Toward Transparent Telepresence

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Telepresence in Popular Culture

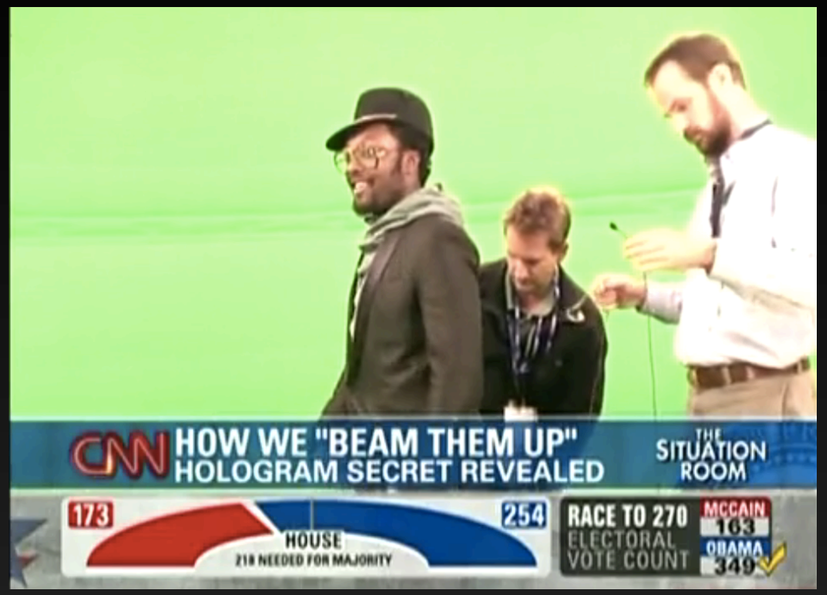
- Princess Leia telepresence in original **Star Wars** (1977)
- US Election night CNN (2008): remote correspondent "hologram" in same room with news anchor
- CISCO / Musion: telepresence of US reps "on stage" with CISCO CEO in India (2009)

Princess Leia Telepresence, Star Wars (1977)

Remote News Correspondent "Hologram" (2008)

Remote News Correspondent "Hologram" (2008)

~40 fixed video cameras in semicircle in capture area



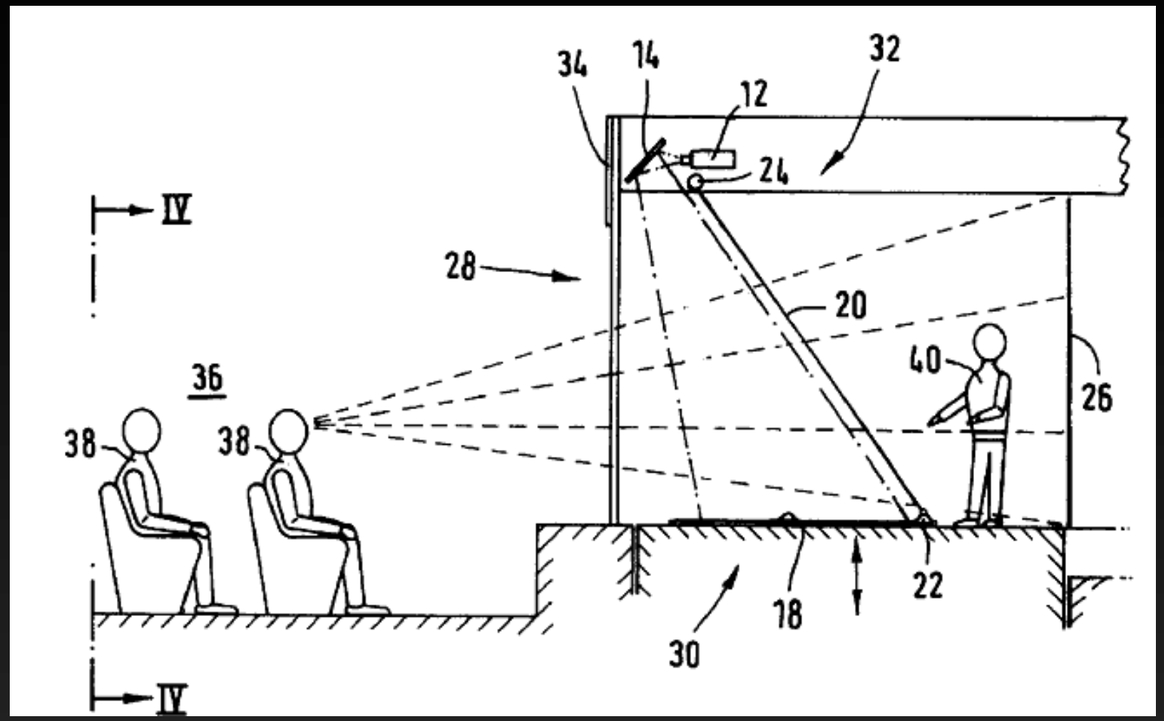
extract segmented image(s) of remote person

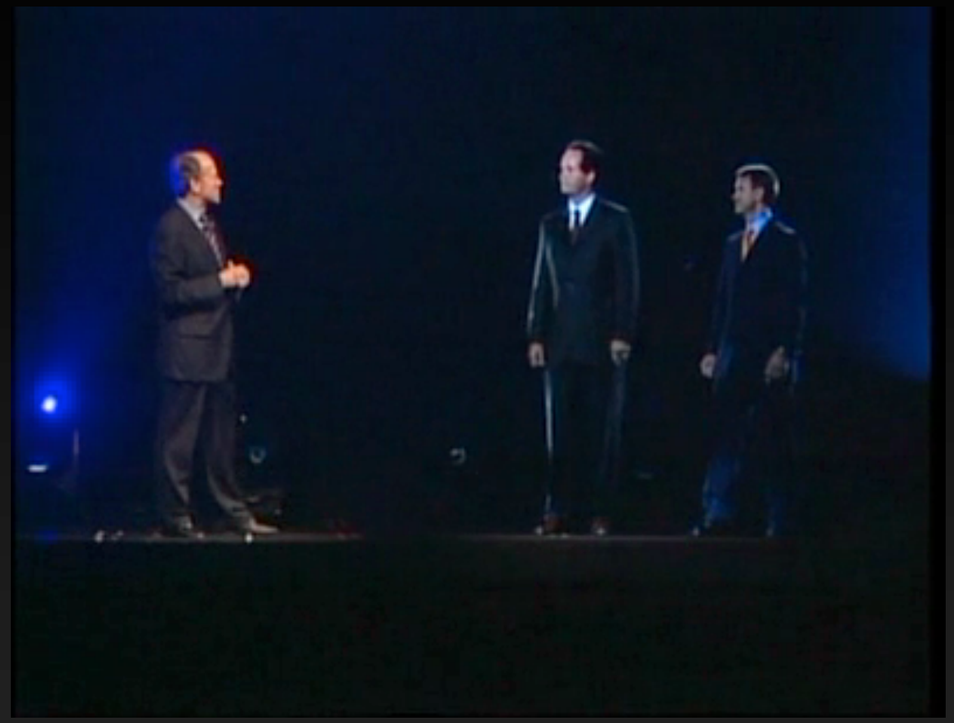
2D composite(?) overlay onto tracked studio camera

CISCO / Musion: Stage telepresence (2009)

http://www.eyeliner3d.com/cisco_telepresence_holographic_video_conferencing.html

CISCO / Musion: Stage telepresence (2009)





- US Patent 5865519: "Device for displaying moving images in the background of a stage," by Uwe Maass 1999
- Pepper's Ghost Effect, ca.1862 London, John Henry Pepper
- Giambattista della Porta, Magia Naturalis, Naples, 1558.
  http://en.wikipedia.org/wiki/Magia_Naturalis

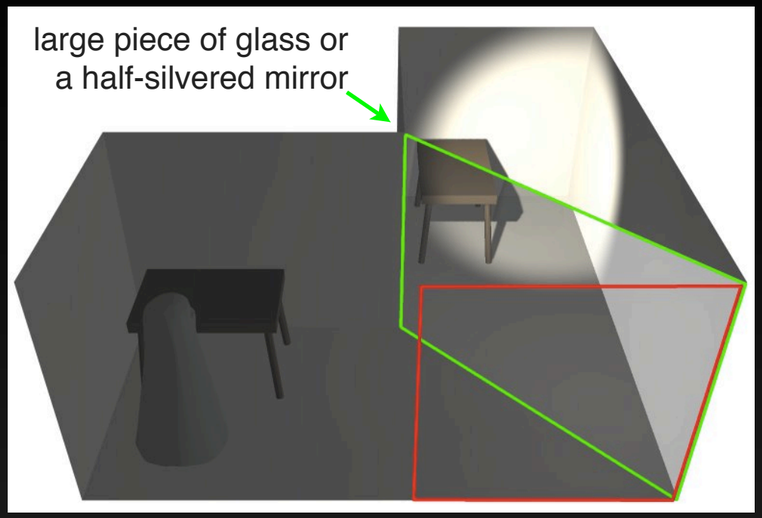
http://www.eyeliner3d.com/cisco_telepresence_holographic_video_conferencing.html

Earlier description of Pepper's Ghost effect: della Porta(1558)

Giambattista della Porta, Magia Naturalis, Naples, 1558. from the 1658 English language translation:

Let there be a chamber wherein no other light comes, unless by the door or window where the spectator looks in. Let the whole window or part of it be of glass, as we used to do to keep out the cold. But let one part be polished, that there may be a Looking-glass on bothe sides, whence the spectator must look in. For the rest do nothing. Let pictures be set over against this window, marble statues and suchlike. ***For what is without will seem to be within, and what is behind the spectator's back, he will think to be in the middle of the house, as far from the glass inward, as they stand from it outwardly,*** *and clearly and certainly, that he will think he sees nothing but truth. But lest the skill should be known, let the part be made so where the ornament is, that the spectator may not see it, as above his head, that a pavement may come between above his head. An if an ingenious man do this, it is impossible that he should suppose that he is deceived.*

http://en.wikipedia.org/wiki/Pepper%27s_ghost

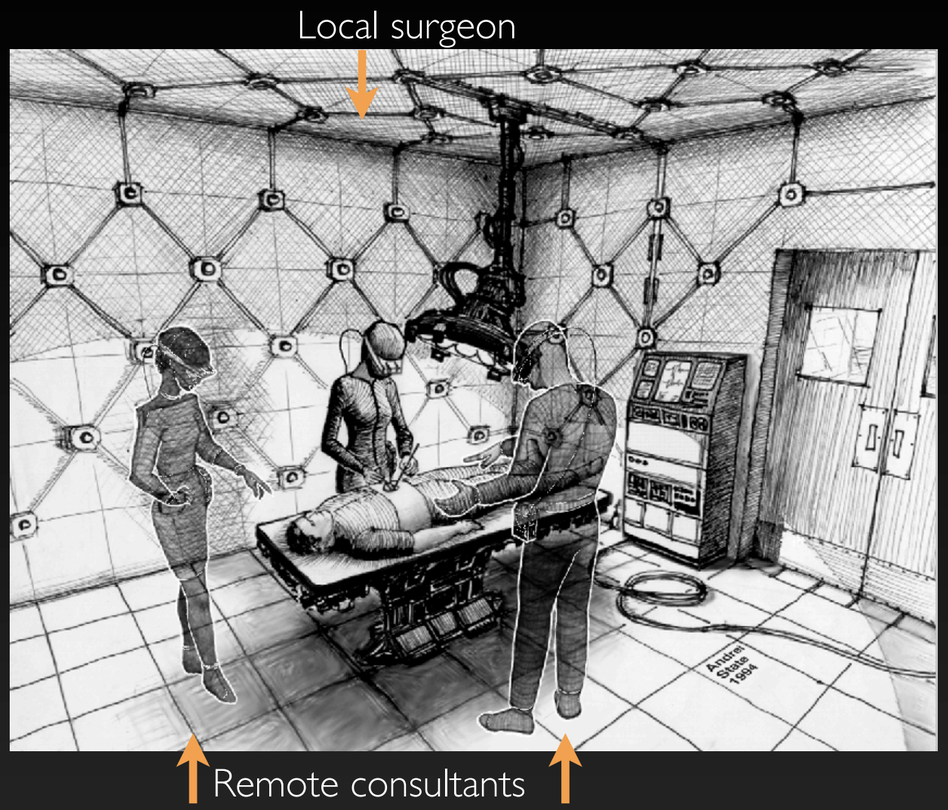


Impact of Telepresence in Popular Culture

- Princess Leia telepresence in original Star Wars (1977)
- US Election night CNN (2008): remote correspondent "hologram" in same room with news anchor
- CISCO / Musion: telepresence of US reps "on stage" with CISCO CEO in India (2009)
- In NONE of these do participants see each other in their own 3D space
- Nevertheless, many people may think Telepresence is
  1. Already done, available today or
  2. A special effect "trick"

