Walking through the Immersive World!

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Why are we so fascinated with Mixed Reality ?!

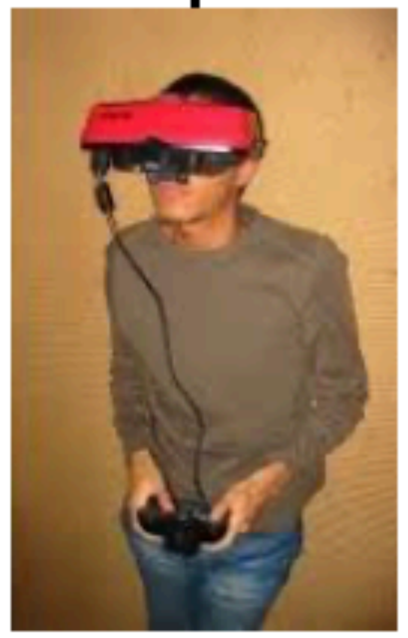
- Experiencing the immersion and presence
- Next level being
- Cognitive immersion effect
- Moving from perception to precision: problem solving
- A portal to infinite potentials
- Contextual intelligence in motion: AI as the mind, MR as the lens

History of Virtual Reality: Pioneering Era

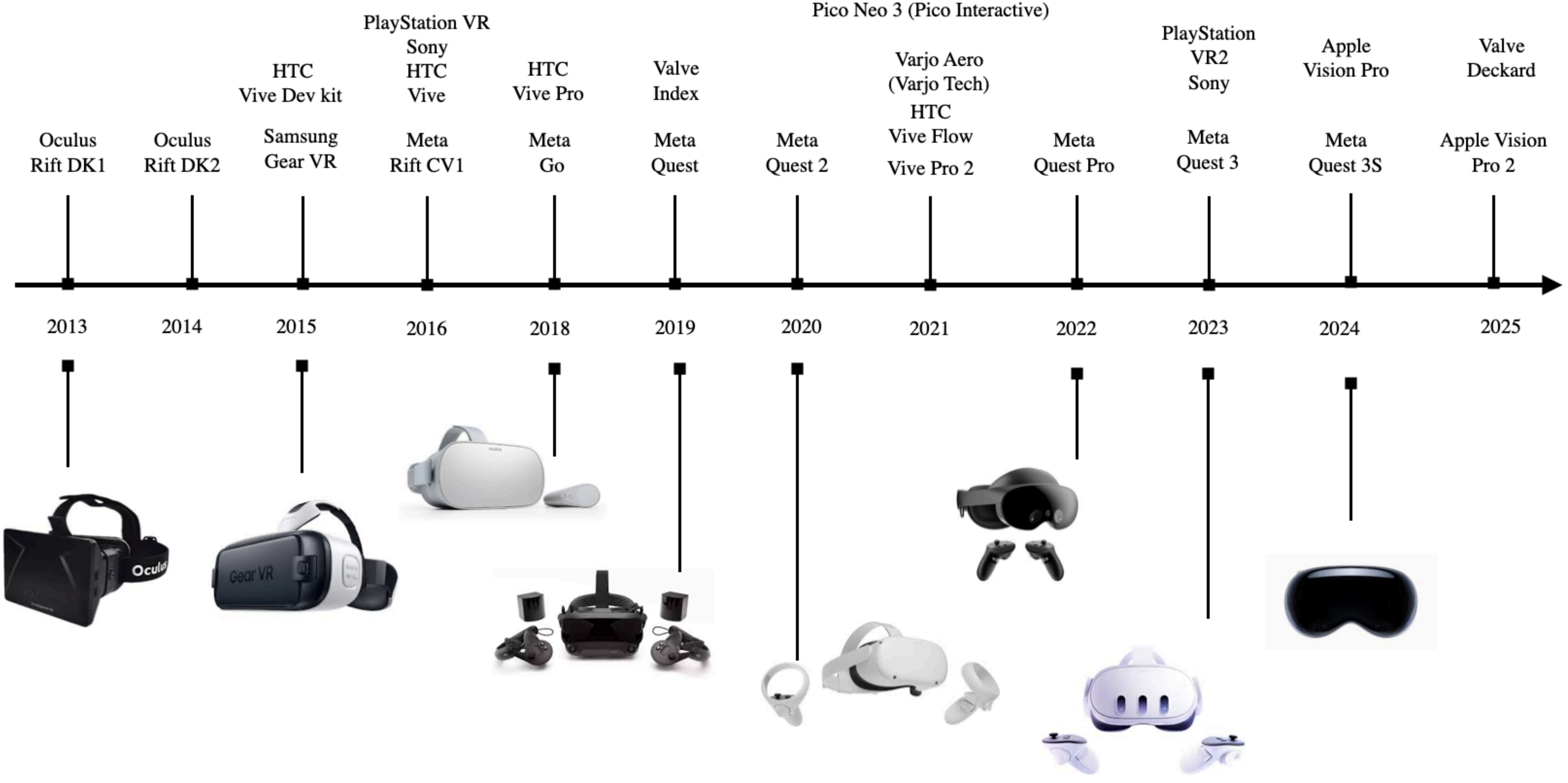
Sword of Damocles	1968	Ivan Sutherland (Univ. of Utah)	First HMD with head tracking
VCASS	1984	McDonnell-Douglas (U.S. Army)	Military simulation system
VPL EyePhone	1985	Jaron Lanier (VPL Research)	First commercial HMD for VR
VPL DataGlove	1989	VPL Research	Early gesture control device
Virtuality 1000CS	1991	Virtuality Group (UK)	Arcade VR with tracking, stereoscopic 3D
Nintendo Virtual Boy	1995	Nintendo	1st consumer VR headset
Sony Glasstron	1997	Sony	Wearable display; some VR features
CyberMaxx	2001	VictorMaxx	Early PC-compatible VR headset
eMagin Z800 3DVisor	2007	eMagin	Head-tracked 3D display for PCs
Forte VFX1 Headgear	2010	Forte Tech	High-end PC VR headset



