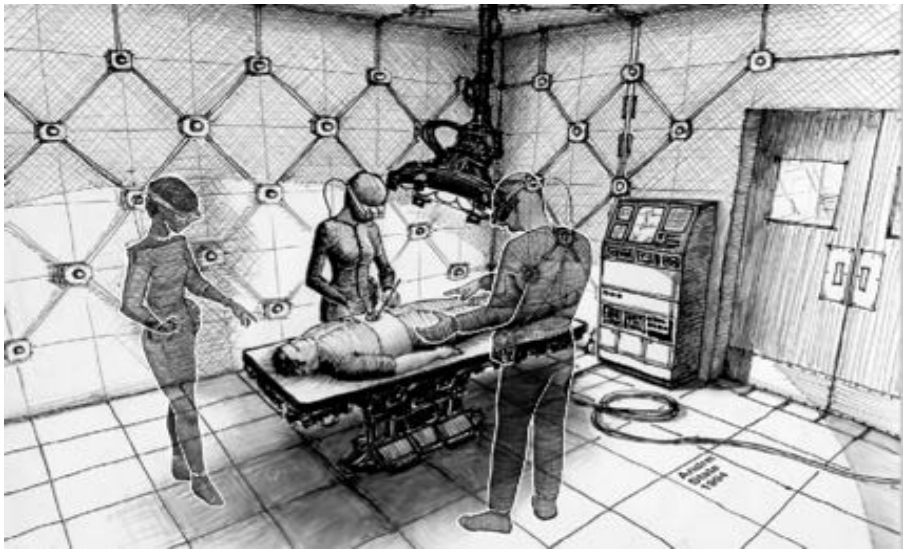
Advanced Displays and Techniques for Telepresence



Surgical Consultation Telepresence

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Video Teleconferencing vs Telepresence

- Video Teleconferencing
  - Conventional 2D video capture and display
  - Single camera, single display at each site is common configuration for Skype, Google Hangout, etc.

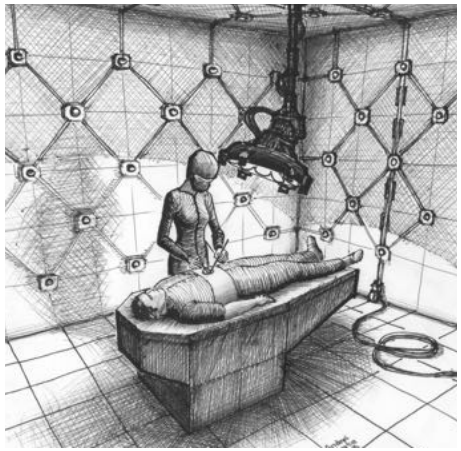
- Telepresence
  - Provides illusion of presence in the remote or combined local&remote space
  - Provides proper stereo views from the precise location of the user
  - Stereo views change appropriately as user moves
  - Provides proper eye contact and eye gaze cues among all the participants

