# REVERSE PASS-THROUGH VR

Facebook Reality Labs Research

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# Abstract

***Reverse-through VR.***

“We introduce reverse pass-through VR, wherein a three-dimensional view of the wearer’s eyes is presented to multiple outside viewers in a perspective-correct manner, with a prototype headset containing a world-facing light field display. ”

“A three-dimensional view of the wearer’s eye is presented to multiple outside viewer.”

This prototype of the display with the nature eye usage method which connect the real world the the visual world through display device with the eye image with some social behavior requirement.

- ➢ Pass-through was the topic during this research.

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CCS CONCEPTS
• Computing methodologies → Virtual reality.

KEYWORDS
reverse pass-through, light field displays, virtual reality

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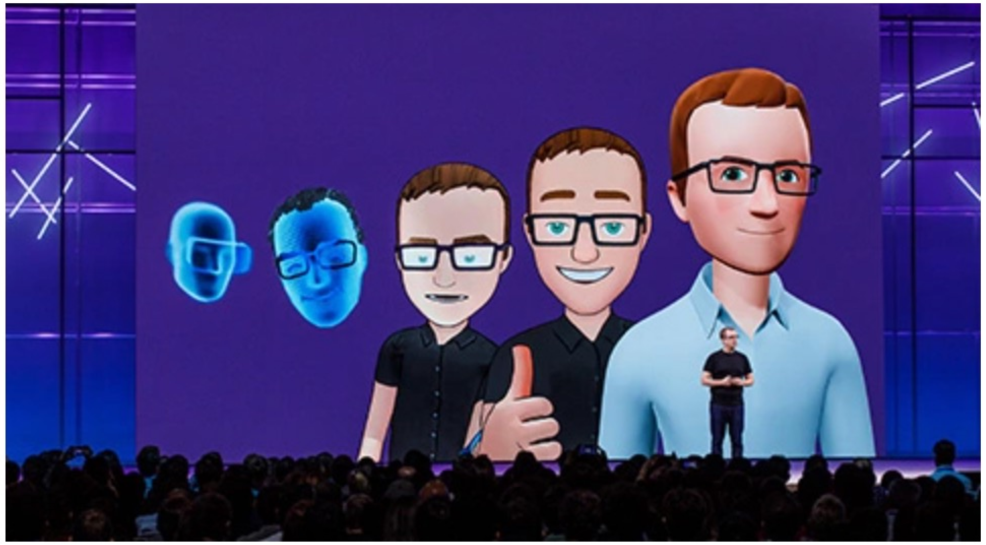


# Reality Labs Research

While VR and AR may seem like distinct experiences today, over time they'll converge and allow us to combine real and virtual worlds freely. And Reality Labs Research is focused on helping to build that future.

Reality Labs Research brings together a world-class team of researchers, developers, and engineers to create the future of AR and VR, which together will become as universal and essential as smartphones and personal computers are today, changing how we work, play, and connect.

We're developing all the technologies needed to enable breakthrough AR glasses and VR headsets, including optics and displays, computer vision, audio, graphics, haptic interaction, full body tracking, perception science, and true telepresence.