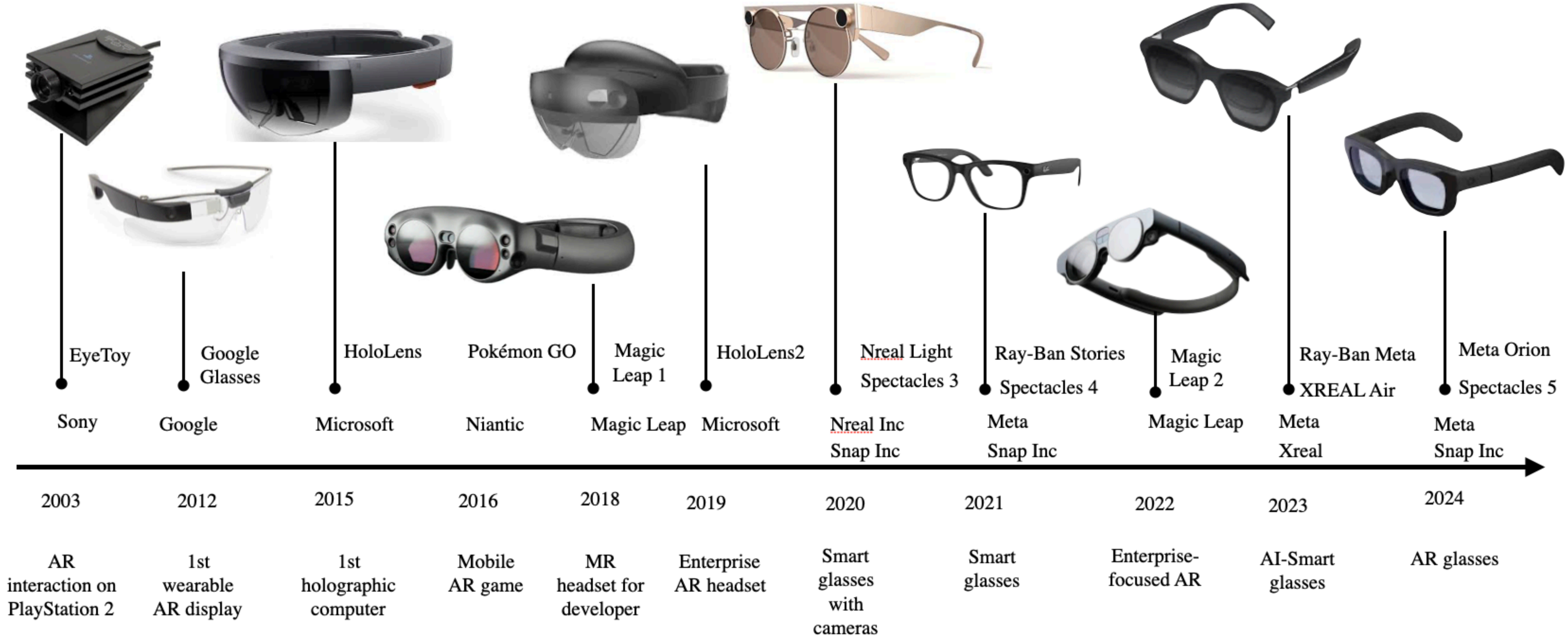





History of Virtual Reality: Recent Era



History of Augmented Reality:



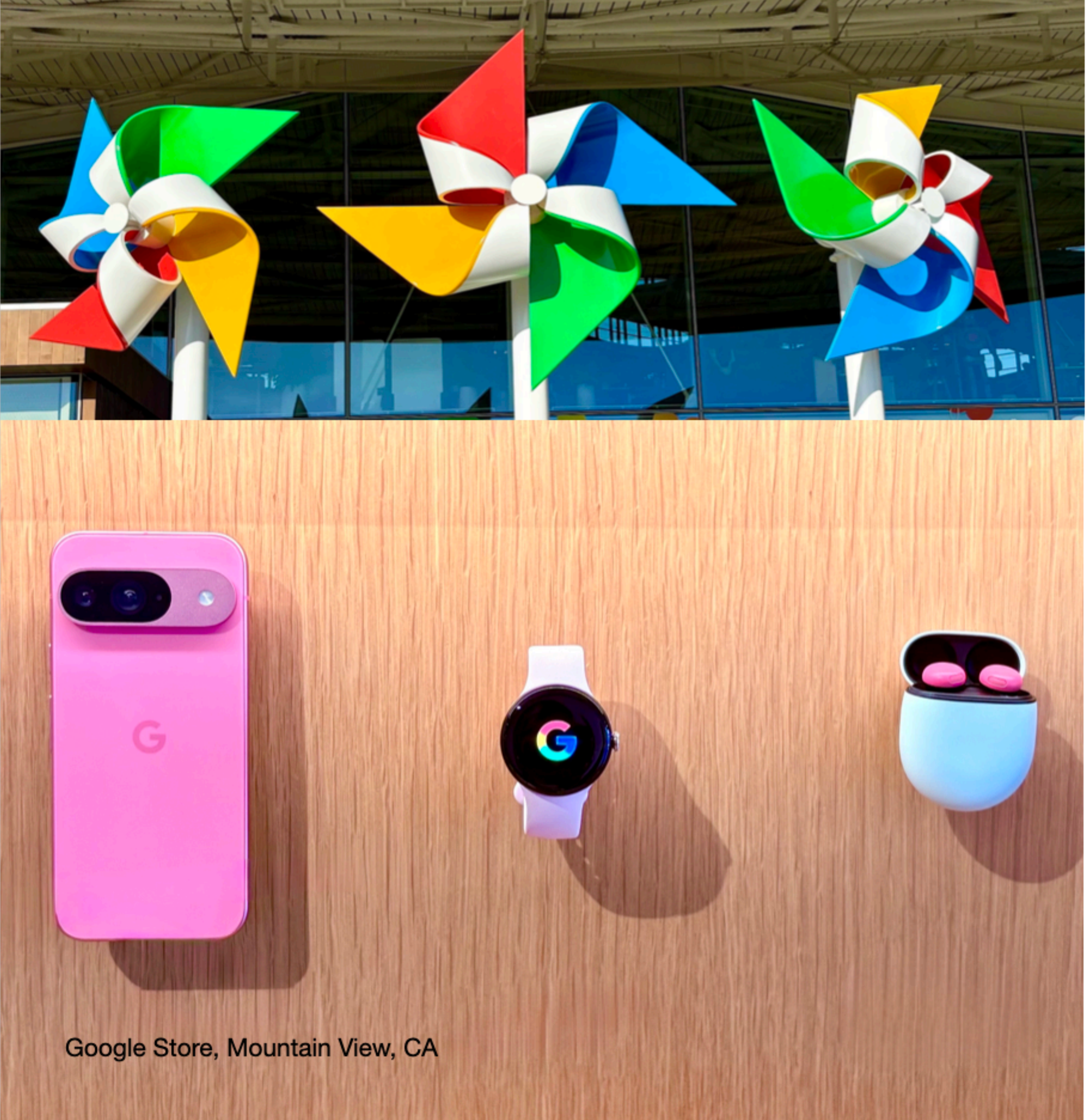

HW
XREAL
Google
htc
SONY
Snap Inc.
SAMSUNG
MagicLeap
XR
SW
REC ROOM
Ultraleap
MAWARI
Enabler
OMNIVISION
Warby Parker
Essilor Luxottica