UNC Telepresence Vision (1993-4)

- Surgery with
  - Local surgeon
  - Remote consultants
- Technology
  - Scene acquisition (3D)with many cameras
  - Display (3D) with head-mounted displays



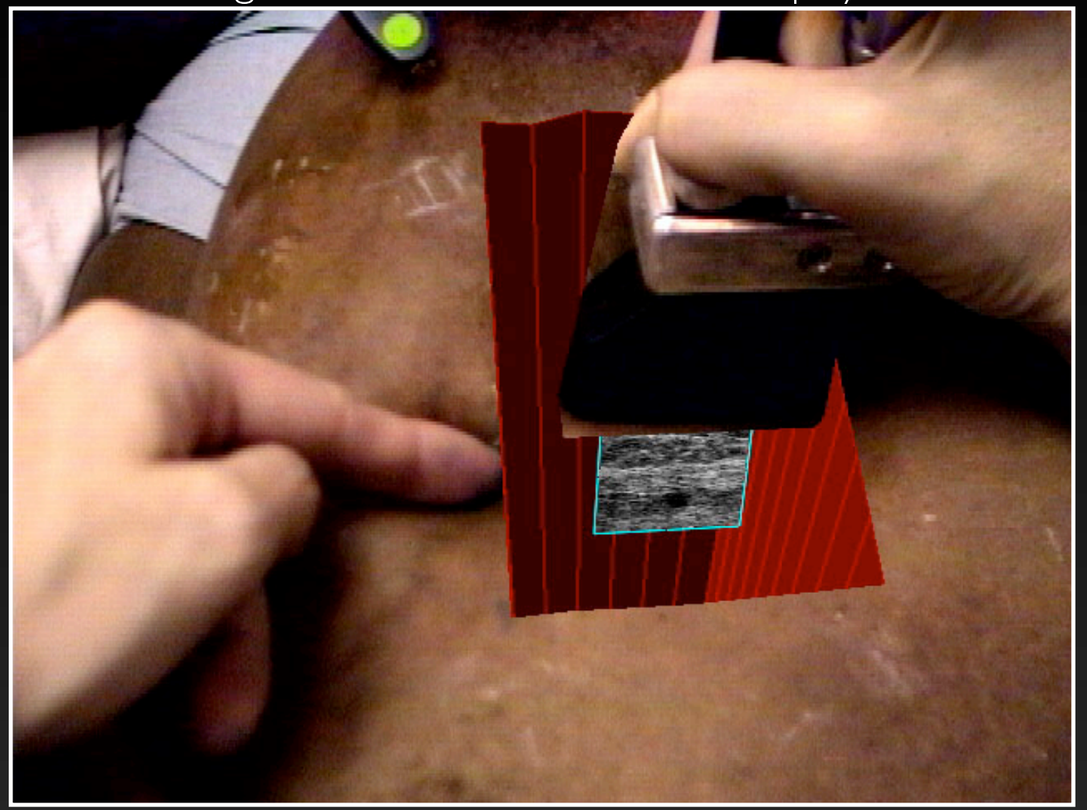
Neumann, U and H Fuchs (1993). **A Vision of Telepresence for Medical Consultations and Other Applications**. Proceedings of the Sixth International Symposium on Robotics Research

Fuchs, H, G Bishop, K Arthur, L McMillan, R Bajcsy, S Lee, H Farid and T Kanade (1994). **Virtual Space Teleconferencing Using a Sea of Cameras**. Proc. of the First International Symposium on Medical Robotics and Computer Assisted Surgery

Augmenting MD with local data in 3D*

* Real-time 3D scene acquisition too difficult

Image in MD's Head-Mounted Display



- Ultrasound image calibrated to inside of patient
- Visualized within an "open pit" inside the patient

State, A., M. Livingston, W. Garrett, G. Hirota, M.C. Whitton, E.D. Pisano (MD) and H. Fuchs. **Technologies for Augmented Reality Systems: Realizing Ultrasound-Guided Needle Biopsies**. Proc. SIGGRAPH 1996

Lessons Learned about HMD for Augmentation

- Video see-through HMD more useful than optical see-through for proper augmentation of real and virtual scene
- Cameras on HMD need same point of view as the user's eyes
- Wide field of view difficult to achieve
- Eye contact w/ video see-through HMD almost impossible

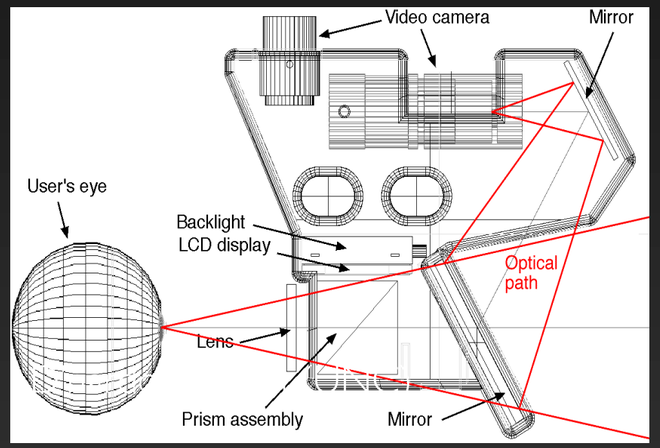
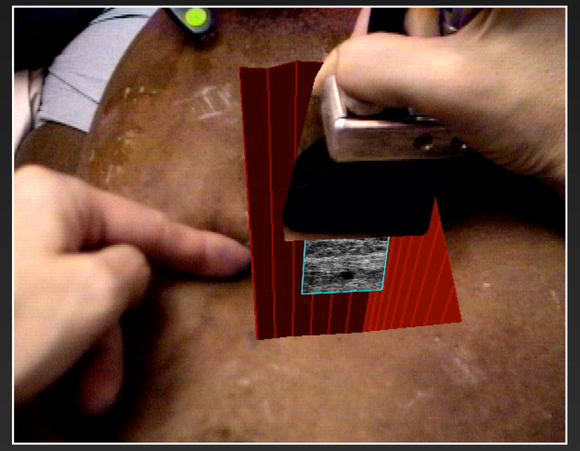
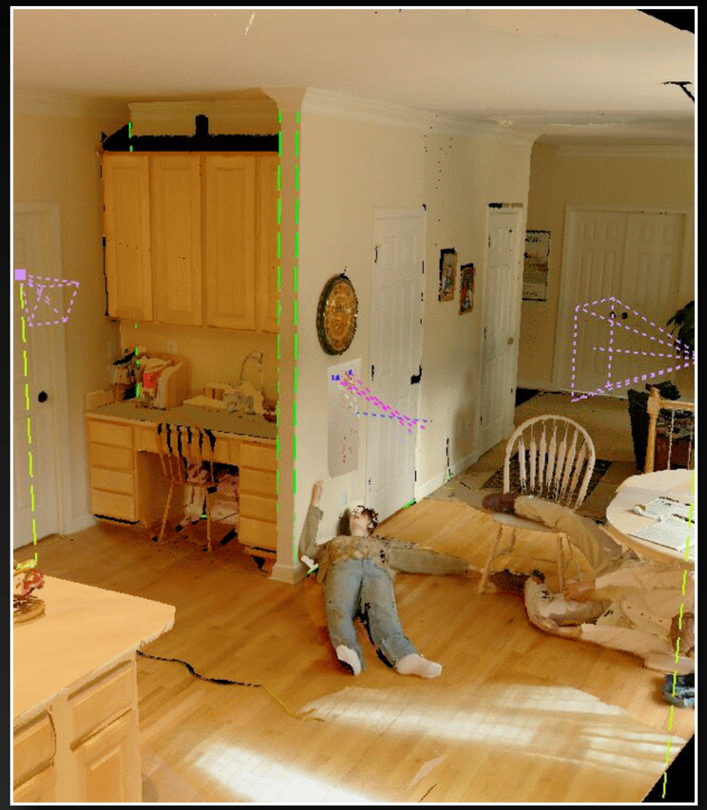


Image in Head-Mounted Display



Laser canner for Room-scale Scene Acquisition

- Developed to have a "gold standard" for 3D room acquisition (ca. 2000, Lars Nyland, UNC)
- Laser time-of-flight plus color camera texture
- Sold commercially by 3rdTech.com



(US) National Tele-Immersion Initiative (1997-2001)*

- Display: Large-screen stereo with passive stereo glasses (head-tracked)
- Acquisition: Laser scan of remote room, plus ~9 camera dense stereo for remote human
- **Lessons learned:**
  - "Hole in the wall" illusion is appealing
  - Displays expensive to scale to multiple users at one site
  - Acquisition needs better (continuous?) calibration & more compute power

* Advanced Network & Services; Brown U; UNC; U of Pennsylvania

What's Possible with Large 2D Displays?

- Limitations of current commercial systems
  - Poor eye contact
    - Can't tell who a remote person is looking at
  - Low spontaneity
    - Can't move about, use white board, move closer
    - Not good for casual encounters
- Improve eye contact & support for casual encounters

Cisco TelePresence 3000

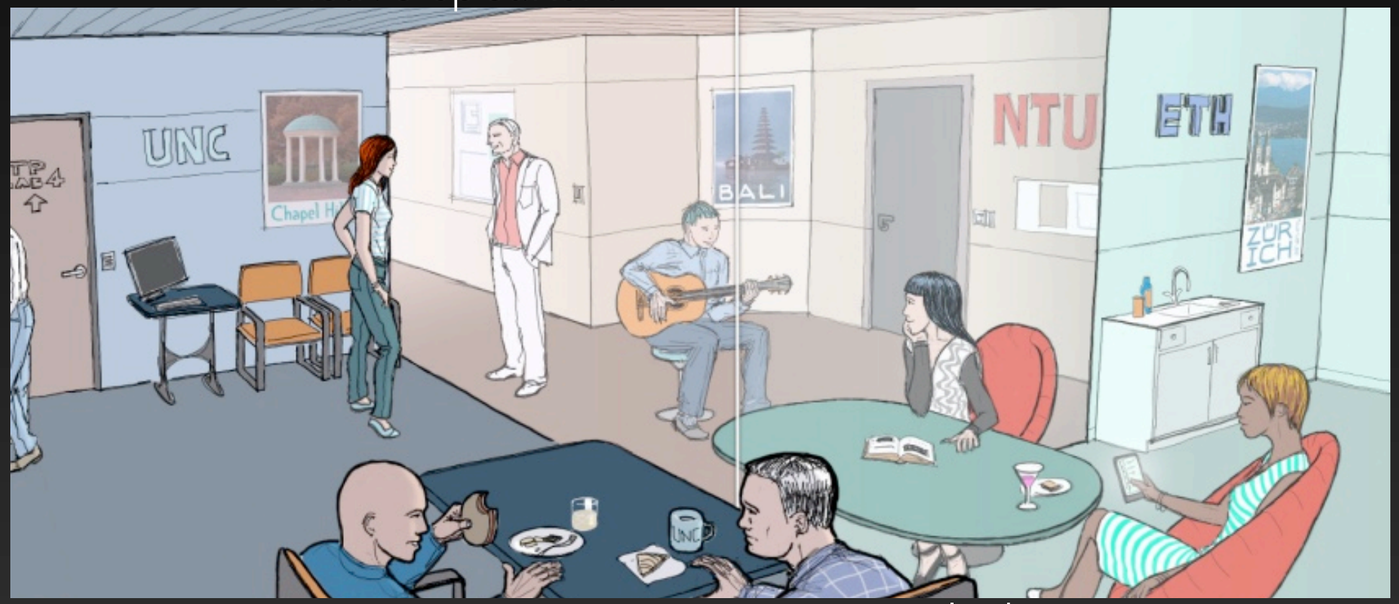
http://newsroom.cisco.com/dlls/2009/prod_022409.html

