AR devices

Smart glasses

- The problem of **alignment in AR** is defined as the task of overlaying a virtual model of an object on top of a real-world instance of the same object such that the position, orientation, and scale of the virtual model matches perfectly with the pose and dimensions of the real-world object
- Accurate alignment of the virtual model with the real object requires accurately estimating the render transformation function between the coordinate systems of the headset and the object in real-time
- This is particularly challenging in optical-see-through devices because the headset, which is usually mounted on the user, is a moving frame of reference
- The real-world object can also move and can even change its shape, if deformable (as in the example of surgeons trying to align pre-operative scans with live organs)
- Recomputing the transformation function every time the user moves their head, or the object moves — can be computationally expensive
- Additionally, the system should be robust to varying illumination and noise in the environment
- Use of ToF cameras and other sensors for spatial mapping is really helpful

AR devices



AR devices

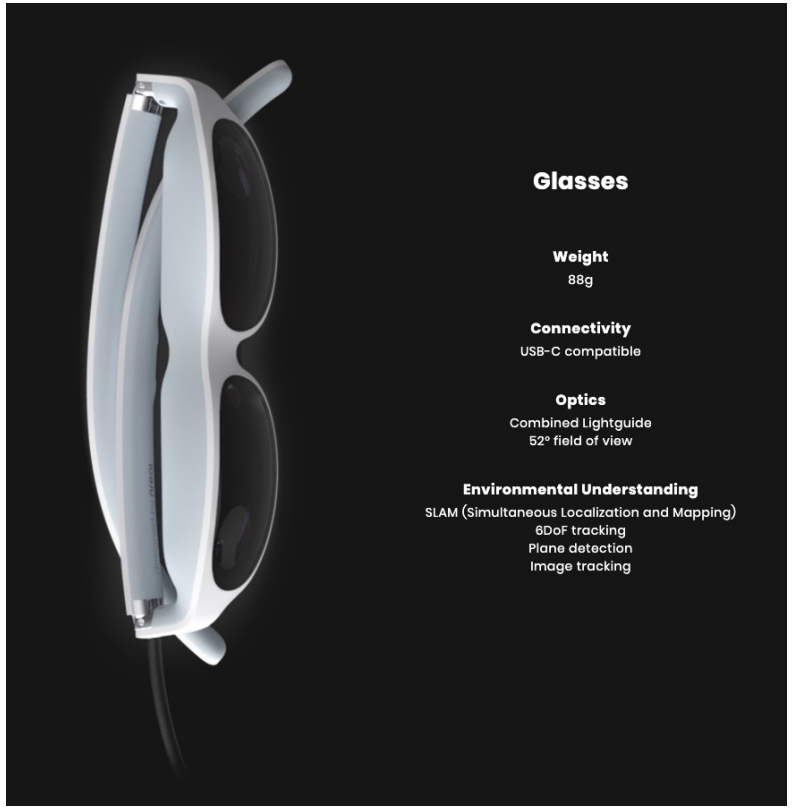
Smart glasses: Hololens 2 and Magic Leap (Azuma's definition, spatial mapping, still limited FOV)

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

https://www.youtube.com/watch?time_continue=6&v=HD9jeo9M8vo

AR devices

Smart glasses (spatial mapping with no depth camera, SLAM)



Nreal light (display, cameras, SLAM)

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

https://www.youtube.com/watch?v=VGjt6y3a_sE

AR devices

Smart glasses (**just adding contextual information**)

Google Glass

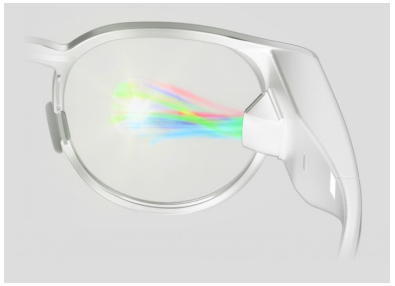
Vuzix M300

Vuzix Blade

AR devices

Smart glasses (**just adding contextual information**)

Bose frames: only augmented audio
(no camera, no display, but IMU)



North focals: no camera but laser display

AR devices

Smart glasses (**just adding contextual information**)

- Bosch is doing away with images projected onto lenses. Instead, its Light Drive glasses will beam images directly onto users' eyeballs with tiny lasers.

https://www.youtube.com/watch?v=ylGaEHuCuAs&feature=emb_logo

AR devices

Apple AR glasses release date rumours, features & patent news

Apple is working on an augmented reality device! We look at all the latest Apple AR glasses rumours, including the release date, price, and features of Apple's smart glasses

By Lewis Painter | 22 Oct 19

Apple Glasses

Apple is rumored have a secret team of hundreds of employees working on virtual and augmented reality projects.