Meta (USA)
Apple (USA)
Google* (USA)
Snap in (USA)
Microsoft (USA)
MagicLeap (USA)
Vuzix (USA)
HP (USA)
Valve (USA)
Varjo (Finland)
Lynx(France)
VRgineers (Czech Republic)
Pico (ByteDance) (China)
DPVR (China)
Xreal (China)
Lenovo (China)
Huawei (China)
HTC (Taiwan)
ViewSonic (Taiwan)
Sony (Japan)
Samsung (SK)
Zero Latency VR


Google headquarter, Mountain View, CA

Google, the earliest to join the AR/VR train

- Google introduced **Google Glass**, a wearable AR device with a display; however, the market was very skeptical:
    - User interface and product design didn’t fly
    - Privacy became a concern
    - Use cases were limited
- **Project Astra**, a wearable AR glass, with a color display, AI assist and rich set of sensors, 2024
- **Daydream**, a VR platform that included a headset and controller, 2016.
- **Android XR**, an operating system for AR/VR devices, as its new focus, 2023.



- Early experience in AR
- AI as the core enabler for smart glasses
- Commitment to Android XR for immersive ecosystem
- Leveraging partnership for HW development
- Success with new hardware product introduction

- Consumer adoption challenges
- Lack of flagship consumer AR device
- Bridging research and product efforts
- Inconsistency HW strategy

Building the Metaverse: Meta's Vision in AR/VR

- Dominant market share of Meta VR lineup
- Aggressive investment
- Developing/enhancing social presence and avatar
- Integrated HW-SW ecosystem
- Focus on mass-production of AR glasses at a manageable cost

- Unclear use cases
- “Killer App”
- High cost of the truly game-changing AR technology
- Close ecosystem as opposed to an open platform

Snap inc booth, AWE 2025, Los Angeles, CA

The Augmented Reality Lens: Snap's Vision for the Future

- Innovative AR hardware
- Lens studio & creator ecosystem (300K creators to build 3M lenses)
- Strategic acquisitions to build full-stack AR (WaveOptics and Compound Photonics)
- Mainstreaming AR with lenses (300M users)

- Slow consumer adoption of spectacles
- Revenue vs. R&D spend in AR hardware
- Under-leveraged AR platform beyond snapchat

Microsoft’s limited but influential role in AR/VR

- 1st generation of HoloLens, 2016
- Shift to enterprise and eventually dropped HoloLens
- Core technology development
- “good at enterprise” but failed enterprise (IVAS):
  - Requirements misalignment
  - Technology maturity and battlefield readiness
  - Cost and public scrutinizing
  - Lack of competency in HW development
- Lacking rapid iteration in complex AR hardware.

Integrating Apple's Ecosystem with Spatial Computing

- Software 1st approach
- Apple acquired multiple companies in the XR field: PrimeSens (2010), Metaio (2015), Faceshift (2015), Flyby Media (2016), Vrvana (2017), Akonia Holographics (2018)
- Apple’s first "spatial computer," a mixed-reality headset, **Vision Pro,** in 2024.
- Playing the long game

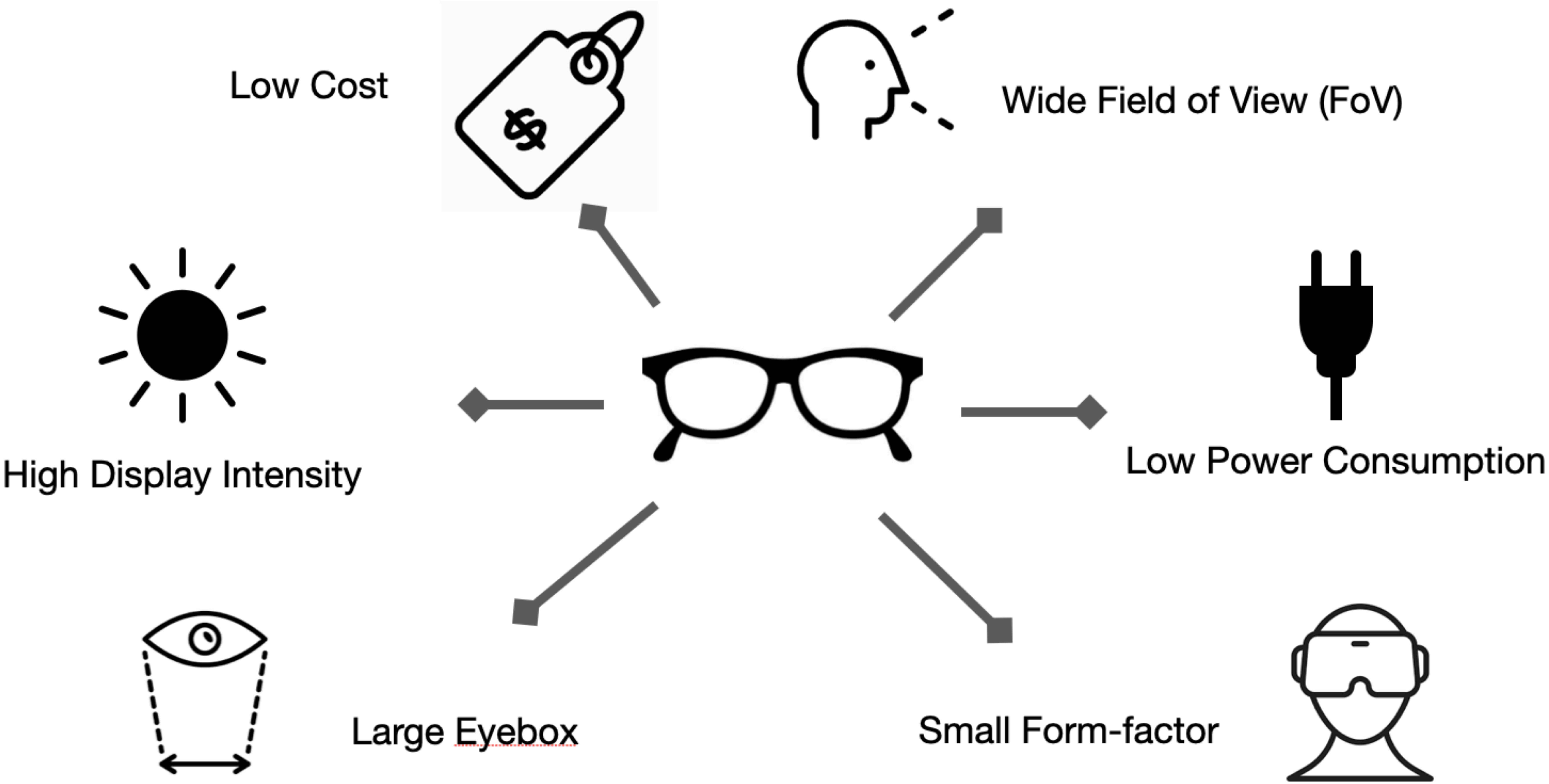
- High-end industrial design and premium HW
- Seamless integration with robust Apple ecosystem
- Emphasis on privacy and security
- Leveraging strong brand loyalty and market influence
- Strong control on the supply chain
- Expansion and investment in spacial compute ecosystem