UNC-Cisco Telepresence Wall Project

Goal: Best possible view for multiple people in each room with a 2D display wall

- Support casual awareness of activities in the remote room
- Support life size, one-on-one eye contact between people engaged in direct conversation

Active speakers

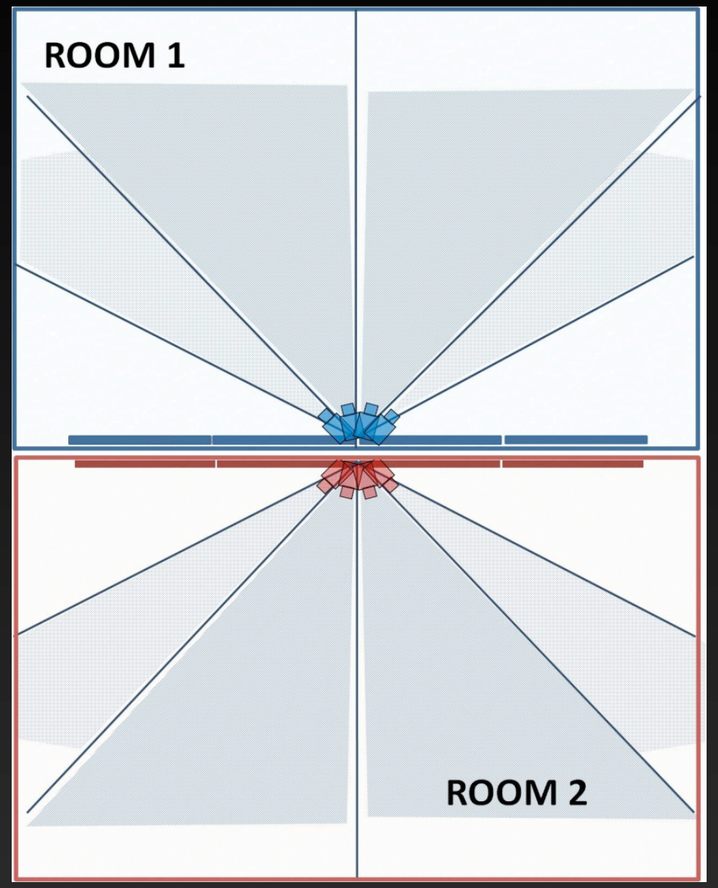


casual observers

What to put on a 2D display ? wall

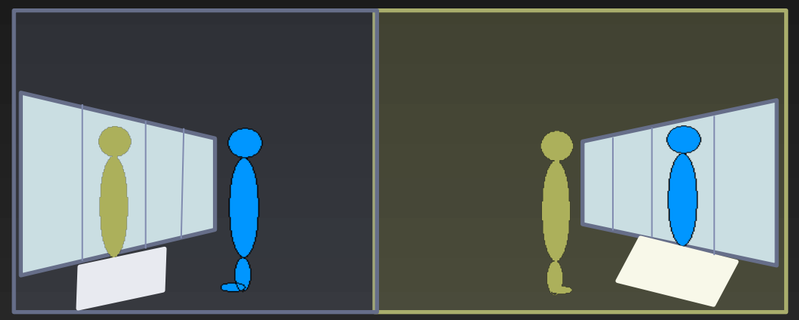
- Give the illusion that two adjacent rooms separated by a wall of windows
- Cluster of cameras at the middle of each room's display wall

panorama view of the other room
(distorted in extreme-wide-angle photograph)

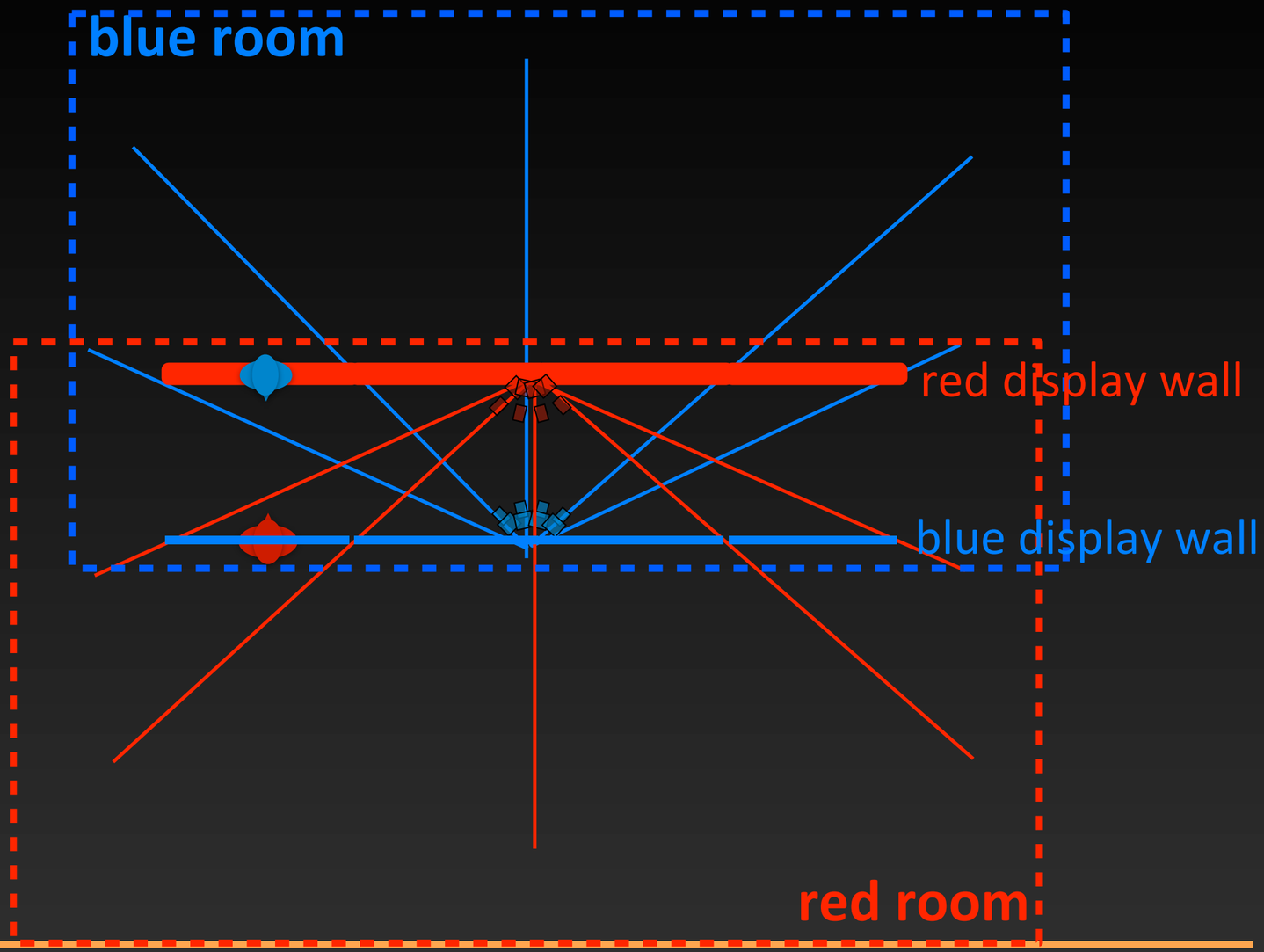


Show People Life Size

- Show people life sized when they talk at a comfortable distance (~1.1 Meter)
- Match FOV of a camera with size of a display panel.