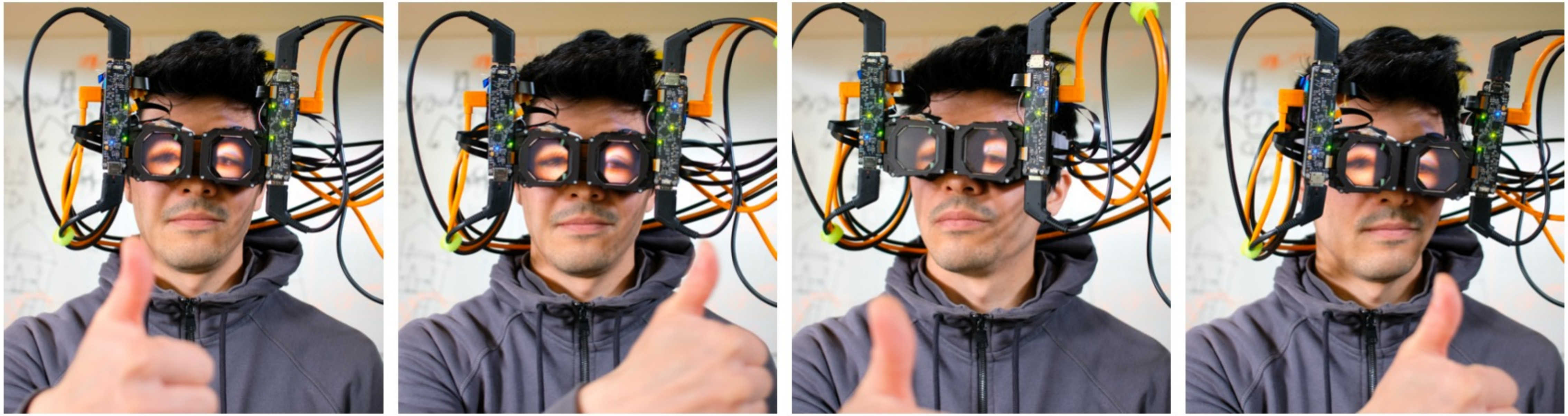
https://tech.fb.com/ar-vr/

# INTRODUCTION

"In recent years, ***virtual reality*** (VR) headsets have become a ***consumer technology***, with the hope that their uniquely immersive display and interaction systems will lead to more compelling entertainment, productivity, and telepresence applications.

Yet, as emphasized by Gugenheimer et al. [2019], little attention has been paid to resolving a core deficiency: VR displays isolate the user from their environment and, in doing so, limit VR use and acceptance in shared and public spaces [Mai and Khamis 2018; Schwind et al. 2018].

Eliminating this isolation is a key motivation for the development of video pass-through VR, wherein the VR headset user sees a reproduction of their external environment and the individuals within it. Yet, a crucial gap remains: External viewers cannot hold a natural conversation with a VR headset user, whose upper face and eyes remain occluded."



External viewer with different direction to review the Pass through image.

https://dl.acm.org/doi/10.1145/3450550.3465338

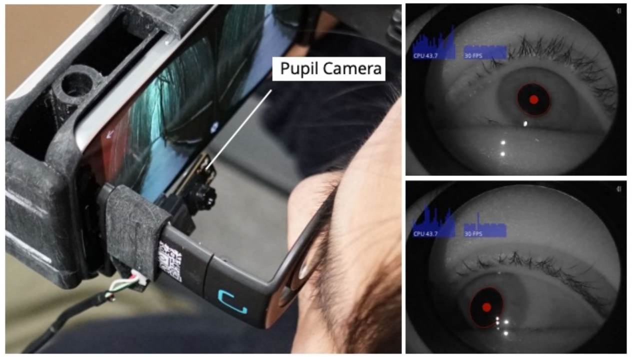



**Figure 3. Eye tracking function enabled with single eye camera.**

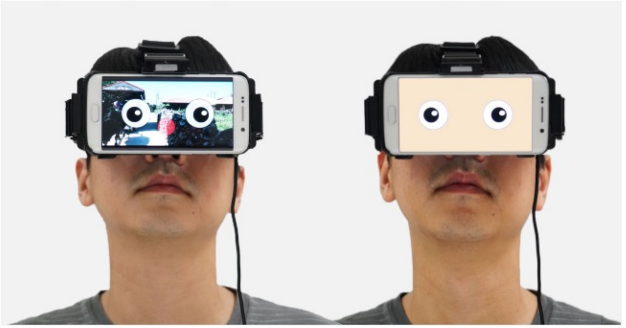


**Figure 4. Front screen allows a players interaction state to be communicated with outsiders by displaying the players presence in the virtual or real world and visual attention.**