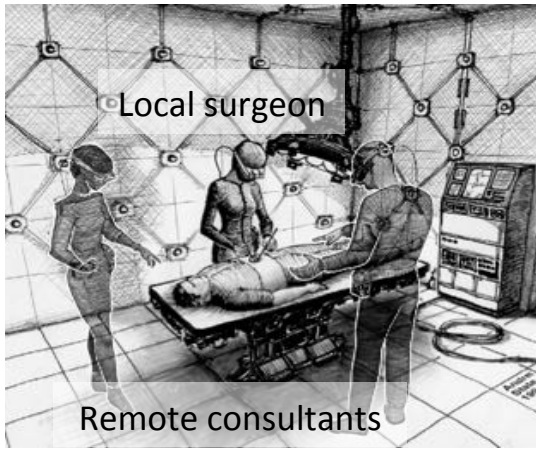
Cisco TelePresence 3000

Three distant rooms combined into a single space with wall-sized 3D displays

Telepresence Component Technologies

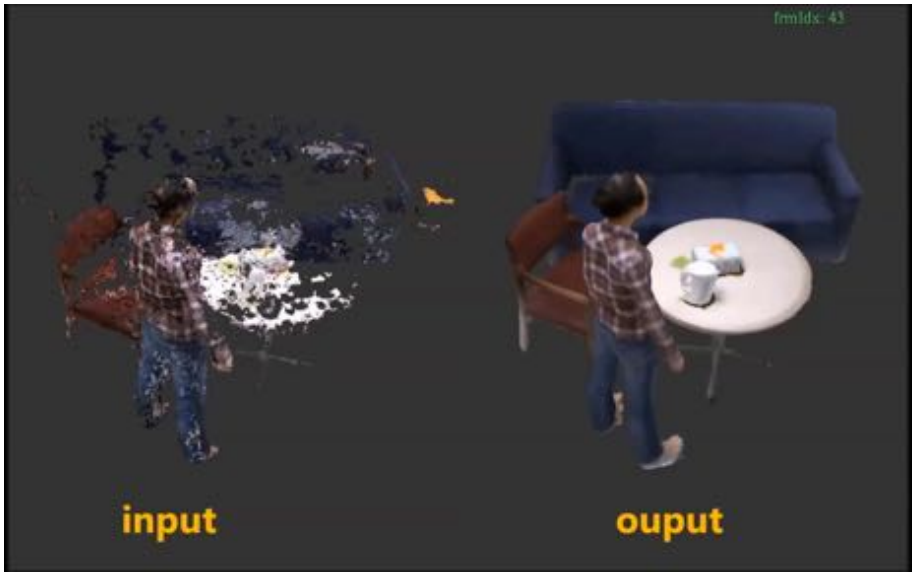
- Acquisition (cameras)
- 3D reconstruction
- Communication network
- Viewer viewpoint tracking
- Generation of image(s) for display
- Display presentation





3D Telepresence Component Issues

- Acquisition (cameras)
  - RGB or depth cameras, number, placement (fixed, moving, head-mounted, anticipating the position of remote users,...)
- 3D reconstruction
  - Combine input from many color+depth cameras
  - View the set of 3D color points in space
  - Fit surface of polygons around the 3D points
  - Enhance polygon surfaces with model-based info (e.g., human skeleton) or time-based integration,light-field info,..
- Communication network
  - Bandwidth, compression-decompression,..
- Viewer viewpoint tracking
  - Tracked area instrumented or not; indoors, outdoors
  - Low latency (30msec,… 100microseconds)
- Generation of image(s) for display
  - Rendering quality, latency, power usage
- Display presentation
  - Large format: Different stereo image pair for each viewer (require stereo glasses or not)
  - Near-eye: eyeglasses form factor, wide field of view



3D reconstruction from ~10 Kinect color+depth cameras (Dou et al, IEEE VR 2014)

Display Alternatives*

Large, fixed:

pro: nothing to wear on the face

(at most, wear sunglasses, like at 3D movies)

con: only see the remote people on far side of the display;

local & remote participants can't be in same shared space


Holografika

Head-worn:

Virtual Reality:

pro: cheap, immersive

con: cannot see own body, local people and space


Oculus

Augmented Reality:

pro: see own body and local environment

con: wide field of view just out of reach, clunky

-virtual objects (distant people) cannot occlude real world, either appear transparent or real world has to be dark


Microsoft Hololens

* Only near-term deployable technologies

Large Format 3D Displays: without glasses

Challenge:

Different image to be seen by each viewer

emit a different color to each direction

Solution: ~ 100 rear-projectors for a human life-size display

Alternatives: if only a few viewers, steer the beam to only those places where there is a viewer

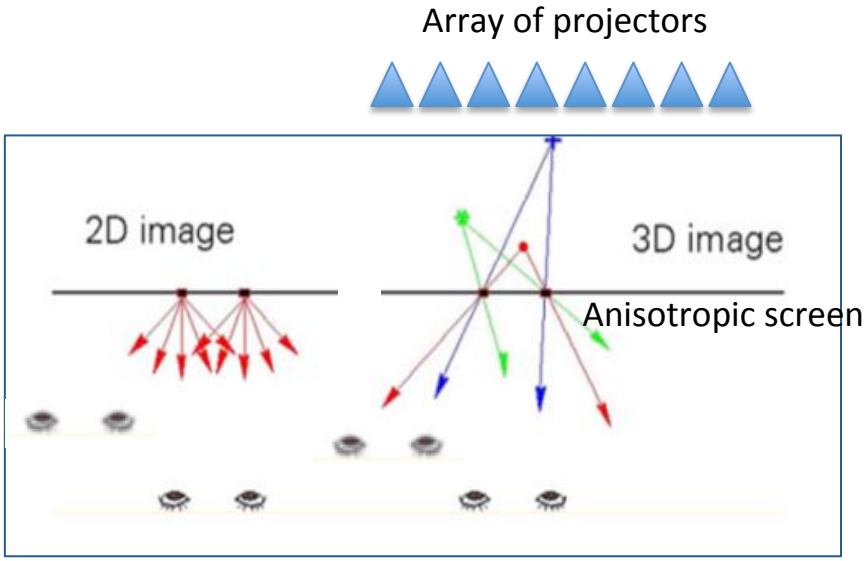
multi-layer displays:

passive or active barrier displays

compressive, tensor displays

steerable backlight displays

Remaining Challenges: compression artifacts, insufficient switching speed of spatial light modulation displays (LCDs), low light efficiency