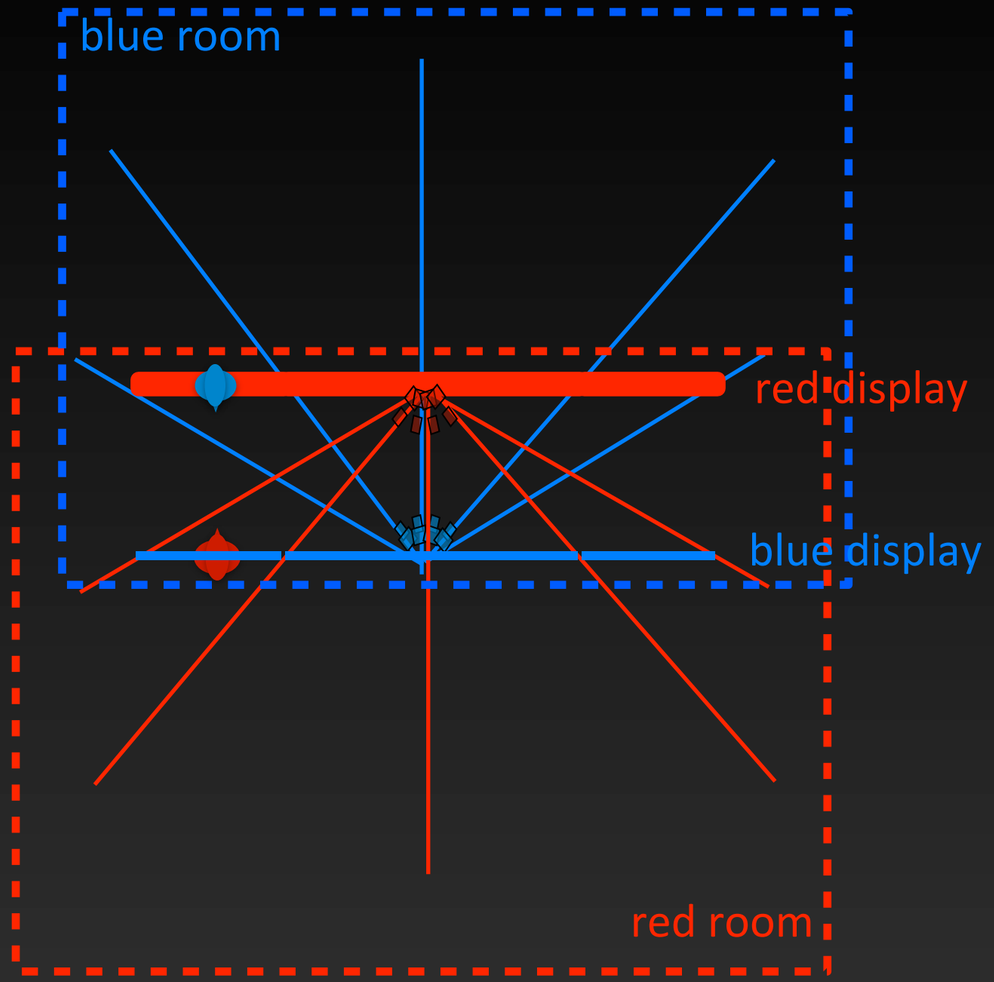
Life-sized people shown on display



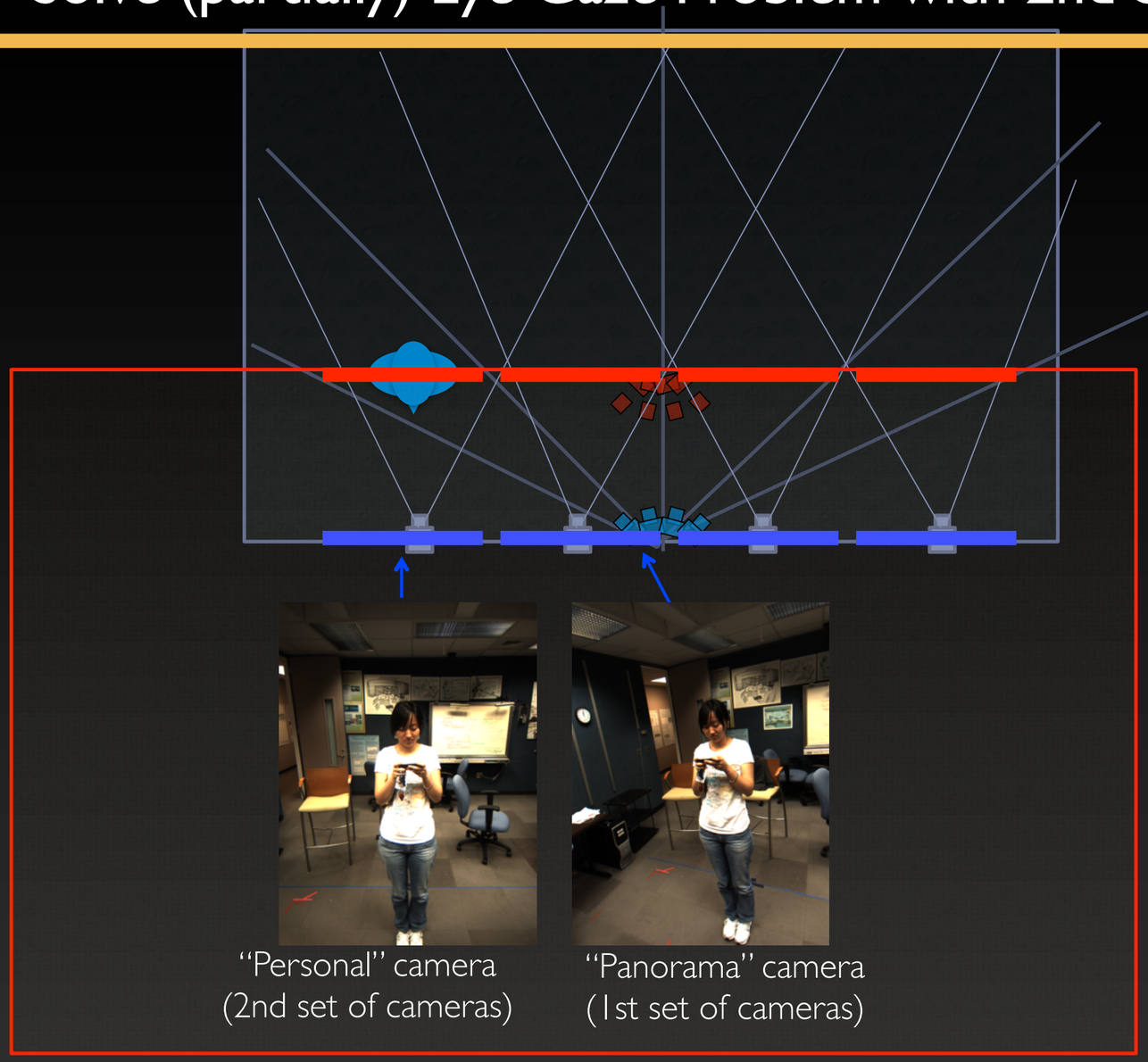
Eye Gaze Problem

- Especially severe for display panels towards the edge of room
- Caused by camera aimed at the people from the side.

Incorrect eye gaze in the panoramic view

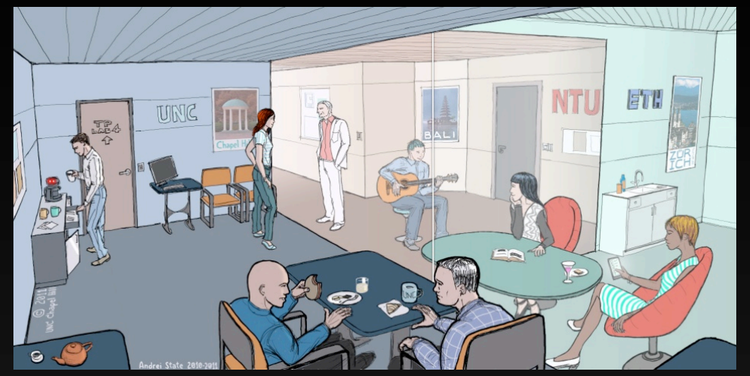


Solve (partially) Eye Gaze Problem with 2nd Set of Cameras



"Personal" camera
(2nd set of cameras)

"Panorama" camera
(1st set of cameras)

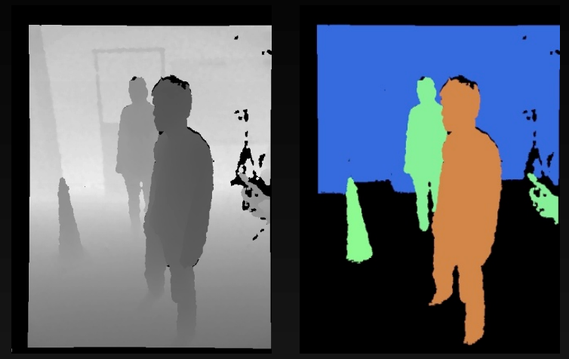


Problem: Most cameras view people from some angle, not directly from front.

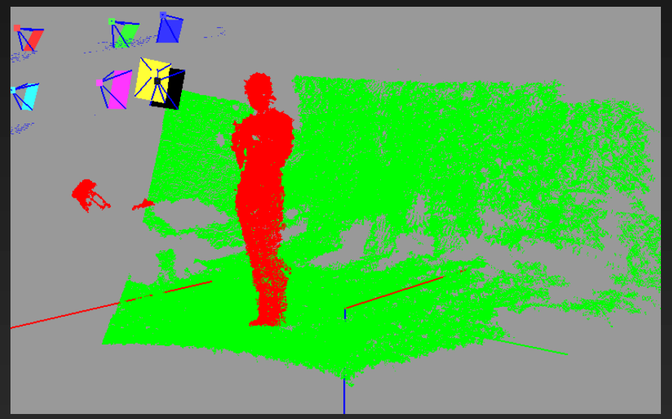
Solution: add a set of forward-facing cameras near the location of one's conversation partner

Segment individuals near the screen from both sets of camereas

Segment connected component(s)

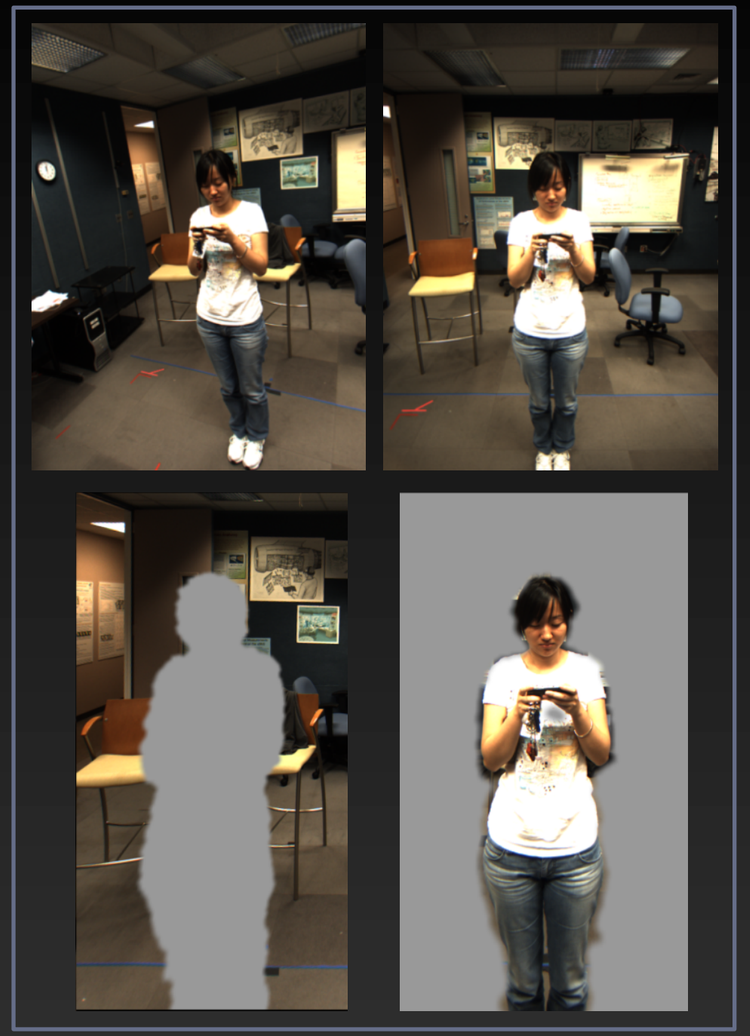


2D to 3D



3D to 2D

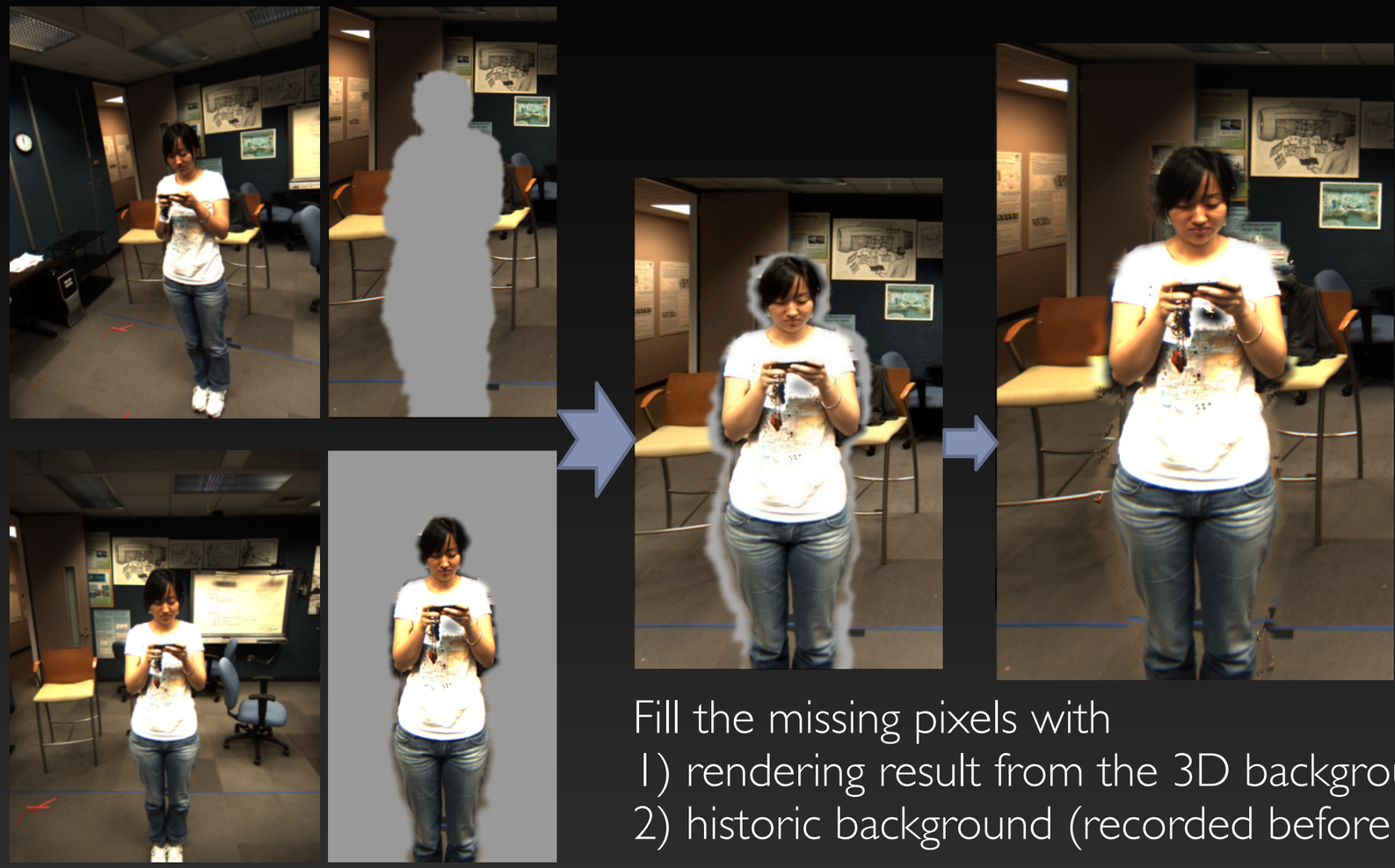
Reproject 3D segmented points to both Personal and Panorama cameras