- Lack of consumer attraction due to high cost and bulkiness
- Mixed response to the core technologies

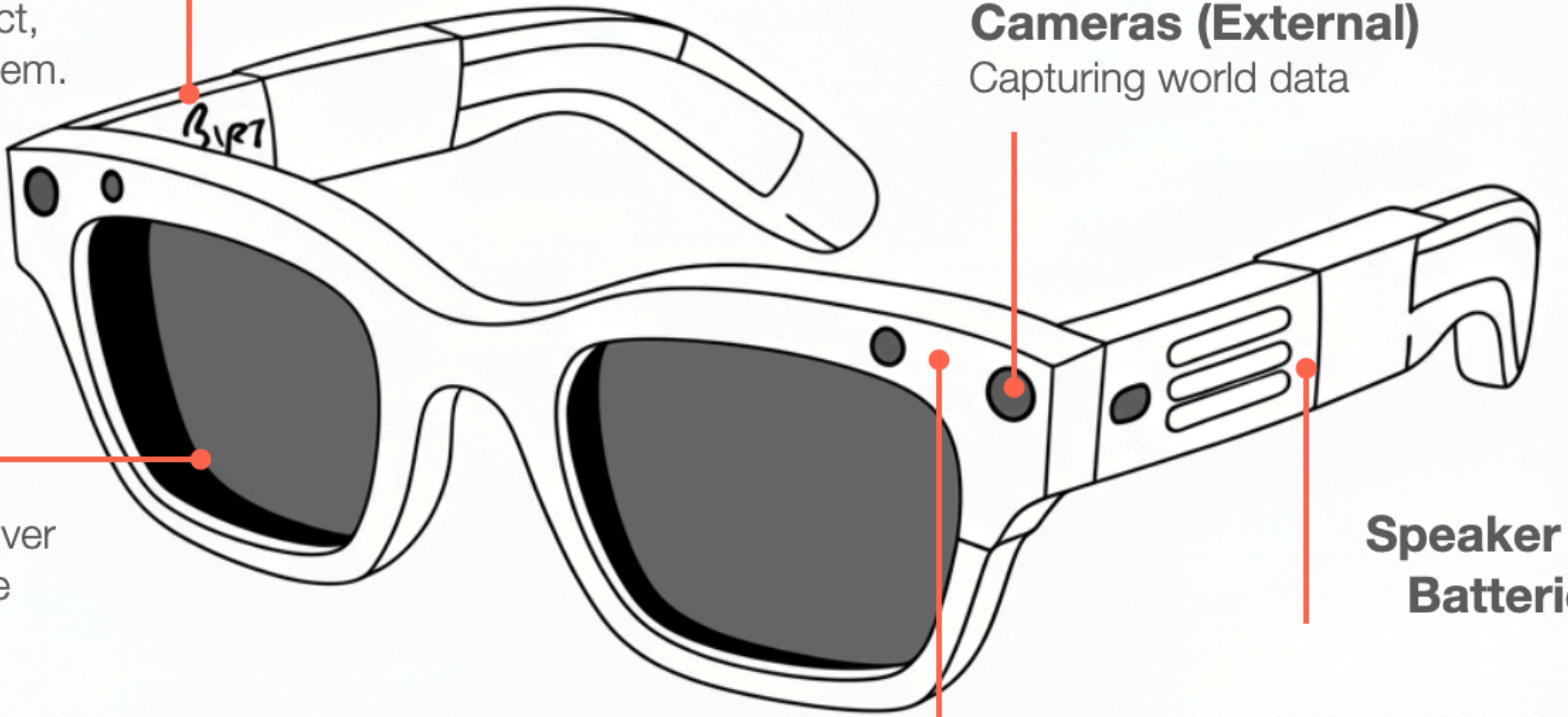
Beyond Glasses FormFactor

Mojo Vision, Saratoga, CA

Design Specifications



Key Technology Components



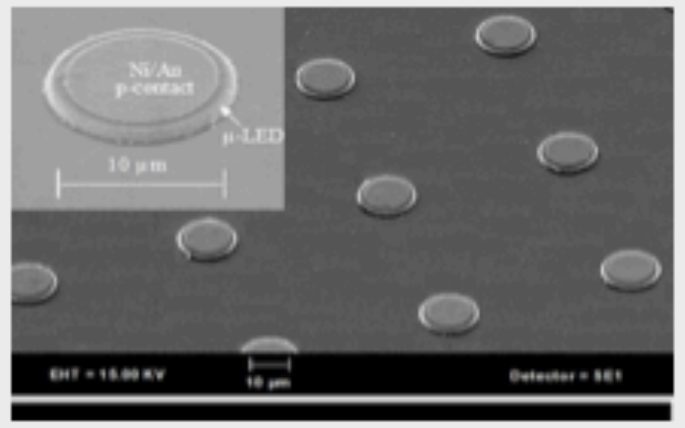
Display Technology

MicroLED

Each pixel is a self-emissive LED directly bonded on a silicon CMOS backplane.

✓ High brightness, contrast and pixel density
✓ Fast response times
✓ High power efficiency

- Expensive
- Complex processing

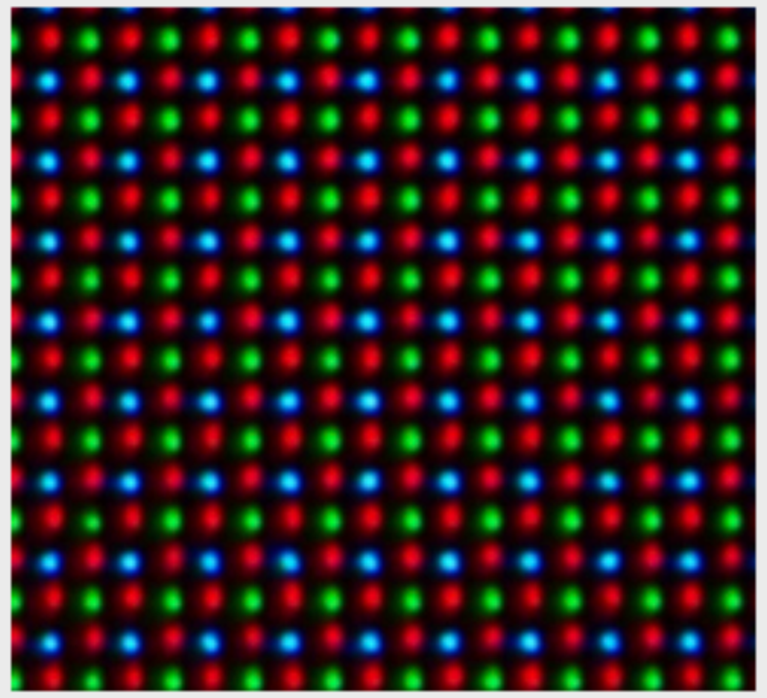


Micro OLED

Self-emissive panels where individual organic light-emitting pixels are directly integrated onto a silicon CMOS backplane