Holografika

Large, Fixed Displays with Shutter Glasses

- Easier than eyeglass-free multiview displays
- Shutter glasses select which user (both eyes) sees a particular sub-frame
  - Like stereo, just 6 subframes instead of 2

Beck et al, VR 2013

- Future: could reduce number of projectors by sacrificing some color resolution
- Future: faster display speeds (micromirrors) will enable less expensive solutions (e.g., 4 user system with 2 projectors)

6 stereo projectors, each assigned permanently to 1 of 6 functions:

1: Left eye Red
2: Left eye Green
3: Left eye Blue
} Polarizer A filter

4: Right eye Red
5: Right eye Green
6: Right eye Blue
} Polarizer B filter

Each of 6 subframes assigned to one of 6 users (wouldn't work for 7 users)

Fixed Displays vs Near-eye Displays

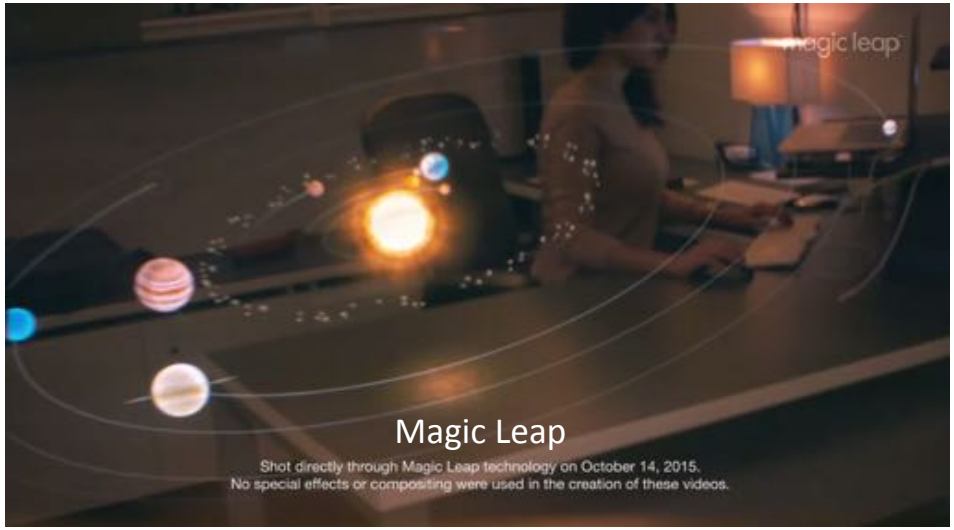
- With fixed displays, participants (local and remote) cannot all be in the same shared space, sit next to each other,..
- For sharing local space, need displays that users wear, so virtual objects (distant people) can be located anywhere
- Requirements for near-eye displays
  - See local surroundings (own body, table, material) and virtual objects
  - Proper occlusion between real and virtual objects

Near-Eye Display Challenges

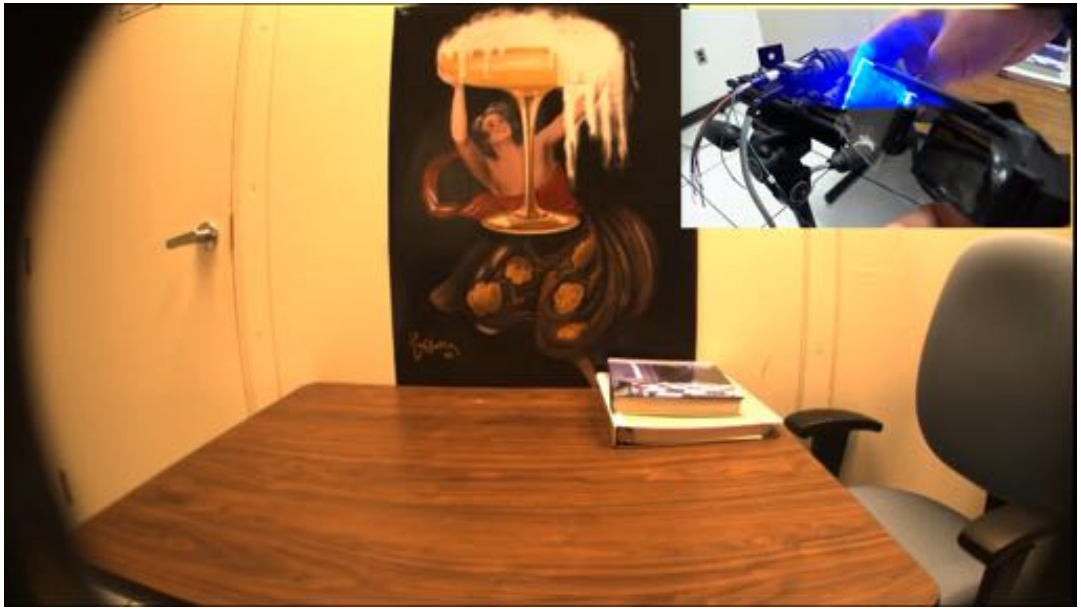
- Closed VR headsets probably unacceptable for telepresence
- Open Augmented Reality headsets