Put all the image layers together

"Panorama" camera
(1st set of cameras)

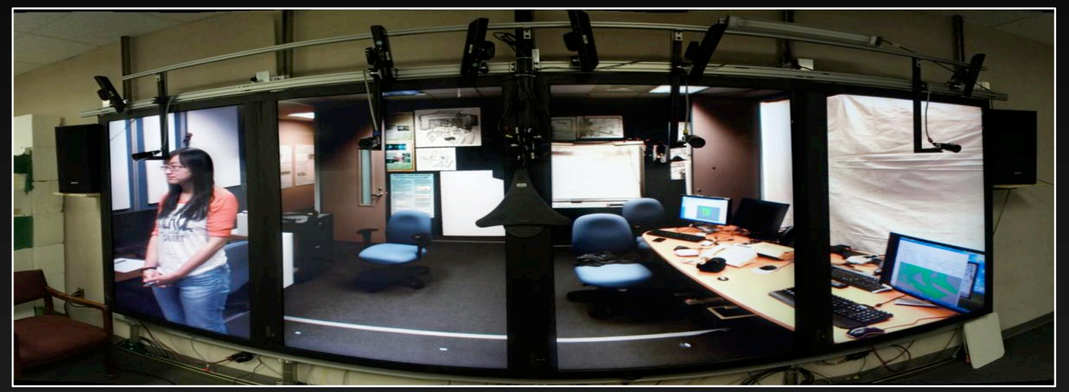
"Personal" camera
(2nd set of cameras)



Fill the missing pixels with
1) rendering result from the 3D background points, and
2) historic background (recorded before session)

Show Nearby Person from Personal Camera

- **Segment** the image of the individual out of the panorama image
- **Add** the person's image from the personal camera to the panorama



Panorama view

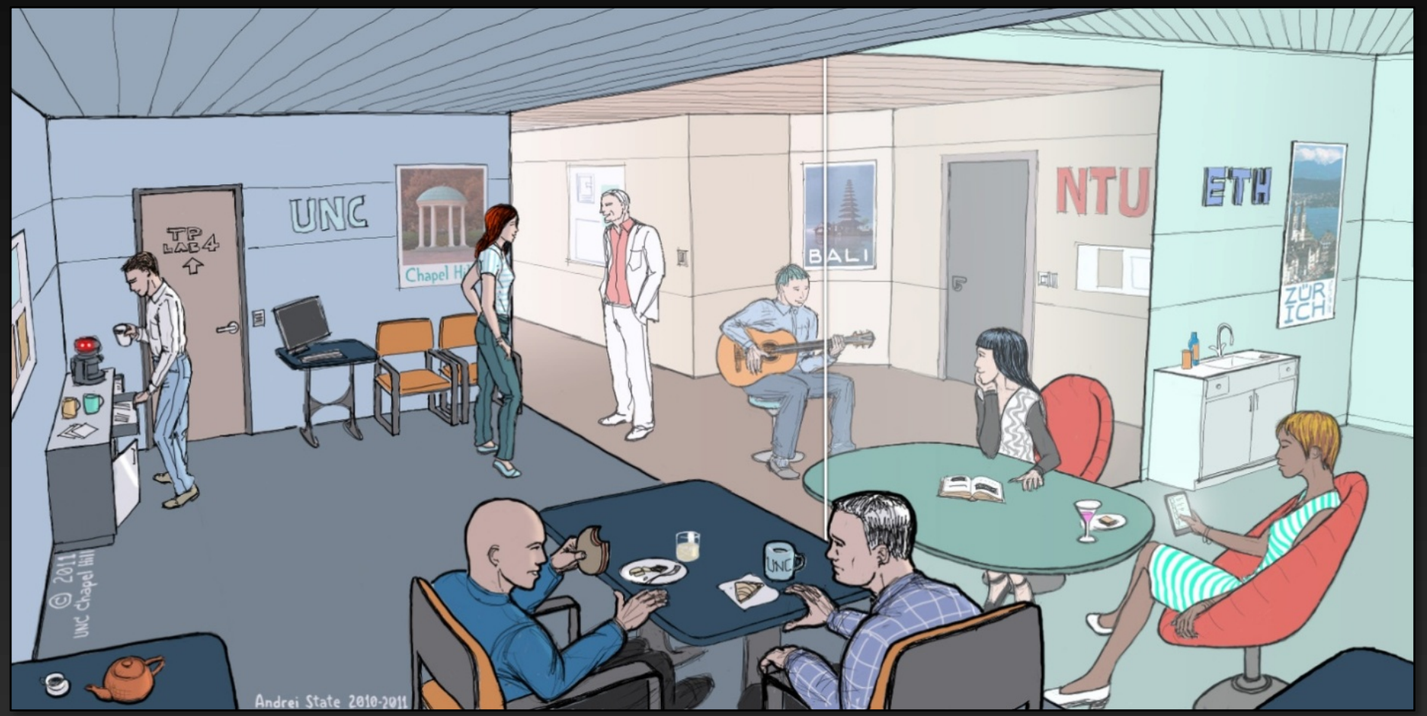
Panorama view with the front-facing person

Telepresence Wall (video)

Telepresence Acquisition & Display 2012

Acquisition: Multiple depth cameras

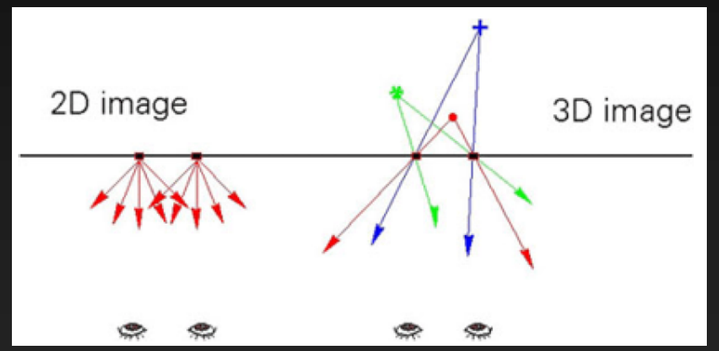
Display: Multi-viewer autostereo



Autostereo Display Choices

Multiple viewers each receive unique stereo views without wearing special glasses

- Hologram – Life size, real-time is beyond state of the art
- Volumetric Displays
- Barriers / Slits Displays*
- Lenticular / Lenslet Displays



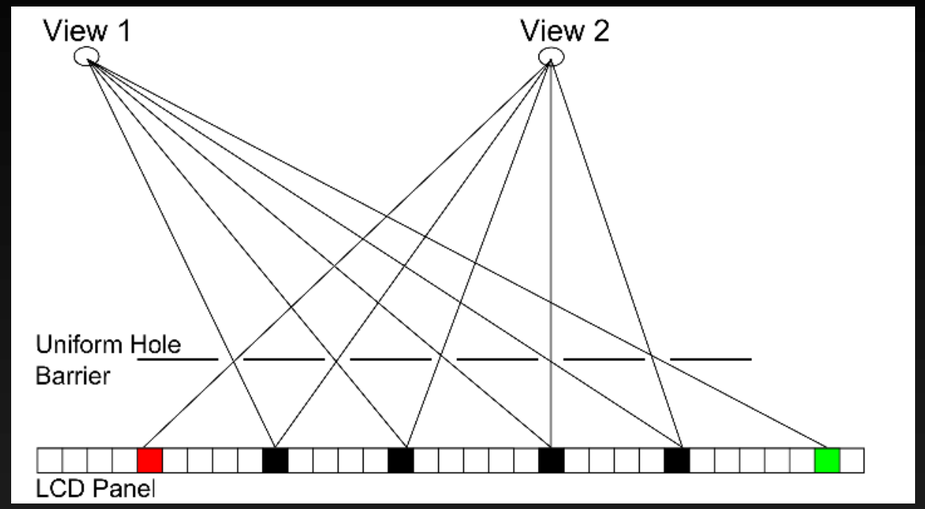
holografika.com

* see, especially, work of Douglas Lanman@ MIT Media Lab

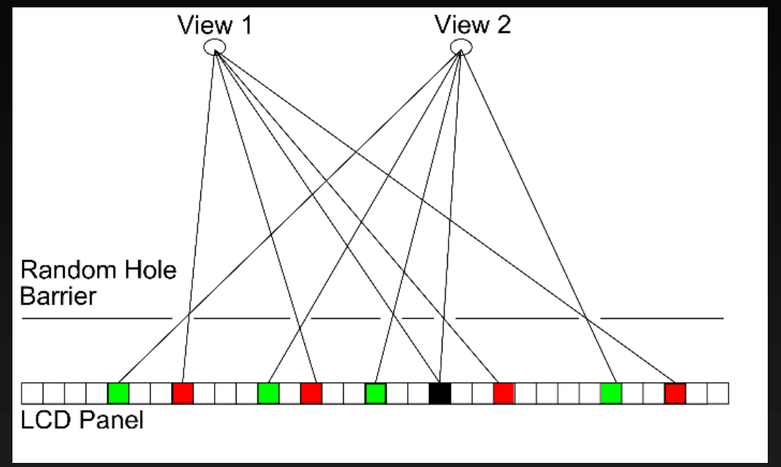
Random Hole Display: Simple Idea

- Conflicting pixels are randomly distributed

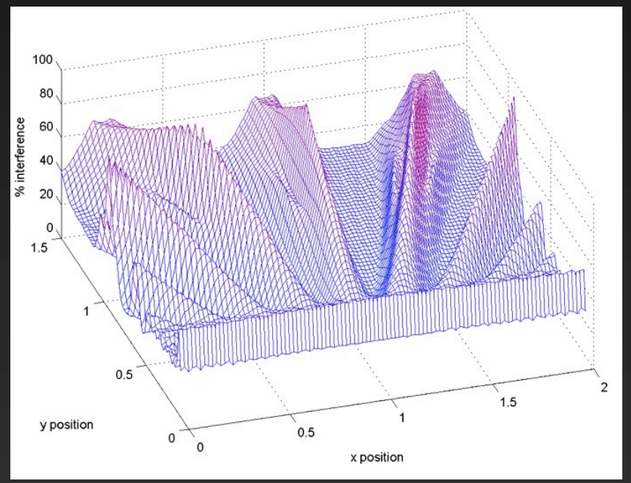
Regularly spaced slits: multi-viewers fail