✓ High contrast, pixel density
✓ Fast response times
✓ Compact size

- Low intensity
- Susceptible to OLED burn-in

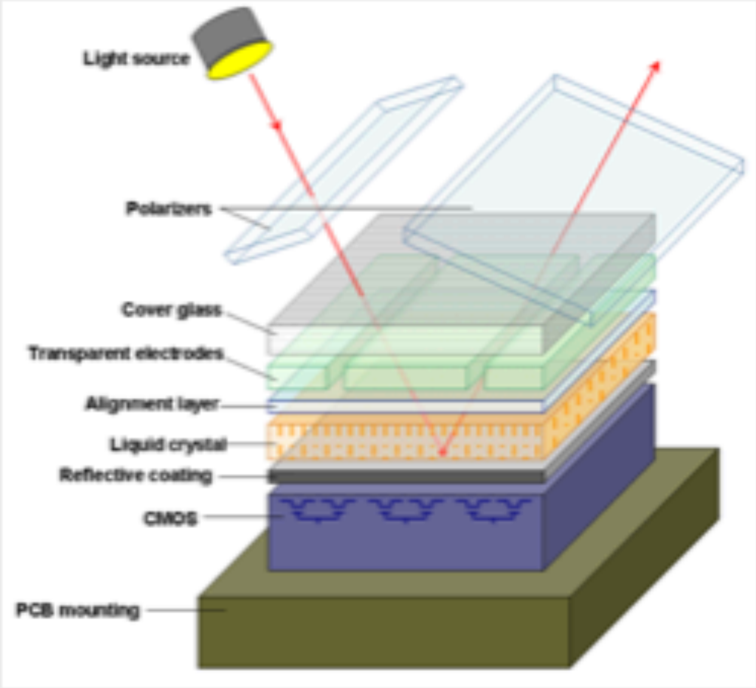


Liquid Crystal on Silicon (LCOS)

A reflective display where an external light source is modulated by a liquid crystal layer on a silicon backplane.

✓ High resolution
✓ Good fill factor

- Requires an external light source
- Slow refresh rates



Laser Beam Scanning (LBS)

A scanning modulated laser beams (RGB) generates an image directly onto a tiny mirror or waveguide, or the user's retina.

✓ High resolution, brightness and contrast
✓ Compact size

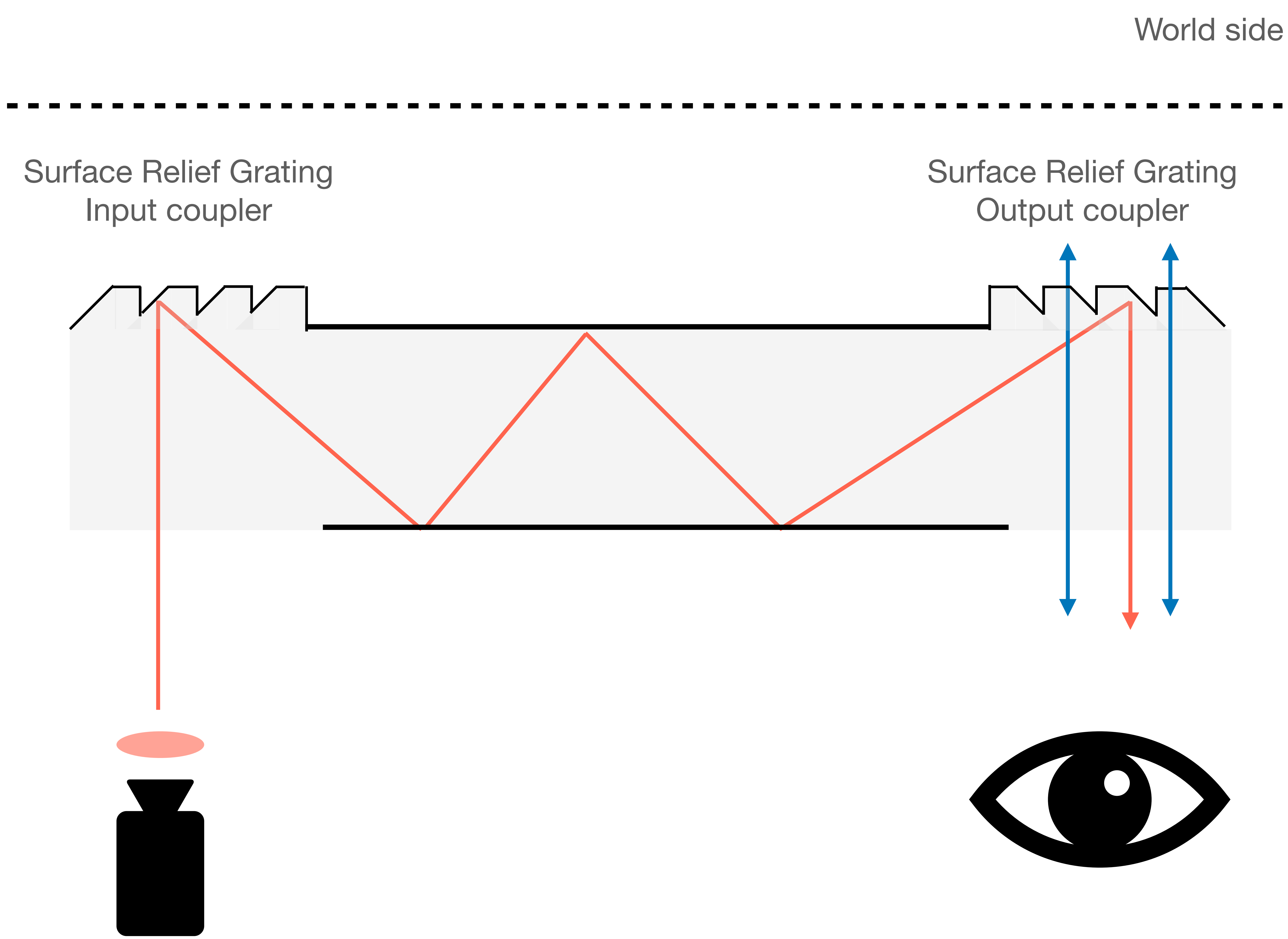
- Suffers from "laser speckle" (a grainy appearance)
- Color uniformity issues
- Eye safety concerns

Waveguide Technology | Surface Relief Grating/ Diffractive

Surface Relief Grating (SRG) waveguide is an optical system that utilizes microscopic, patterned structures etched onto the surface of a transparent substrate to manage light. These gratings diffract light from a micro-display or light engine into the waveguide, where it propagates through total internal reflection (TIR).

