RETINAL PROJECTION DISPLAY FOR INTEGRATED SMART GLASS SOLUTIONS

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Near-to-eye Devices for AR/VR in 2012

Virtual Reality

Immersive virtual world for gaming, education, entertainment, ...

Augmented Reality

Informative interaction with the world, social or professional

Large Field of View, large Eye Box, high resolution, improved image quality

The beginning of the 2010s brought renewed interest in media and science for AR and VR developments, a field of visual interaction investigated for many years in military research and science-fiction movie production.
Near-to-eye Devices for AR/VR in 2019

Virtual Reality
- Occasional, short duration use
- Immersive experience
- Visual and ergonomic comfort (FOV, Vergence Accom. Conflict, multifocal, ...)

Augmented Reality
- Daily, long duration use
- Informative experience
- Device compactness and design, Brightness, prescription lens compatibility

Mixed Reality
- Periodic, medium duration use
- Interactive experience
- Latency, Occlusion

- HTC Vive Focus Plus
- Lynx Headset
- Hololens2
Our visual mental representation is spatial but our visual sensitive perception is angular.

*Micro Displays, as a translation of our visual representation, has been conceived as a spatial device.*
Conventional Smart Glasses Optical designs are constrained by the use of a spatial display that requires an angular transformation to address the eye. Generally performed by a lens in free space propagation, this transformation limits the device integration.
The question of a display that could project directly the image on the retina is open.

CEA Tech has proposed to investigate the self-focusing effect as a solution for retinal projection.

This phenomenon is an illustration of the Huygens-Fresnel principle.

Its implementation in a see-through near-eye display involves a complex association of integrated photonics and holography.
In the CEA Tech design, the image is transferred on the system as information data, not as an image.

The device is related to the telecommunication domain through its complex waveguide structure.

For more informations on the device principle refer to the paper in Optica October 2018.
Current Research Activities

Self-Focusing Imaging

Diffractive effects involved on the retinal image formation process
Analysis of the imaging performance

Single-mode waveguide distribution @ 532 nm

Design, simulation, fabrication and characterization of the complex waveguide structure used to address the Emissive Point Distribution from the laser array

Pixelated Hologram recording

Conception of the optical set-up used to validate the concept of distributed Holographic Elements (hoels) Recording of the holograms on the appropriate material

Waveguide/hologram interfacing

Technological solutions involved in the active addressing of the hoel from the waveguide

Eye-Model

Integration of the eye characteristics for the design of the system
Inclusion of the eye safety considerations
Self-focusing has been evaluated experimentally for retinal image formation. The Emissive Point Distribution choice is a critical element of the design. It fixes the solution to the compromise between image resolution and image contrast/sharpness.
Silicon Photonics for Visual Applications

Single mode propagation in the visible range requires transparency and demanding micro/nano structuration.
SiN is chosen for its transparency and compatibility with CMOS technologies.

Futur prototypes will focus on the interaction between the waveguide network and the hologram.
Holographic Developments

The hologram is made of a mosaic of various pixelated holograms encoding different angular directions, their distributions fix the EPD of the display

The holographic printer is a research prototype to evaluate the pixelated holograms behavior for retinal projection evaluation

Spectral/goniometric characterization of the hologram in specular reflexion (Laser Driven Tunable Source, LDTS, Energetiq)
**Summary**

- AR technology is a dynamic domain strongly impacted by the **physical limitations** of the near-to-eye device development.
- CEA Tech is investigating a **disruptive solution** based on lensless retinal projection.
- This upstream research requires the development of **technological building blocks** related to silicon photonics and holography.

- First prototype for a static retinal projector based on a pixelated hologram should be presented by the end of the year.
- A prototype to validate the interaction between SiN waveguide and hologram should be presented in 2020.