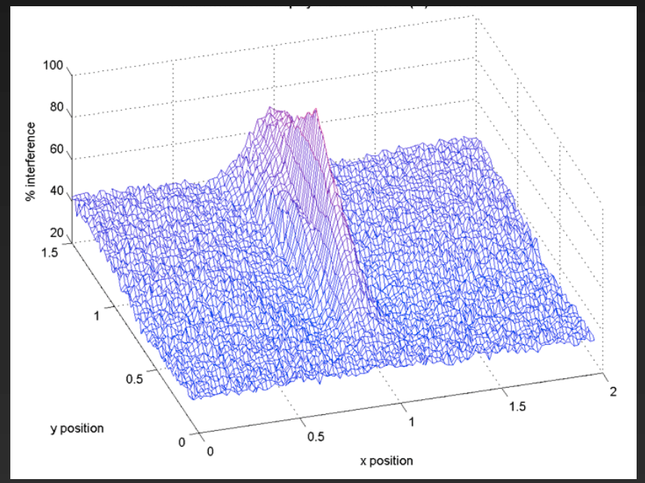


Random Hole Display: random conflicts



Conflicts with two vierws

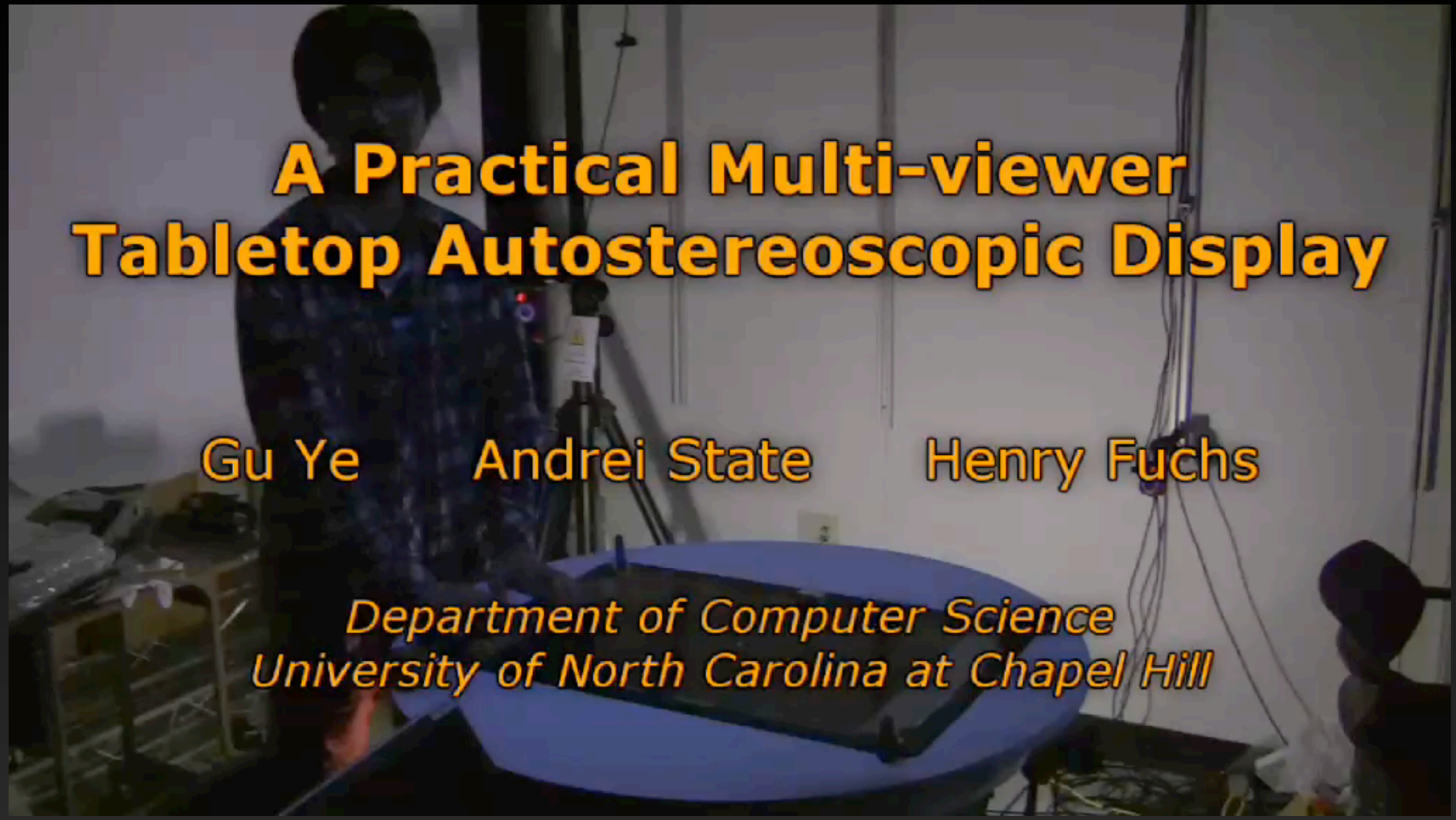




Traditional Barrier Slits: regular conflicts

New random Barrier x

Simple, Multi-viewer Autostereo Display

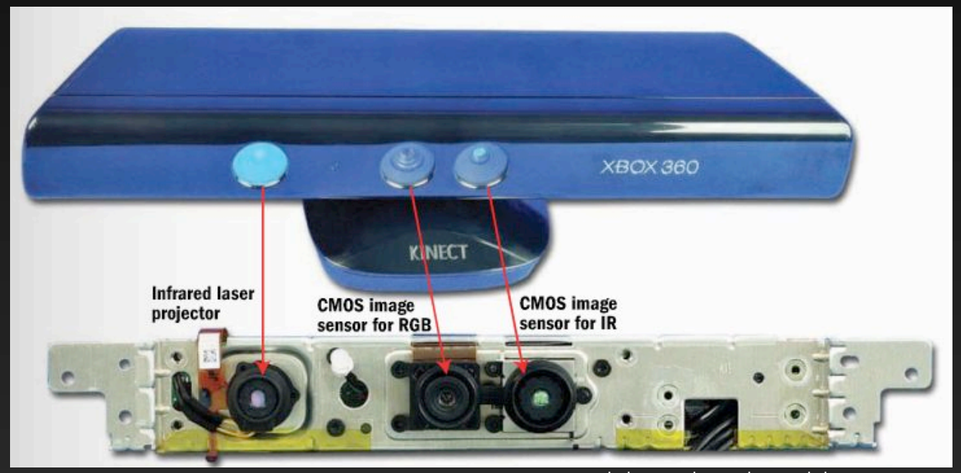


Ye, Gu, Andrei State and Henry Fuchs. *A Practical Multi-viewer Tabletop Autostereoscopic Display,* **Proceedings ISMAR 2010**.

Model Generation w/inexpensive commodity RGB-Z cameras

Microsoft (PrimeSense)Kinect depth & color camera: simultaneous color & depth images, 30Hz ($ 150)

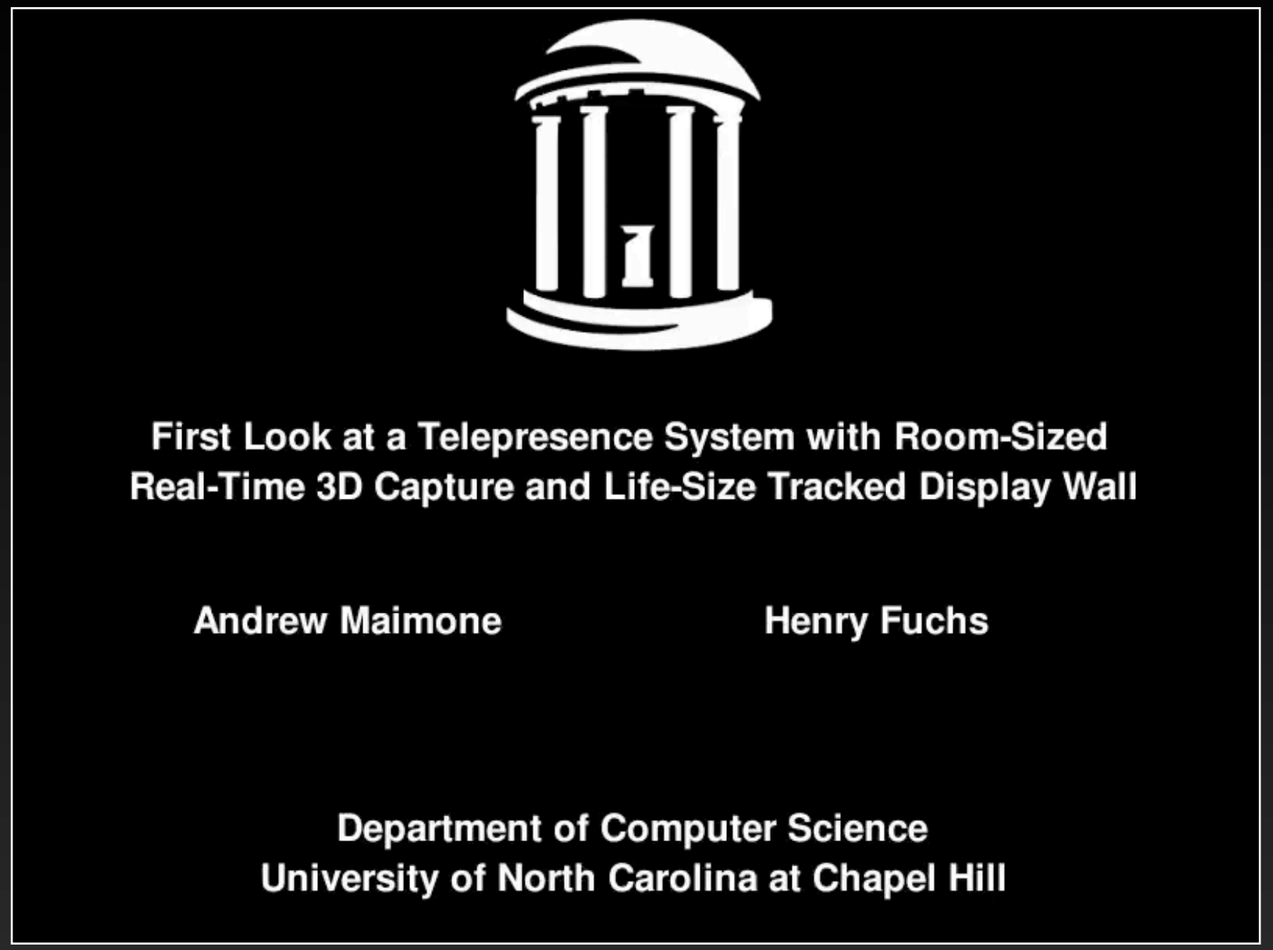
- Introduced Nov. 2010, as an Xbox 360 peripheral
- Rapidly adapted for wide variety of other uses



mickey-cheatham.blogspot.com

Room-Sized Real-Time 3D Capture with 10 Kinects

1. Capture with multiple Kinects
   a. Necessary to capture entire room
   b. More difficult than scanning room with a single Kinect
      - IR pattern projection from each Kinect confuses the depth acquisition subsystems
      - Any surface only observed by a few Kinect scans/frames vs many frames
2. Many video streams difficult for single PC to read and process
3. Multi-PC acquisition difficult due to difficulty of distributing & gathering (in real-time) video streams and GPU-intensive computations over multiple GPUs



Maimone, Andrew and Henry Fuchs. **A First Look at a Telepresence System with Room-Sized Real-Time 3D Capture and Life-Sized Tracked Display Wall**, *Proceedings ICAT 2011*.