Diffractive WG:

- Low efficiency
- Hard to manufacture repeatedly
- Lack of uniformity (imperfections of grating)
- High index materials are expensive (to achieve high FoV)

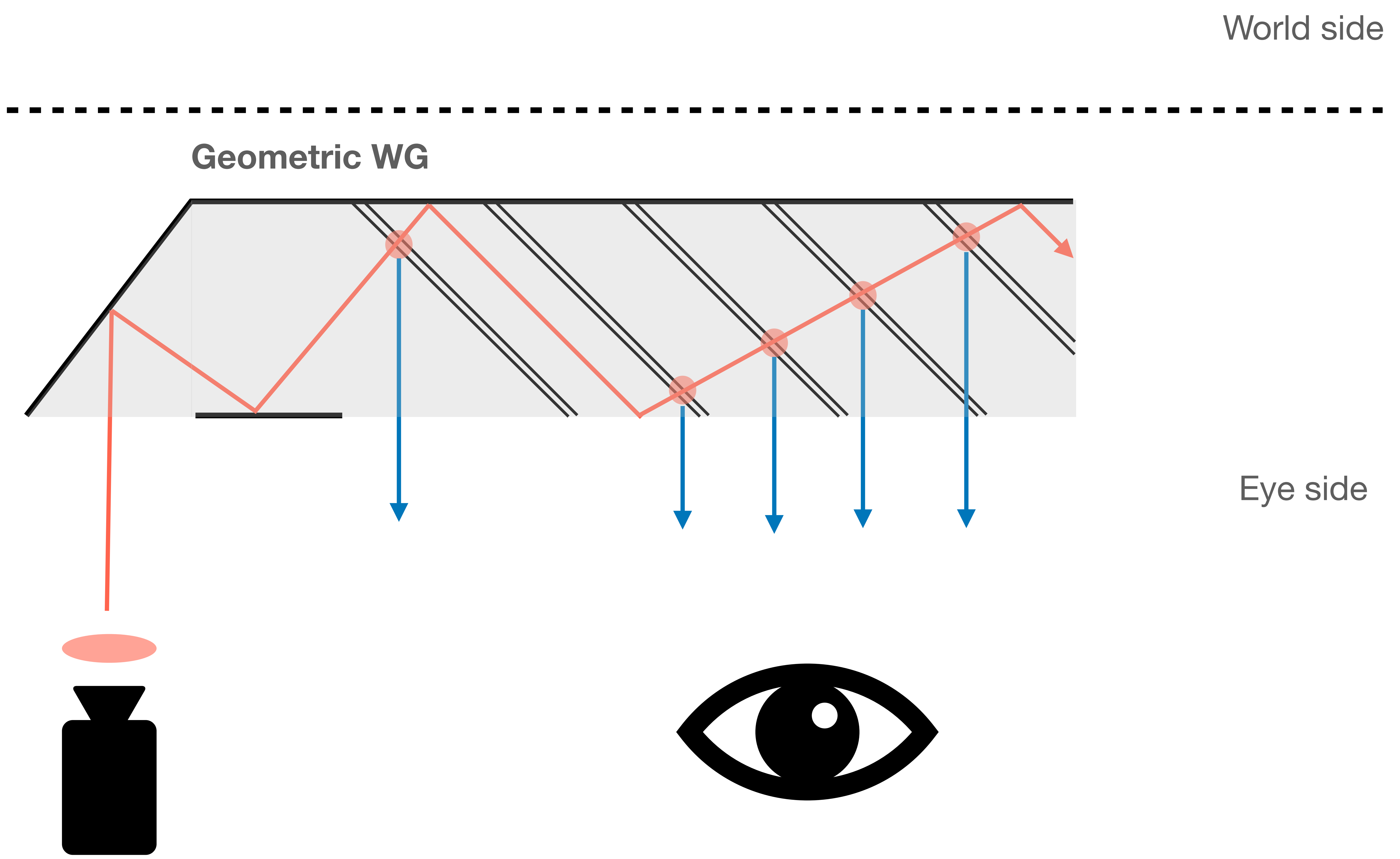


Waveguide Technology | Geometric/Reflective WG

Geometric WG uses an array of miniature reflective or partially reflective surfaces (such as mirrors or beam splitters) to guide light from the light engine to the viewer's eye. This waveguide effectively "folds" the optical path, coupling the virtual image into the viewer's eye, which then overlays onto their view of the real world.

Geometric Reflective WG:

- Bulky couplers (prisms/mirror arrays, glass based)
- High precision fabrication steps (image artifacts)
- Low yield and high cost (fabrication complexity)
- Degraded image clarity (ghosting)