By MacRumors Staff on October 21, 2019

PETER RUBIN GEAR 09.24.2019 02:05 PM

Apple's AR Glasses Are Hiding in Plain Sight

The company's iOS 13.1, due out today, contains new glimpses of smart glasses currently in progress.

NEWS

Apple AR glasses rumors: Latest reports point to 2020 release

At this point, it looks like Apple is barely hiding the development of its AR headset. Here's what we know.

TECH FACEBOOK VIRTUAL REALITY

Facebook says it will build AR glasses and map the world

By Adi Robertson | @thedextriarchy | Sep 25, 2019, 2:14pm EDT

TECH

Facebook working on smart glasses with Ray-Ban, code-named 'Orion'

PUBLISHED TUE, SEP 17 2019·2:42 PM EDT | UPDATED TUE, SEP 17 2019·8:55 PM EDT

Facebook: 'We are building AR glasses'

SEEING THE WORLD THROUGH AR GLASSES

Facebook is working on technology to turn us all into holograms

By Hanna Kozlowska · September 26, 2019

AR devices

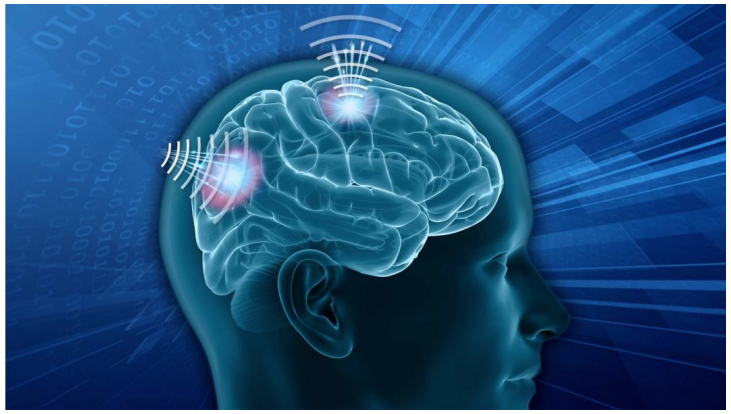
Handheld AR

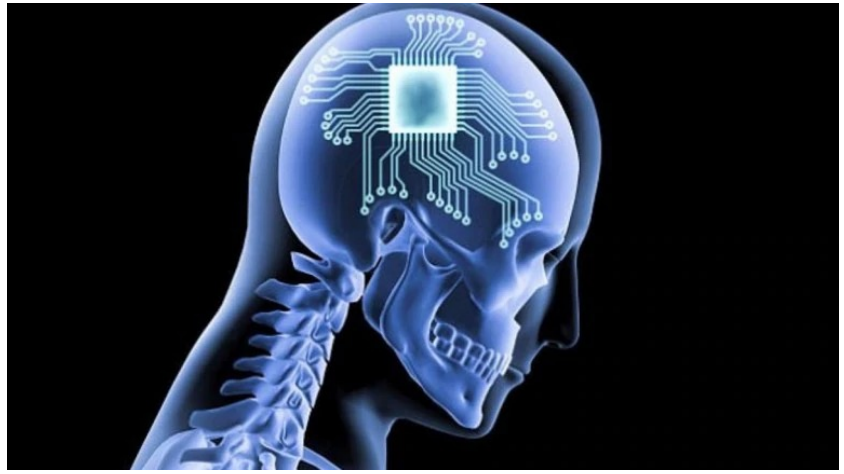
- Although it a special type of video see through, it deserves special mention
- Libraries such as Vuforia, has achieved the use of optical alignment (based on computer graphics techniques able to detect images and calculate its three dimensional orientation) a very common experience in mobiles and tablets
- New approaches based on SLAM (ARKit, ARCore, 6D.ai, Wikitude etc.) are boosting these possibilities and creating exciting AR experiences.