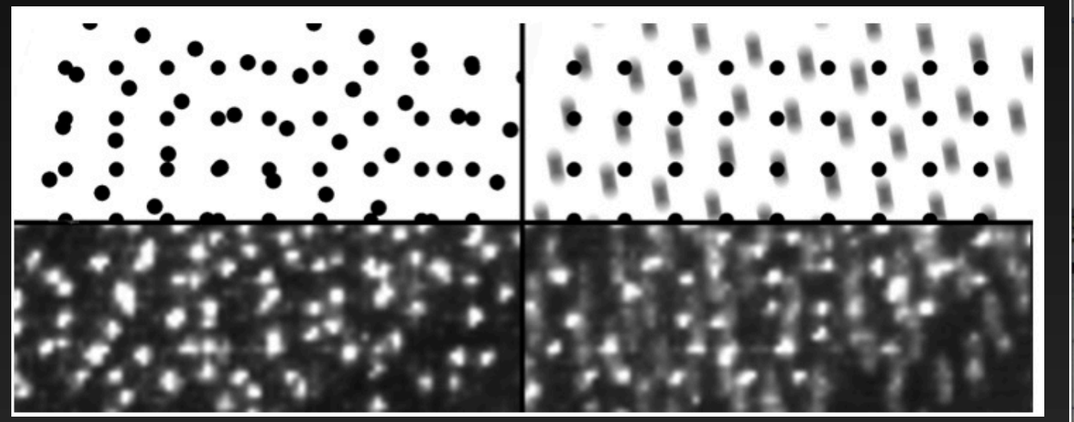
Reducing Interference Between Multiple Kinects Using Motion

Kinects fitted with DC motors with eccentrics

Overlapping IR dot patterns of two Kinects.

idealized

actual



normal with vibrators

Maimone, Andrew and Henry Fuchs. **Reducing Interference Between Multiple Structured Light Depth Sensors Using Motion**, *Proceedings IEEE VR 2012,* March 4, 2012 **(Best Short Paper Award).**

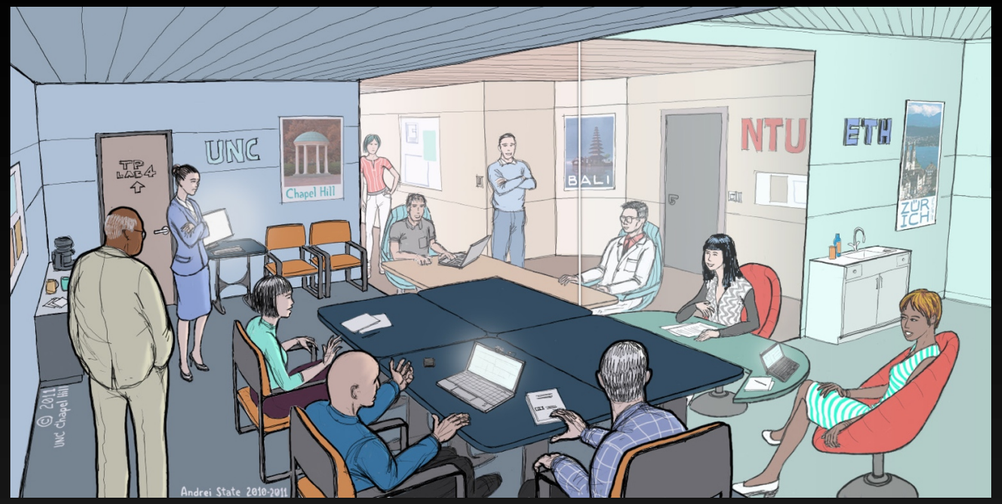
[independently developed at Microsoft -- SigCHI 2012, May 5, 2012]

"*BeingThere*" Telepresence International Research Centre

BeingThere Centre at NTU Singapore

- Funding: S$ 23M= $ 18M USD (over 4-5 years) from Singapore Interactive Digital Media Program Office and NTU, ETH, UNC.
- Directors: Nadia Thalmann (NTU), Markus Gross (ETH), Henry Fuchs (UNC)

BeingThere Center: Initial Projects



1. Room-based 3D Telepresence: "glass" wall interface to distant site

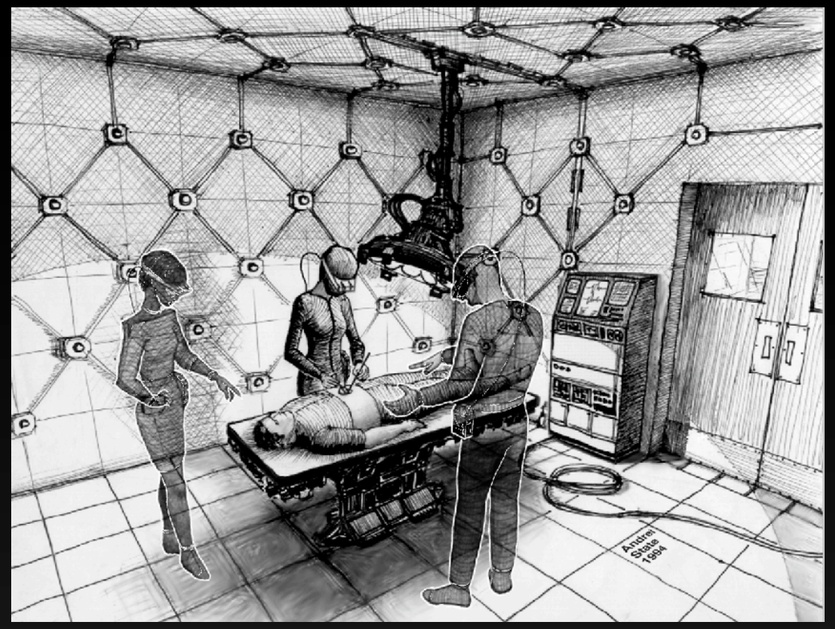
2. Roving Display: autostereo3D display on motion platform

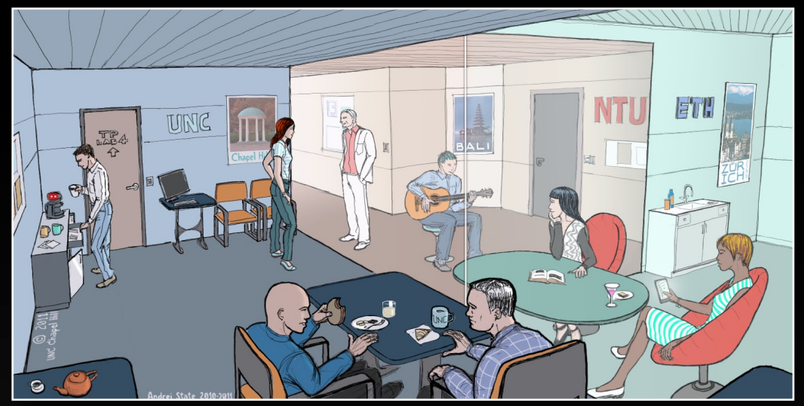
3. Animatronic Robotic Mannequin: human shape, motion, imagery (G. Welch, PI)

4. Autonomous Virtual Humans: human substitute w/memory, awareness, interaction

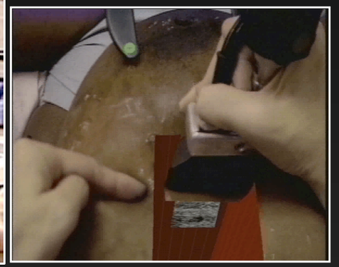
Summary, Conclusions, Future…

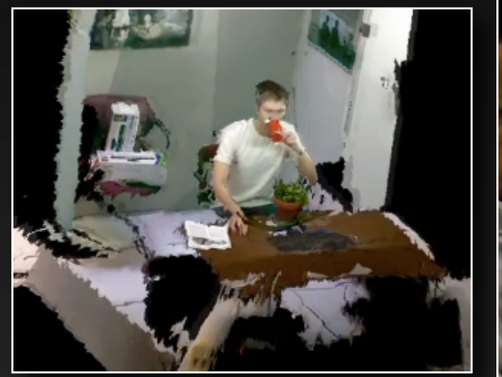
- Telepresence idea is appealing, but unproven
  - Similar to real-time photorealistic rendering in 1965
  - Ivan Sutherland, "The Ultimate Display", 1965 AFIPS
- Harnessing many RGB-Z cameras key to scene acquisition
- Displays
  - Multi-layer displays most promising for multi-viewer 3D
  - Longer term prospect: wide field-of-view head-worn displays, successors to Google Glass, Lumus, Epson

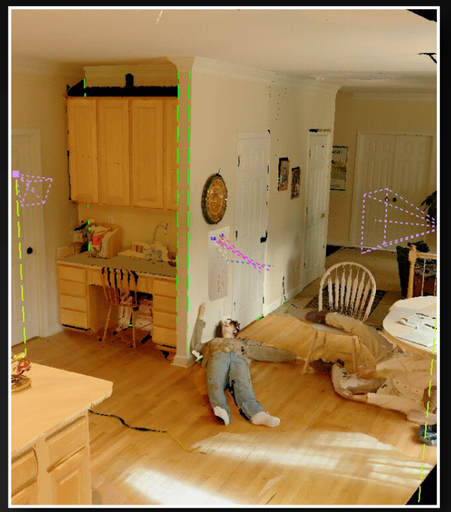


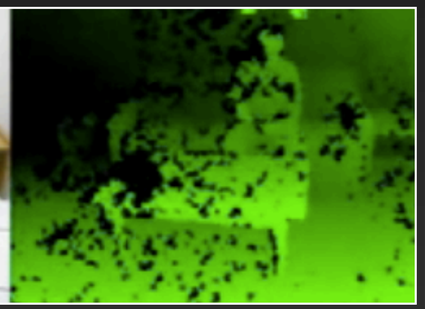


THE END









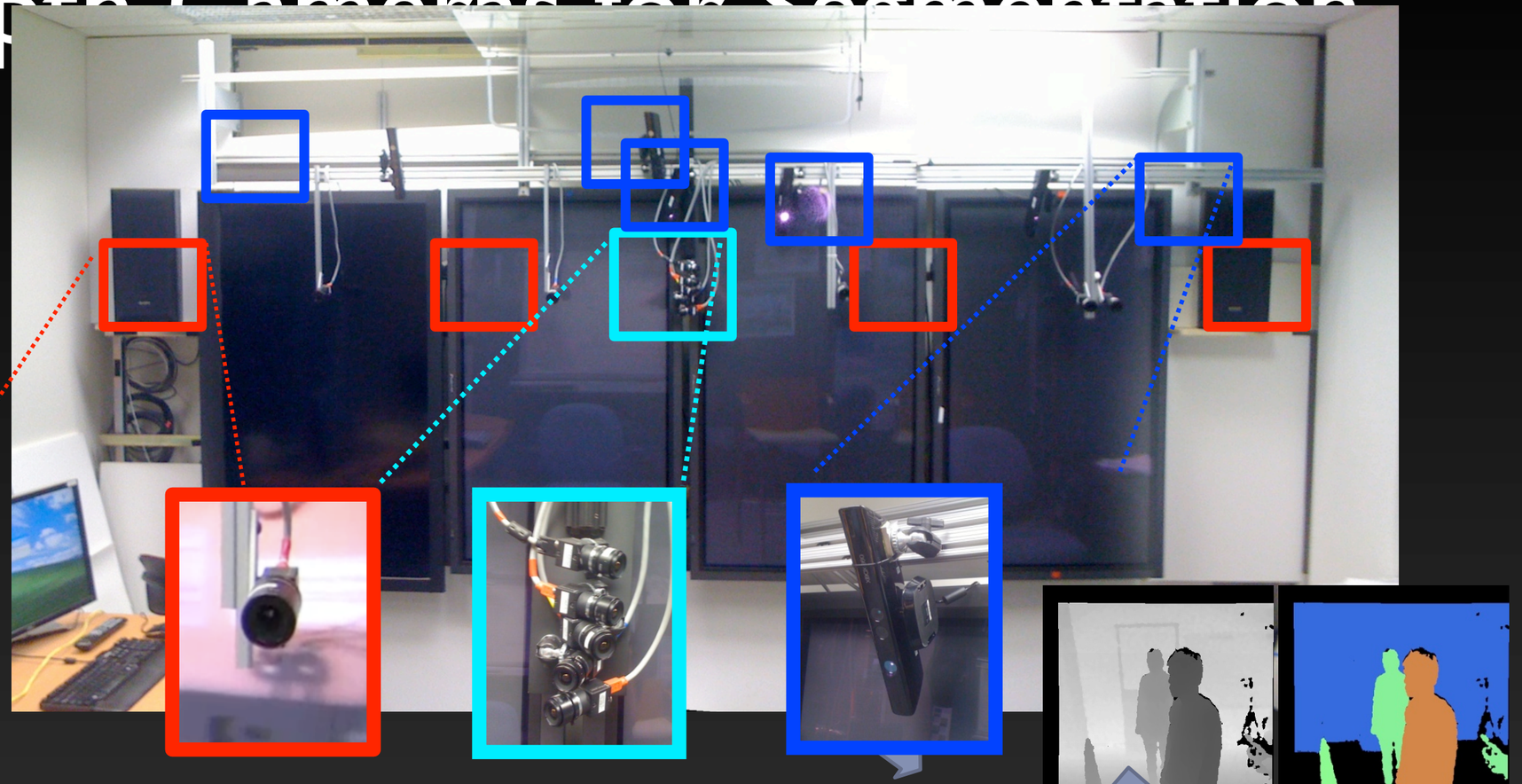
SPARE SLIDES follow

THE END

Augmenting MD with Local Data in 3D (1996)