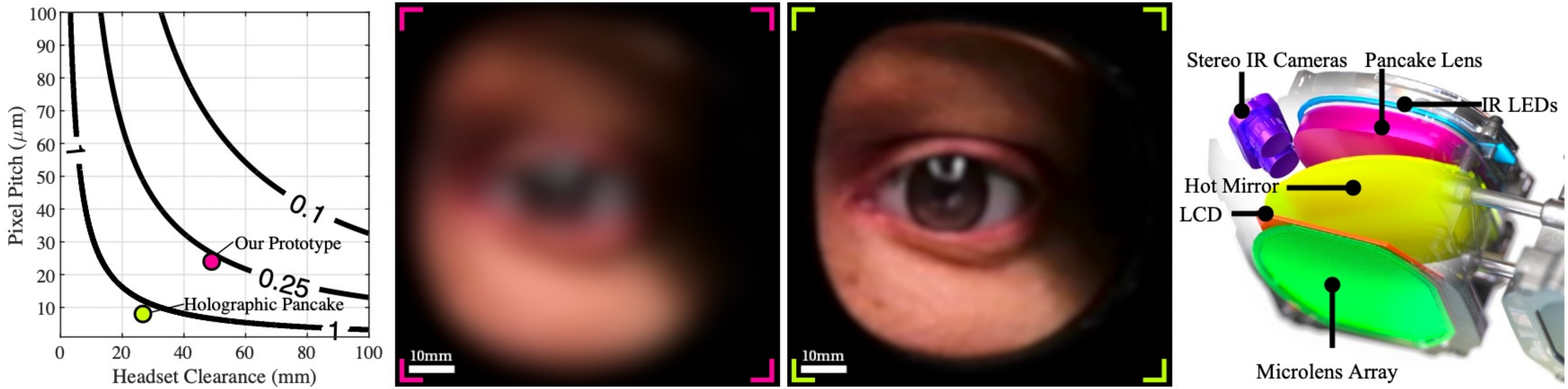
Several efforts have been made to depict the occluded features of a VR headset user’s face on external, world-facing displays.

- “ **Chan and Minamizawa [2017]** depict an eye-tracked illustration of the user’s eyes to give a sense of the user’s gaze direction and attention.”

- “To partially address these limitations, Mai et al. [2017] depict a hand- tuned face model that is aligned to the perspective of a single external viewer and supports a manually controlled gaze direction. “

➢ This research provide some basic idea about external and internal connection with BCI devices in eye vision activities.

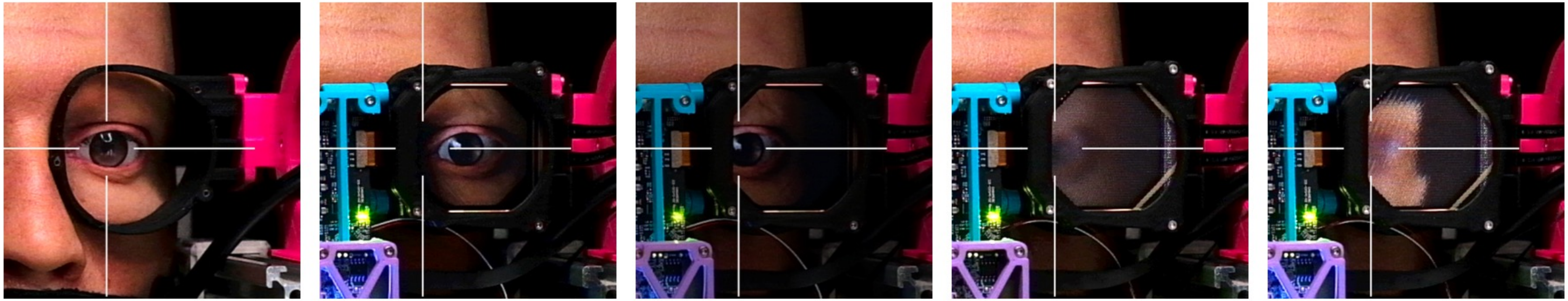
Figure 2




**(a) Light Field Display Resolution** **(b) Our Prototype (Modeled)** **(c) Holographic Lens (Modeled)** **(d) Prototype Layout**