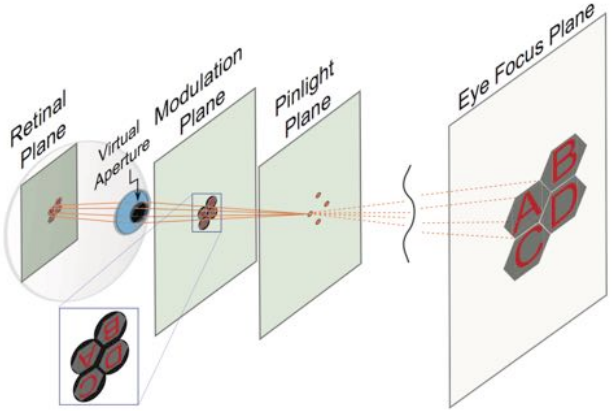
  size ok for narrow Field of View (40 degrees)

  size bulky for wide FoV (90-100 degrees)
- None have occlusion of real world by virtual, so real world has to be kept dark
  - Not good for telepresence: either local environment is dark or virtual imagery is very bright



Wide FoV Eyeglass AR Display:
Maimone et al, Siggraph 2014





Where are We? Which way Forward? 1 of 2

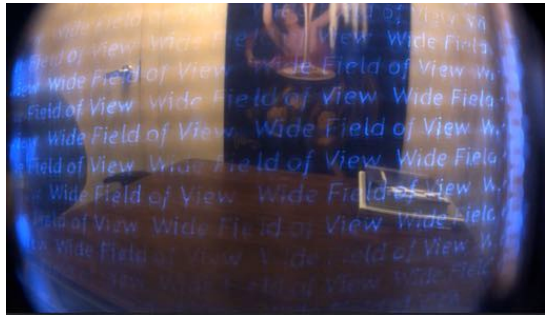
- Now is an opportune time to Telepresence
  - Can ride the VR wave
- Many developing technological pieces,
  - but no collection of them gives a complete solution today for Telepresence
- Similar to personal computer technology ca. 1970
  - Want Alan Kay's Dynabook vision (8 ½" x 11" x 1" with full-color display, touch screen, radio communication to ARPAnet, removable secondary storage)- how to make a Dynabook
  - Challenge: how to get to an effective Telepresence system
- System development:
  - Give up some requirements: cost, bulk, weight
  - For telepresence: use best available AR platform & add temporary enhancements/workarounds
- (Cont.)

