See-Through Head-Worn Displays

- Helmet-mount
  - Rockwell Collins
  - Myovision

- Clip-on
  - MicroOptics
  - Lumus

- Built-in
  - MicroOptics
  - Momensa Machta
  - Lumus
**What's Different?**

- Google Glass prototype, 2012
- MicroOptical Corp. clip-on, late 20th C.
- IBM Visionpad, late 20th C.

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**See-Through Head-Worn Displays++**

- Integrate $\geq 1$ of
  - Orientation tracker
  - Input device
  - Audio
  - Haptics
  - RGB camera
  - Depth camera
  - Radio
  - Computer
Head-Worn Projective Displays

- Head-worn projector image
  - reflected from beam splitter…
  - on to retroreflective screen…
  - reflected back along angle of incidence to viewer

- Image is too dim to see well on non-retroreflective surface
- “X-ray vision”
- Camouflage

- Minolta “forgettable display”
  - H. Hua, A. Girardot, C. Gao, & J. Rolland, 2000

- Retroreflective surfaces
  - L. Brown, H. Hua, & C. Gao, UIST 2003

- Head-Worn Projective Displays
  - M. Inami, D. Sekiguchi, S. Tachi, 2003


- The Secret of Transparency
  - M. Inami, D. Sekiguchi, S. Tachi, 2003

Feiner, COMS W4172, Spring 2018
Head-Worn Projective Displays

- castAR (Technical Illusions) 2013–2017 RIP

See also D. Krum, E. Suma, & M. Boles, Augmented reality using personal projection and retroreflection, Personal and Ubiquitous Computing, Jan 2012, 16(1)

What Needs to Improve?

- Besides aesthetics and comfort,…
Wide Field of View for AR
K. Kiyokawa (Osaka U.), ISMAR 2007

- Head-worn projective display uses hyperbolic beam splitter
- 146° (in theory) horizontal FOV

Wide Field of View for VR

- Predistort image to counteract nonlinear lens distortion
  - Done in GPU
  - Typically not done in 20th C. systems because of computational overhead

See also http://doc-ok.org/?p=1414
Controllable Focus
H. Hua (U Arizona), ISMAR 2008

- Computer-controlled liquid lens
  - Can continuously vary focus or switch between discrete focal planes
- Example: Two discrete focal planes
  - Period limited by speed of lens

Interaction of Real and Virtual
K. Kiyokawa (Osaka U.)

- CRL (Communications Research Lab) per-pixel occlusive optical see-through display
  - K. Kiyokawa et al., ISMAR 2003

A depth camera is used to determine z values for the user's hand
Interaction of Real and Virtual

Trivisio

- AlphaBino per-pixel occlusive optical see-through display

Platform-Mounted Displays

- Fakespace Boom
  - High-resolution (opaque) stereo display
  - Mounted on a counterbalanced arm
    - Serves as a mechanical tracker
    - Makes it easy to manipulate massive display

- Virtual “telescopes”
  - Typically 1DOF (azimuth) or 2DOF (+ elevation)
  - Mechanically tracked video-see-through
Spatial Augmented Reality (SAR)

- Projectors in the environment project onto real world objects whose shape and texture we want to see
  - Augment the real world directly
  - Can avoid encumbering the user