“We advocate for **user-facing cameras**, **real-time reconstruction of facial geometry**, and **autostereoscopic world-facing** displays to deliver an accurate recreation of the user’s hidden face and eyes for an arbitrary number of external viewers.”

# REVERSE PASS-THROUGH DISPLAYS



(a) Ground Truth (b) 2D, Offline (c) 2D Tracked, Offline (d) Light Field, Offline (e) Light Field, Online

(a) Ground truth view of a mannequin head with display assembly removed.
(b) Baseline approach showing an offline photogrammetry reconstruction of the face on an external 2D display.
(c) Offline photogrammetry reconstruction of face reprojected to tracked viewer position on 2D display, supporting one viewer.
(d) Proposed light field architecture displaying offline photogrammetry reconstruction, supporting multiple viewers.
(e) Proposed architecture displaying live reconstruction, supporting multiple viewers. The white crosshairs are aligned to the ground truth pupil position.

# IMPLEMENTATION

Designing a **physical prototype** was to use components that are readily available.

- **hardware subsystems** (the light field display and stereo camera systems) and
- **software sub- systems** (eye image synthesis, camera and display calibration, and light field rendering) following this principle.

**Light Field Display**

The MLA has the following specifications:

- 42° field of view
- 520µm focal length
- 500µm pitch
- F/0.90 measured corner-to-corner (F/1.04 edge-to-edge)

The microlens array is backed by a BOE 1600x1600 color LCD with 24µm pixel pitch (8µm RGB stripe).

## Eye Image Capture and Synthesis

- We designed an eye capture system that is compatible with existing eye tracking architectures.
- We used a pair of near-IR Omnivision OV9281 CMOS sensors driven by an Omnivision OV580 USB stereo capture board.
- A Chroma Technology T700 IR-reflective hot mirror provides a relatively on-axis view of the eye (17.5deg off-axis).

Figure 2 for a cutaway view of the camera geometry.

The requirement **for high-quality, low-latency 3D reconstruction and colorization** from infrared images for a limited domain (eyes) leads naturally to deep learning techniques.

## *Image data processing*

- The resulting dataset contains 10,000 stereo image pairs for color and IR textures, over varying head positions, eye gaze directions, and eyelid poses.
- This dataset was used to refine the AnyNet model, pre-trained on the SceneFlow Driving Dataset [Mayer et al. 2016], over 300 epochs using default parameters.
- To train the colorization network, we captured 300 real IR/color pairs by affixing a color camera (Arducam IMX298) to the headset eye cup such that the entrance pupil was co-located with the left IR camera entrance pupil.
- The CycleGan model was trained on these images for 200 epochs.