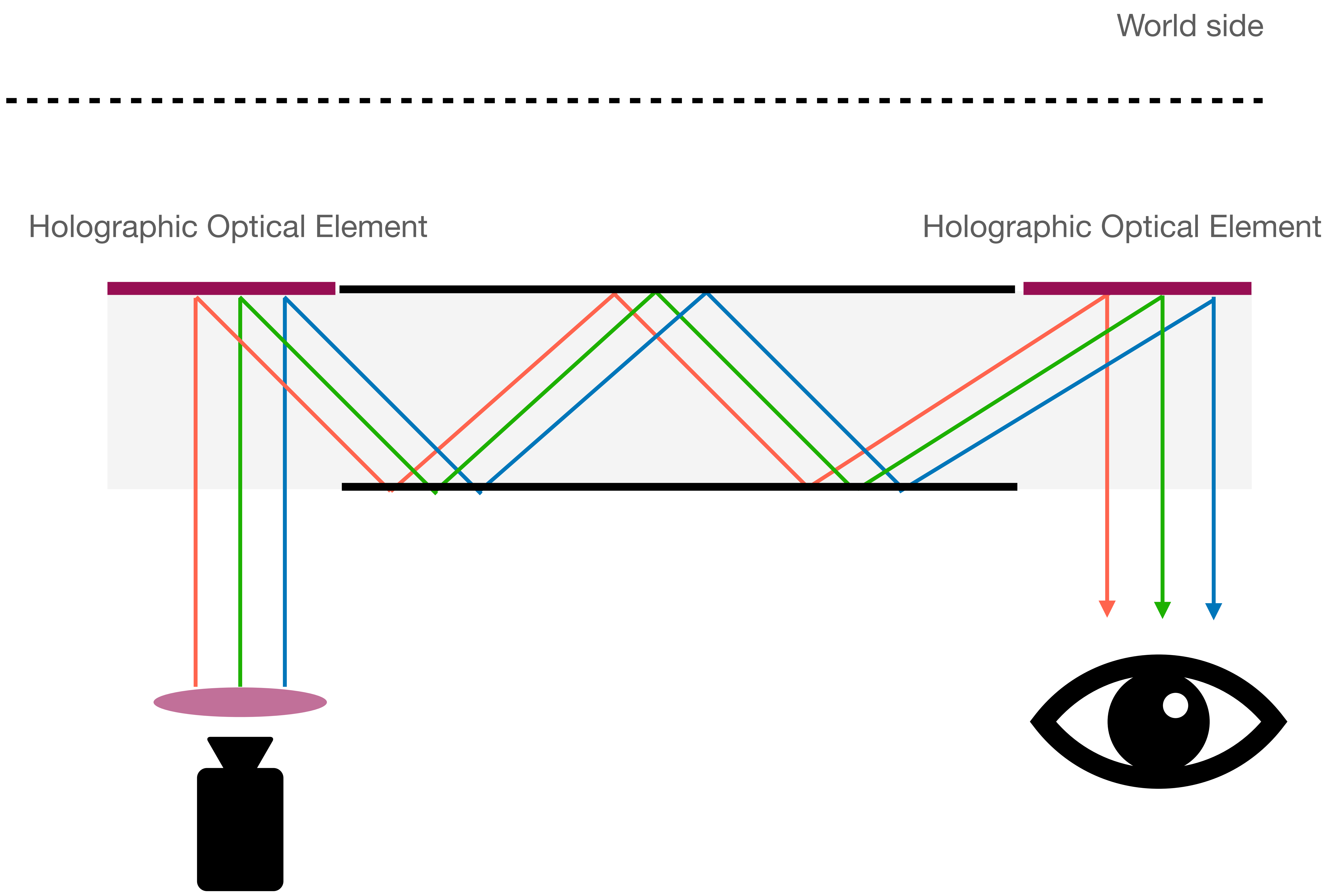


Waveguide Technology | Holographic

Holographic WG employs Holographic Optical Elements (HOEs) to manage light propagation. HOEs are specialized interference patterns recorded within or on the surface of a transparent medium.

Holographic WG:

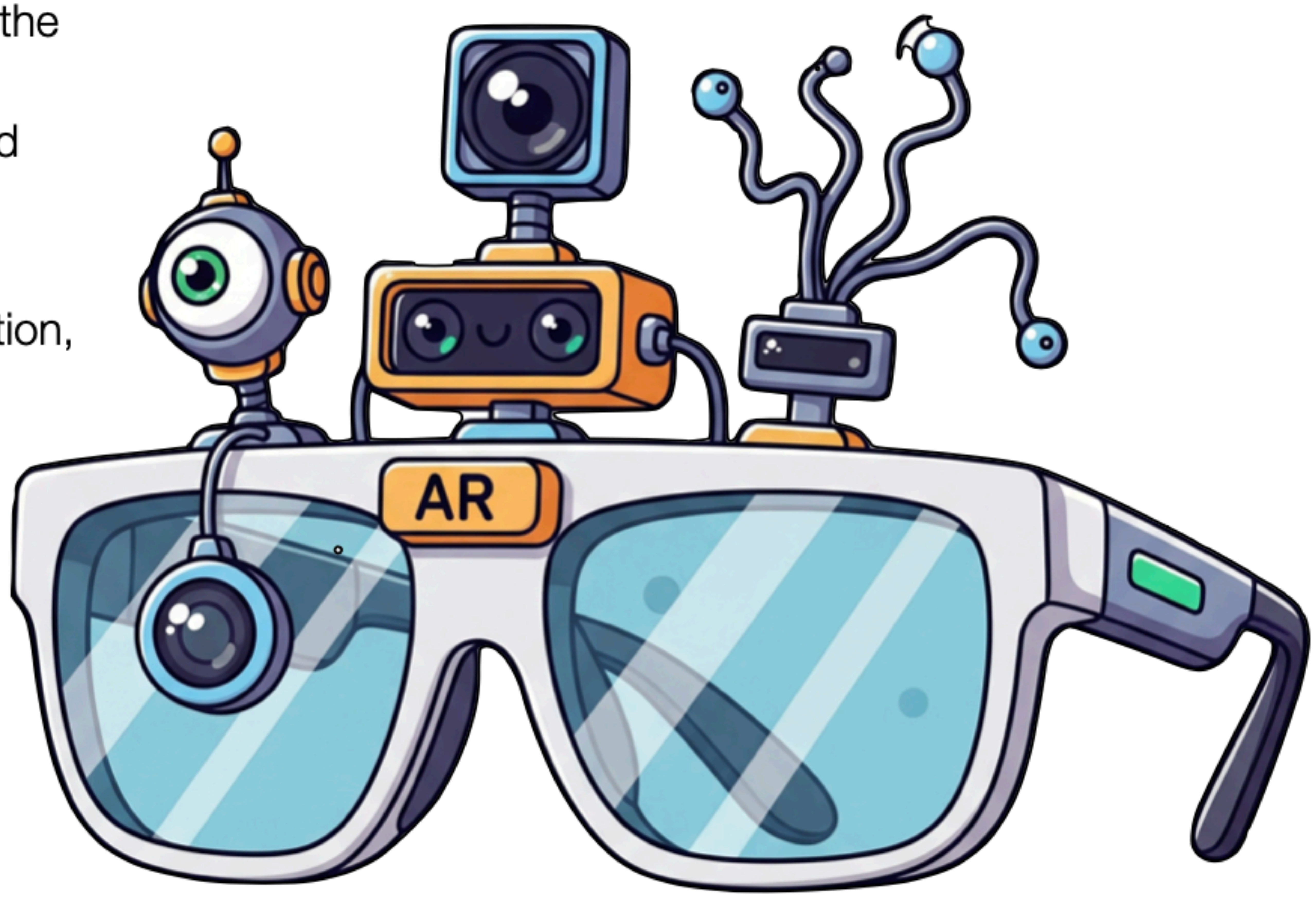
- Chromatic aberration
- Limited efficiency
- Scattering and haze