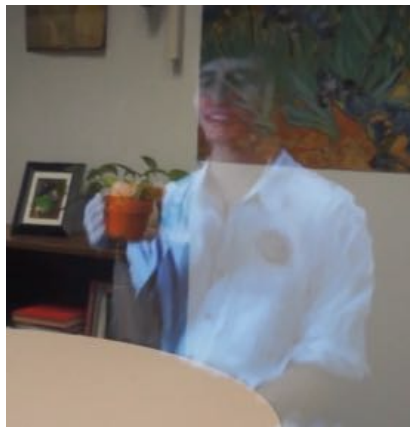

Microsoft Hololens


Meta 2

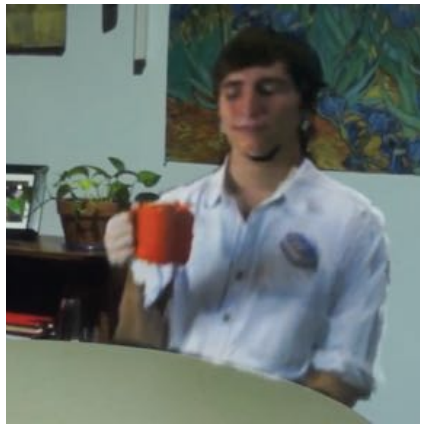
Where are We? Which way Forward? 2 of 2

- Technology development: work on each component problem; integrate into rest of development system.
- Fuchs examples:
  - Wide field of view eyeglasses
    - Maimone's pinlight displays: resolution, diffraction, occlusion,..
  - Occlusion: add to current AR display
    - For temporary system development: lighting control in controlled spaces
    - For permanent technological solution: multi-layer light field displays
  - Head-gear Tracking:
    - Go anywhere with accuracy and low latency: GPS, multiple outward-looking rolling-shutter cameras, multiple IMUs



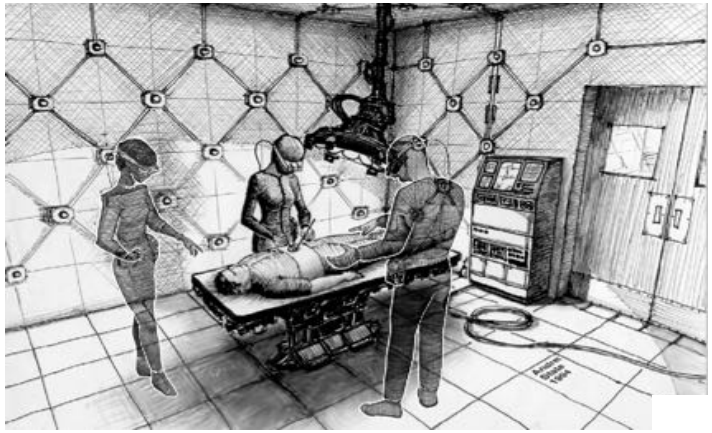


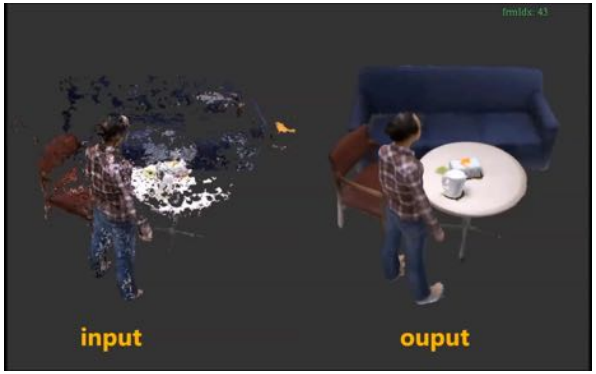
AR without occlusion



AR with occlusion

Magic Leap without occlusion (?)
Headset image bright; room is dark

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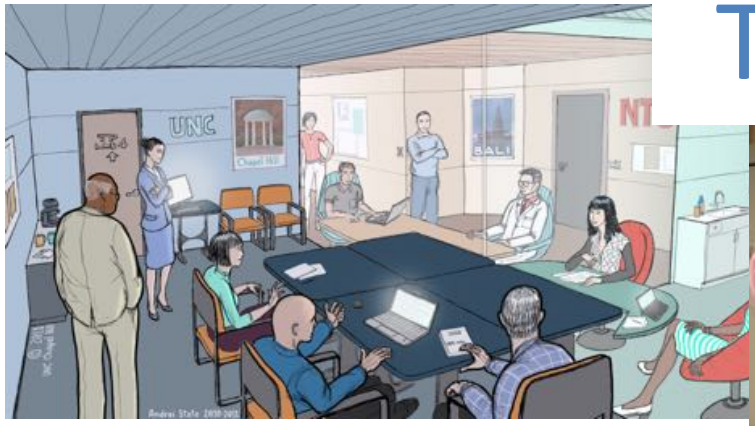
Microsoft Hololens

Thank You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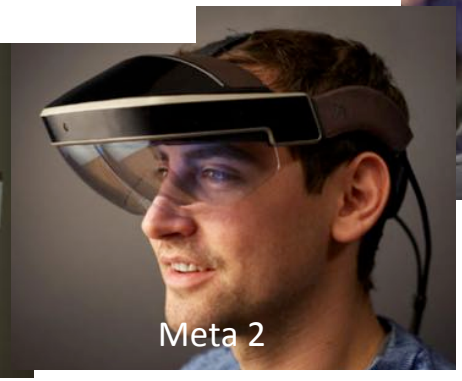
Lumus DK-32


Meta 2


PhaseSpace Smoke


Magic Leap
No special effects or compositing were used in the creation of these videos.