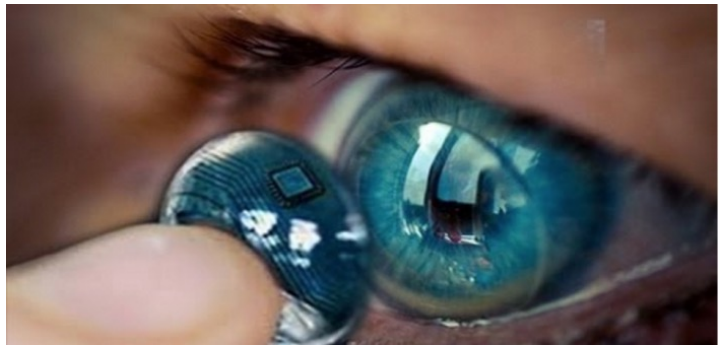
AR devices

Future

- Contact lenses
- Direct access to the brain (Neuralink, Neurable)







mojo

https://www.mojo.vision/

VR/AR devices

	Magic Leap 1	Microsoft Hololens 2	Nreal Light	Snap Spectacles	Lenovo ThinkReality A3	Facebook Oculus Quest 2	Varjo XR-3	Lynx R1
Image								
Standalone Headset	✗ Connects to Computing Unit	✓	✗ Connects to phone	✓	✗ Connects to PC or Motorola Phone	✓	✗ Connects to PC	✓
Optics Type	See-through	See-through	See-through	See-through	See-through	Pass-through	Pass-through	Pass-through
Optics Technology	Waveguides	Waveguides	Birdbath optics	Waveguides	Birdbath optics	Fresnel lenses	Bionic Display	4-fold catadioptric freeform prism
Eye Tracking	✓	✓	✗	✗	✗	✗	✓	✓
Countries Availility	USA / Europe / Japan	29 countries	Germany / Spain / Japan / South Korea	Selected Developers Worldwide	N/A	22 countries	35 countries	Not yet on sale
Release Date	08/2018	11/2019	08/2020	05/2021	Not yet on sale	10/2020	01/2021	Not yet on sale
Field of View - Diagonal	50°	54°	52°	26.3°	N/A	113°	N/A	90°
Field of View - Horizontal	40°	43°	N/A	N/A	N/A	89°	115°	N/A
Field of View - Vertical	30°	29°	N/A	N/A	N/A	93°	90°	N/A
Refresh Rate	120Hz	60Hz	60Hz	N/A	N/A	120Hz	90Hz	90Hz
Display Type	X	X	OLED	N/A	N/A	LCD	uOLED + LCD	LCD
Display Resolution (/eye)	1280x960	1440x936	1920x1080	N/A	1920x1090	1832x1920	1920x1920 + 2880x2720	1600x1600
Weight	316g	566g	106g	134g	130g	503g	594g + headband 386g	Unknown
SoC	NVIDIA Parker	Qualcomm Snapdragon 850	Via Smartphone	Qualcomm Snapdragon XR1	Qualcomm Snapdragon XR1	Qualcomm Snapdragon XR2	Via PC	Qualcomm Snapdragon XR2
RAM	8GB	4GB	Via Smartphone	N/A	N/A	6GB	Via PC	6GB
Memory	128GB	64GB	Via Smartphone	N/A	N/A	64-256GB	Via PC	128GB
OS	Lumin OS	Windows Holographic	Nebula	N/A	Android Based	Oculus Quest system software (Android based)	N/A	N/A
Wifi	Wifi 5	Wifi 5	Via Smartphone	N/A	Via PC/Mororola Phone	Wifi 6	Via PC	Wifi 6
Bluetooth	4.2	5.0	Via Smartphone	N/A	Via PC/Mororola Phone	5.0 LE	Via PC	5.0
Battery	3.5 Hours	2-3 Hours	Via Smartphone	30min	Via PC/Mororola Phone	2-3 Hours	Via PC	3 Hours
Charging	USB-C PD 2.0	USB-PD	USB-C	USB-C	Via PC/Mororola Phone	USB-C	USB-C	USB-C
Price	$2,295 - $2,995	$3,500	$499	Free for selected developers	Not announced	$299	$5,495 + $1,495 / 1 Year	<$1000 Soon on Kickstarter

https://docs.google.com/spreadsheets/d/1aUO8nuXWCnL1xYnpe9tvSgCphifhMRLrFj1enayv0X8/edit#gid=0

AR devices

Future

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

- Neuralink (merging brain and machine, augmented intelligence, bidirectional communication etc.):
  - https://neuralink.com/

AR devices

References:

- "Augmented Human: How technology is shaping the new reality" by Helen Papagiannis
- "Practical Augmented Reality: A guide to the technologies, applications, and human factors for AR and VR (Usability)" by Steve Aukstakalnis
- "Augmented Reality: Principles and Practice (Usability)" by Dieter Schmalstied and Tobias Hollerer