Next-Generation Sensors: Enabling Intelligent Systems

Environmental Sensing Sensors:

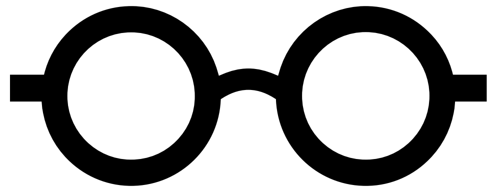
- High-Res RGB Cameras: The "eyes" of the AR glasses
- Depth Sensors (LiDAR and/or Structured Light)
- IMUs (Inertial Measurement Units):
  - Applications: measure motion, orientation, and gravitational forces
  - Accelerometers
  - Gyroscopes
- Microphones



User Sensing Sensor:

- Eye tracking often IR cameras
- Hand tracking (RGB and/or Depth)
- Face tracking

Other Considerations:

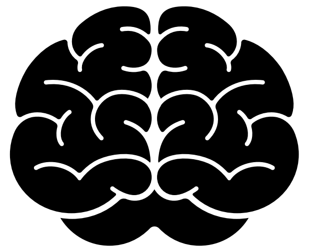


Prescription lens integration:

- Magnetic inserts:
  - ✓ Low cost, easy to attach
  - \- Heavy, potential reflection
- Direct attachment:
  - ✓ Seamless, optimal optical quality
  - \- High cost, not swappable, manufacturing complexity

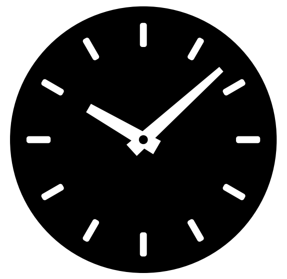
Battery:

There are many active sensors including high res cameras, depth sensors, processors, etc. which are power hungry.



Computational load:

Culprits: Real-time SLAM, sensor fusion, high-resolution rendering, computer vision & AI and eye/hand/face tracking.

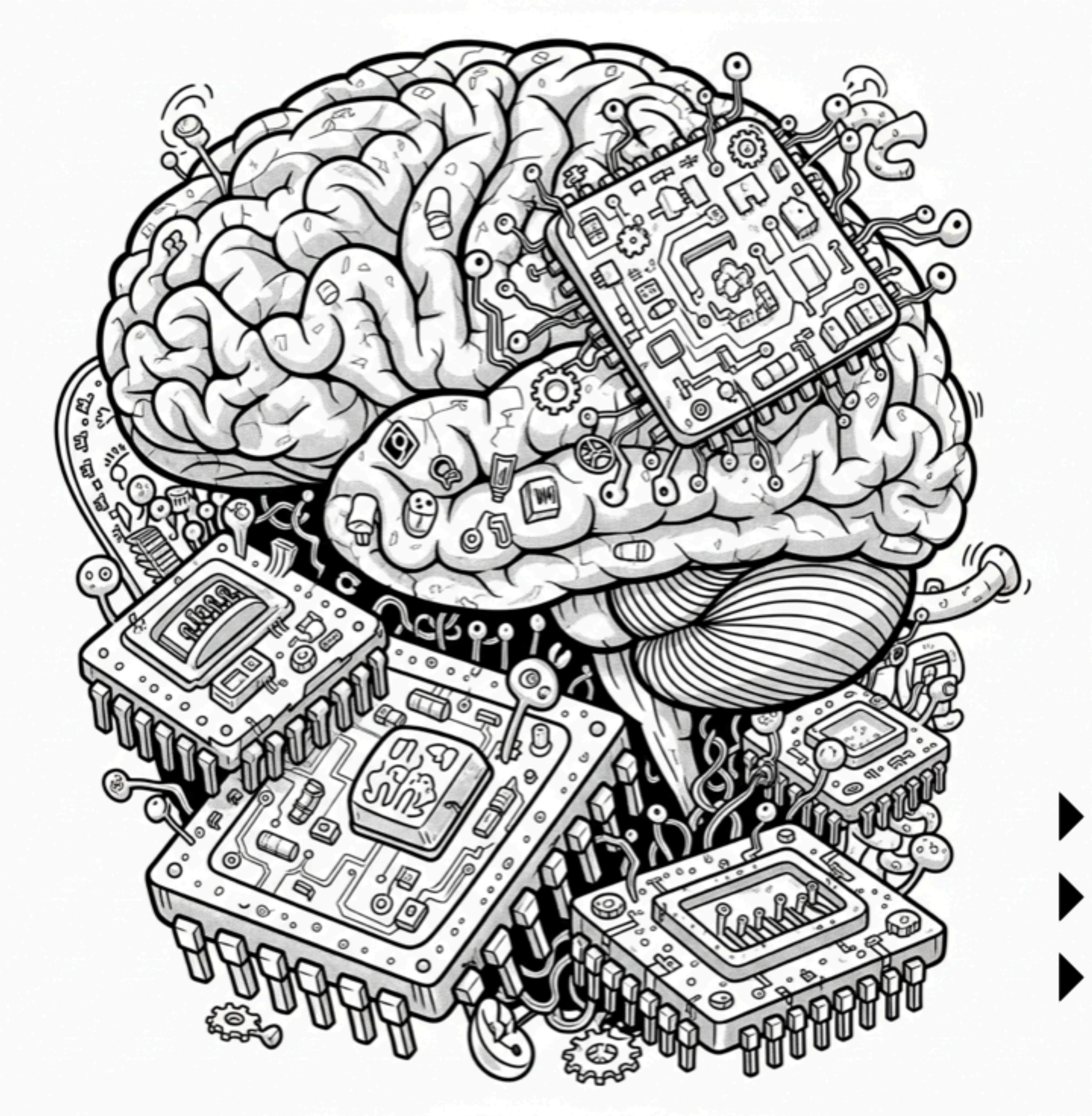


Latency:

High latency leads to motion sickness, interaction fidelity and lack of immersion and realism.

- Options to mitigate: on-device processing, tethered computing, cloud computing, hybrid approaches

Beyond Reality: How AI is Redefining XR



Object Recognition

Contextual Awareness

Human-in-the-loop

Gesture Recognition

Computer Vision

Model validation and refinement

Simultaneous Localization and Mapping

Data collection and annotation

- AI makes AR systems truly understand the physical world
- AR is a "Window" for AI's perception, AR gives AI "eyes" and “ears”
- AR systems can generate data for training AI models

- XR is evolving rapidly with AI being the core driver
- Key players face diverse challenges & opportunities
- Hardware innovation is crucial
- We need to look beyond glasses