State, A., M. Livingston, W. Garrett, G. Hirota, M.C. Whitton, E.D. Pisano (MD) and H. Fuchs. Technologies for Augmented Reality Systems: Realizing Ultrasound-Guided Needle Biopsies. SIGGRAPH 1996

Use Depth Cameras for Segmentation



Front-facing Camera

Panorama Camera Cluster

Kinect Depth Camera

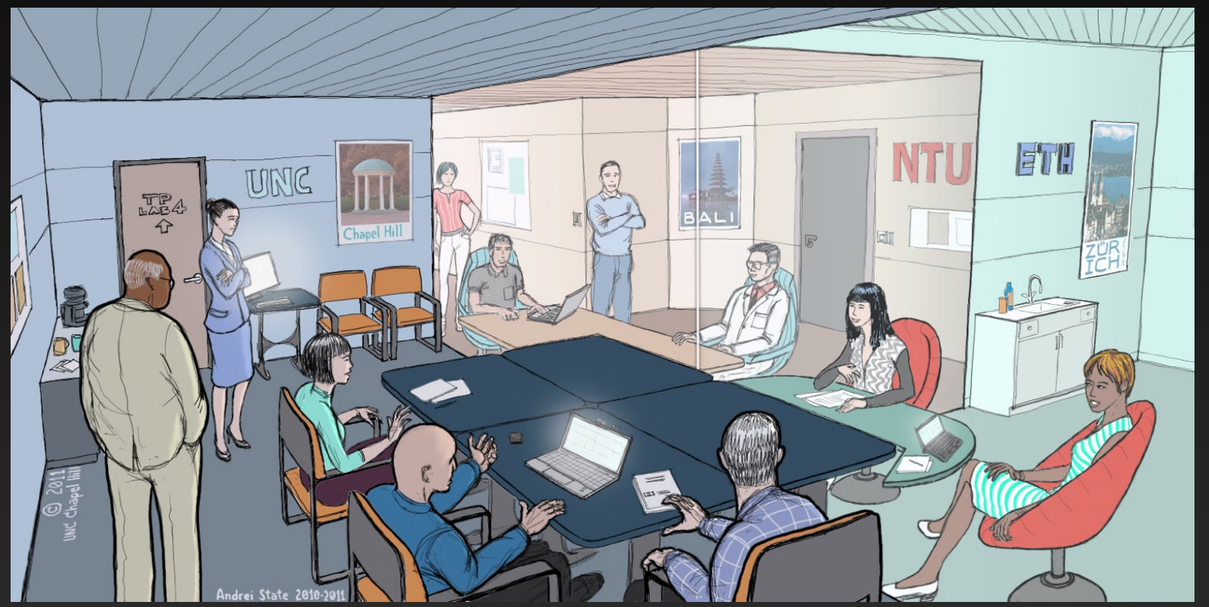
BeingThere Center:

BeingThere Center - NTU

- Co-Directors:
  - NTU Singapore: Nadia Thalmann
  - ETH Zurich: Markus Gross
  - UNC Chapel Hill: Henry Fuchs
- Initial participants: 32 faculty & senior researchers
- Expected: 24 PhD students at NTU, 5-9 postdocs & research associates at NTU; fewer at ETH & UNC
- Two ETH & two UNC researchers in residence in Singapore, each person for 6 months per year

Project 1: Room-based 3D Telepresence

- 3D acquisition of all rooms
- 3D autostereo display for multiple participants



Project 2: Roving Display

- Human-sized autostereo 3D of distant person
- Display is semi-transparent

3D display platform for mobile tele-presence (Copyright Markus Gross, ETHZ, 2009)

Project 3: Animatronic Robotic Mannequin

Mannequin ("Physical Virtual Avatar") Human controller ("inhabiter")

Peter Lincoln, Greg Welch, Andrew Nashel, Adrian Ilie, Andrei State, and Henry Fuchs. *Animatronic Shader Lamps Avatars*. **Proceedings of 8th IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'09)**, October 19–22, 2009.

Project 4: Autonomous Virtual Humans:

Human substitute with memory and awareness when human is absent

if there's time, talk about how the lack of good hmd's forces peole to adopt conventional stereo displays

- innerOptic
- have to give up direct augmentation, remote/virtual is not in same shared space with local.

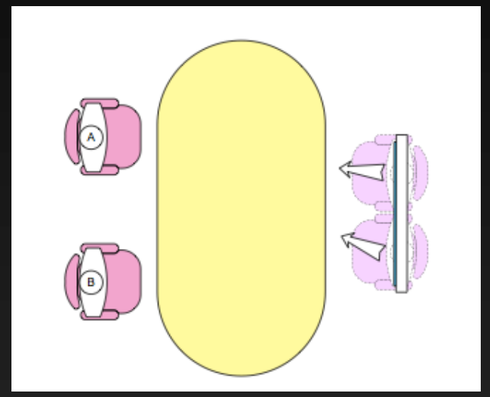
Solutions to Eye Contact Problem (1 of 2)

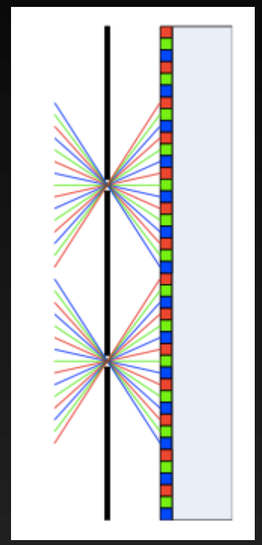
- Personal projectors: (Nguyen and Canny, 2005)
  - Projector for each local person
  - Retroreflective screen
  - Camera at the remote site ***for*** each local person

Nguyen and Canny. Multiview: spatially faithful group video conferencing. ACM CHI 2005.

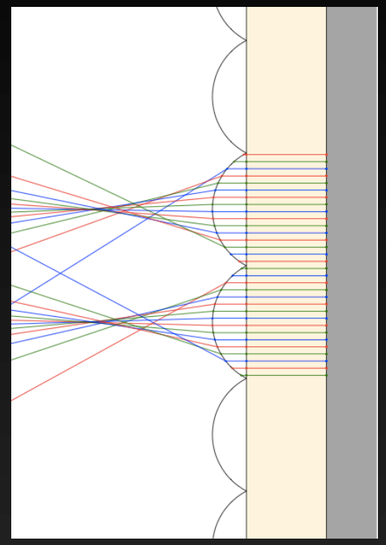
A Solution to Eye Contact Problem (2 of 2)

- Wide Angle Lenticular Display





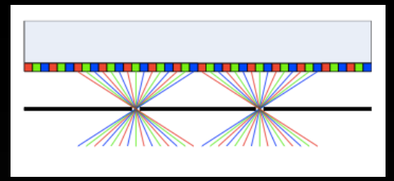
Barrier slits



Lenticular lenses

Lincoln, Nashel, Ilie,Towles, Welch, Fuchs. Multi-view lenticular display for group teleconferencing. IMMERSCOM 2009.

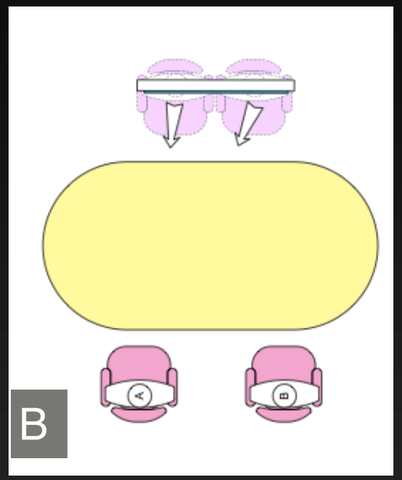
Wide Angle Lenticular Display



- Each local viewer receives a different image (subset of pixels)

Both pointing to person A

A



A's view

B's view

Lincoln, Nashel, Ilie,Towles, Welch, Fuchs. Multi-view lenticular display for group teleconferencing. IMMERSCOM2009.

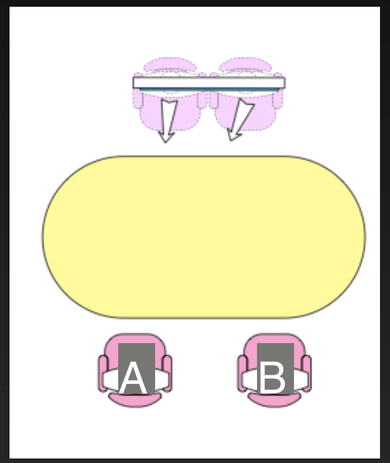
Limitations of Wide Angle Lenticular Display

Both pointing to person A

A's view

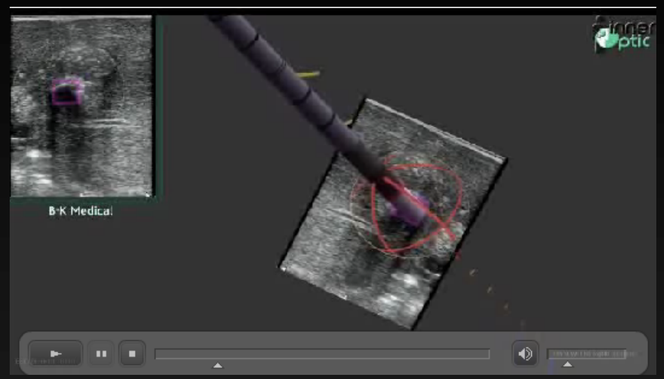
B's view

- Mono view to each participant
- Fixed number of views, set at construction of display
- Fixed geometry of sitting positions, set at construction of display



Lincoln, Nashel, Ilie,Towles, Welch, Fuchs. Multi-view lenticular display for group teleconferencing. IMMERSCOM2009.

Commercial AR System: Stereo LCD



"The InVision System makes guiding a needle into a tumor much easier and more accurate. All surgeons, from novice to expert, will benefit from its 3D guidance."

David Iannitti, MD
Chief of Hepatopancreaticobiliary Surgery
Carolinas Medical Center, Charlotte

Eye Contact Problem Serious?

- Measurably better judgement made about remote person if there is eye contact *
- Game playing with remote team member, determining whether remote partner will be loyal or not

* Nguyen and Canny. Multiview: spatially faithful group video conferencing. ACM CHI 2005.