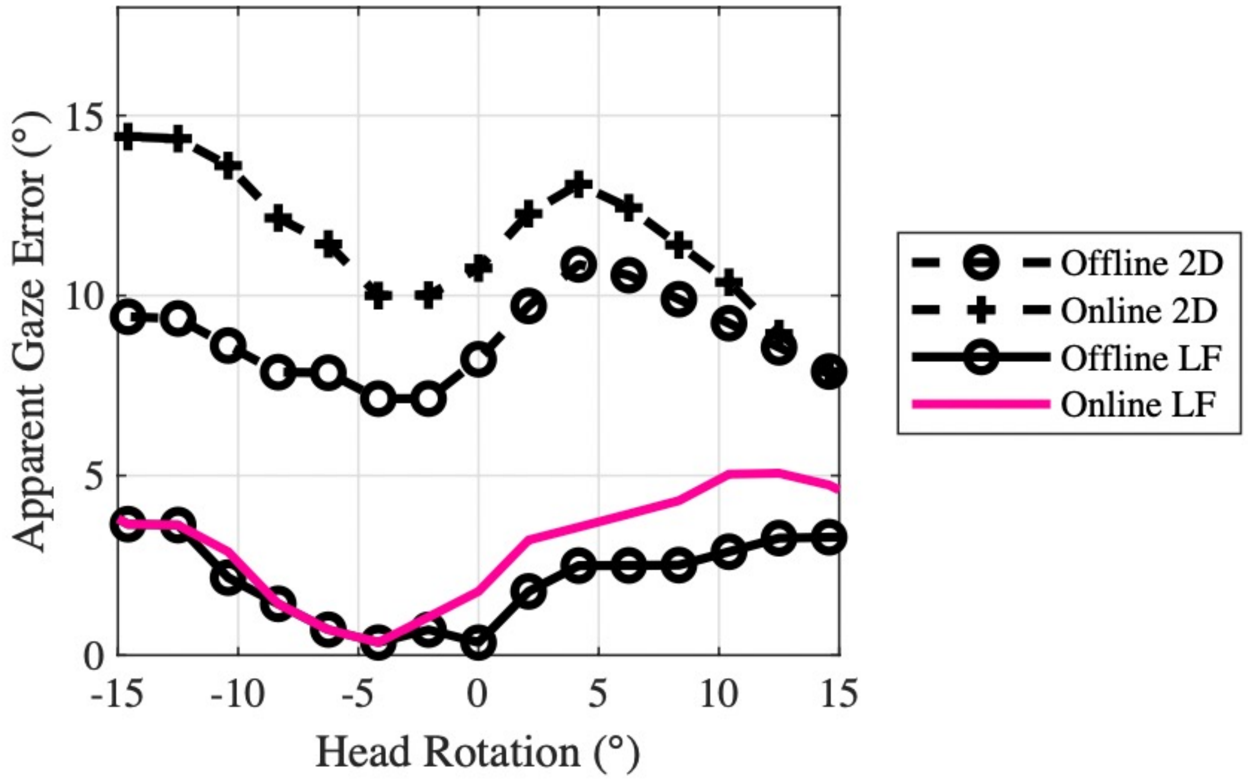



**Figure 4: Estimated pupil reprojection error (in degrees) plotted as a function of horizontal head rotation angle for offline (photogrammetry) and online (live stereo) modes. 2D tracked reprojection consistently shows angular errors that are much higher than the light field display.**

The light field display produces more accurate view perspectives than the tracked 2D output. Not only do the 2D pupil rotation errors exceed the light field output everywhere, those approaches only work for a single person and are thus not viable for social or professional settings.

# RESULTS

- Prototype hardware by swapping in the same LCD, but without the MLA.
- One full display pod to a two-axis gimbal comprised of two Thorlabs HDR50/M rotation stages and 3D printed support assemblies.
- A viewing angle of 12.5 azimuthal rotation from the axis of the display.
- The tracked 2D output reprojection falls within the 32mm range mentioned earlier, but only works for a single viewer assuming perfect face tracking.
- light field displays are suit- able for reverse pass-through VR.

## Connection & Comments

VR and AR devices with technical solutions combined inside, some biotech with the needs with the humanity. Some advance requirement connect to person, social and work are still under review and demand.

The technologies during the usage for some requirement still based on the needs for demand.
The devices with the technologies in this devices based on the eye with real time image transition and optimize some display technology in some angle with outside people which need to understand the person in AR/VR with some recognition and emotions display through eye.

In another way, some other solutions with inside/outside world connection still under the development process which would make it better than the idea which could be realized in the reality world.

https://www.youtube.com/watch?v=TiVa-o8uh6Q

https://www.youtube.com/watch?v=NOk_M1Ib5F0