BEYOND REALITY (2027): THE FUTURE OF VIRTUAL AND AUGMENTED REALITY

Bruce Thomas

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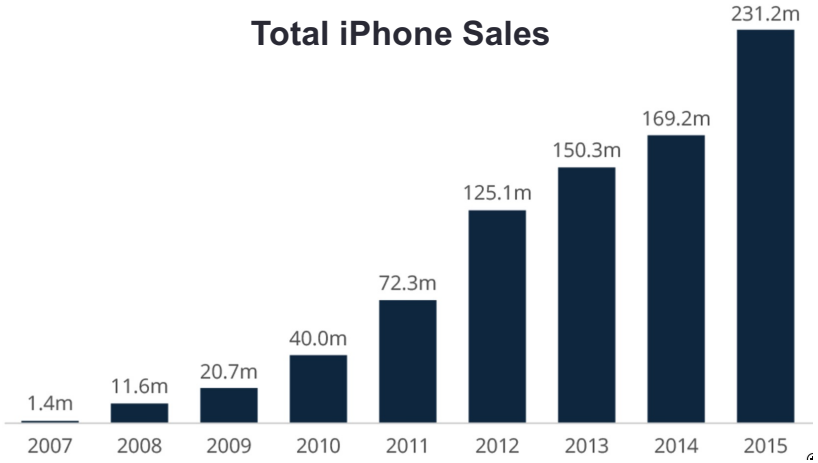
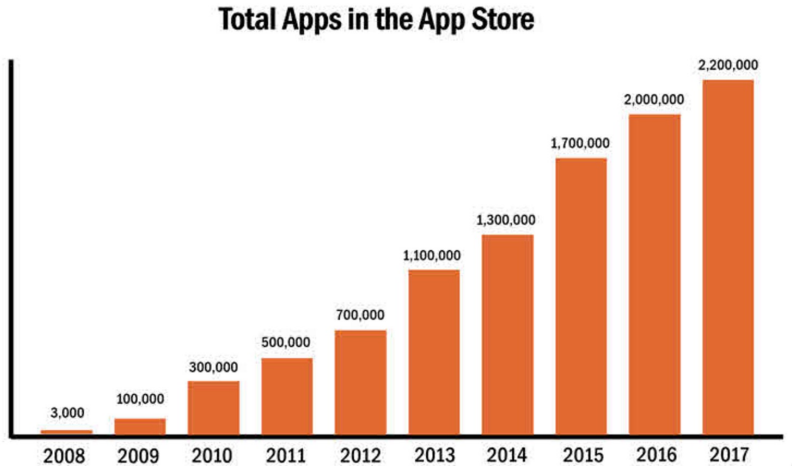
University of South Australia

2007…

- Introduction of the iPhone

2017 …





- Transformed the industry
  - Over 700 million iPhones sold, over 2 million apps available

2017 …

- Growing range of AR/VR devices

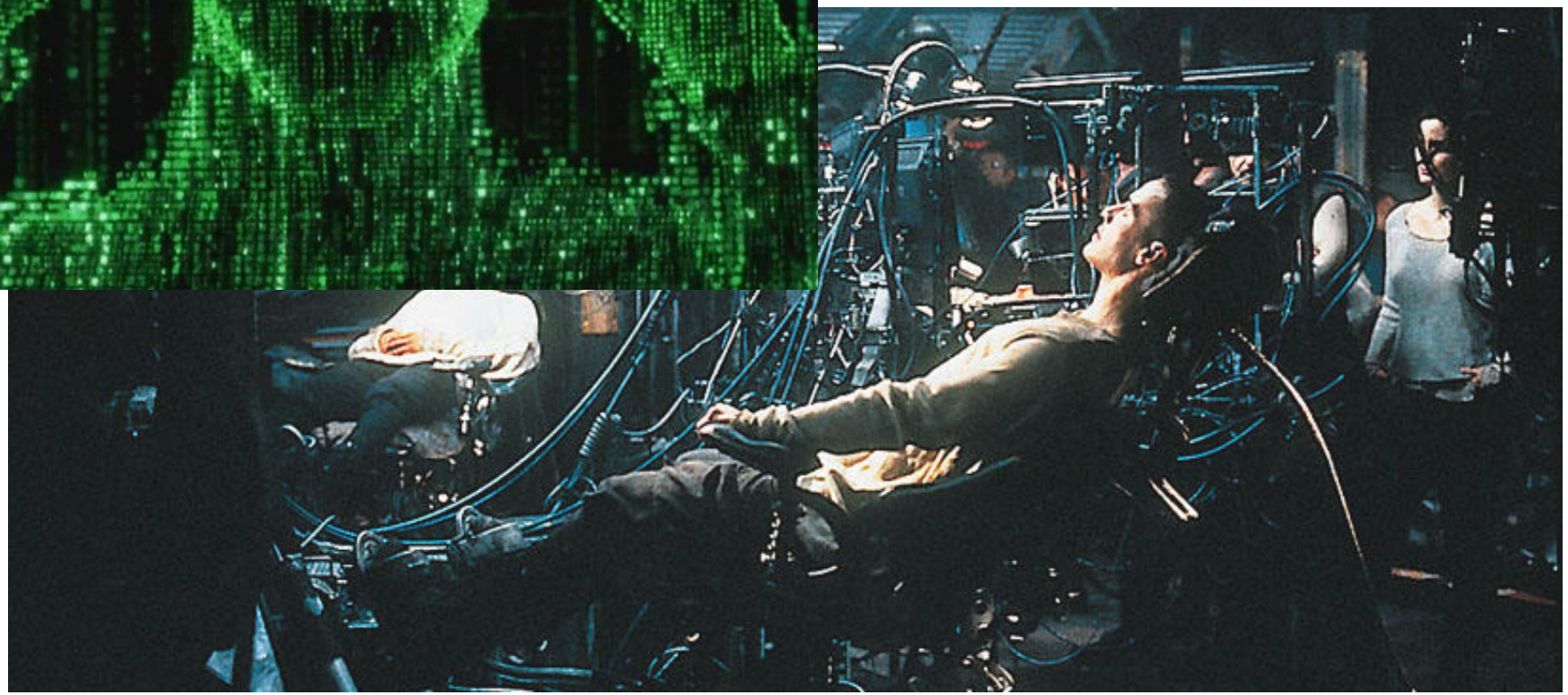
2027 …

- What does the future hold for AR/VR ?

VIRTUAL REALITY

Prof Bruce Thomas
University of South Australia

What is Virtual Reality ?



Virtual Reality

- Virtual reality is replacing the physical world stimulus (light, sound, touch, taste, and smell) with computer generated sensations.

Today

Tomorrow - HoloDeck (1974)

- https://www.youtube.com/watch?v=oZwtVz7z0wM

The Ultimate Display

"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal".

Ivan Sutherland, 1965

Sutherland Display

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

Key Characteristics for VR

- Virtual Reality has three key characteristics
  - 3D stereoscopic display
  - Wide field of view display
  - Low latency head tracking

- When these three things are combined they provide a compelling immersive experience

VR Experience

- “This is so real..”
- https://www.youtube.com/watch?v=pAC5SeNH8jw

2016 - Rise of Consumer HMDs

Oculus Rift

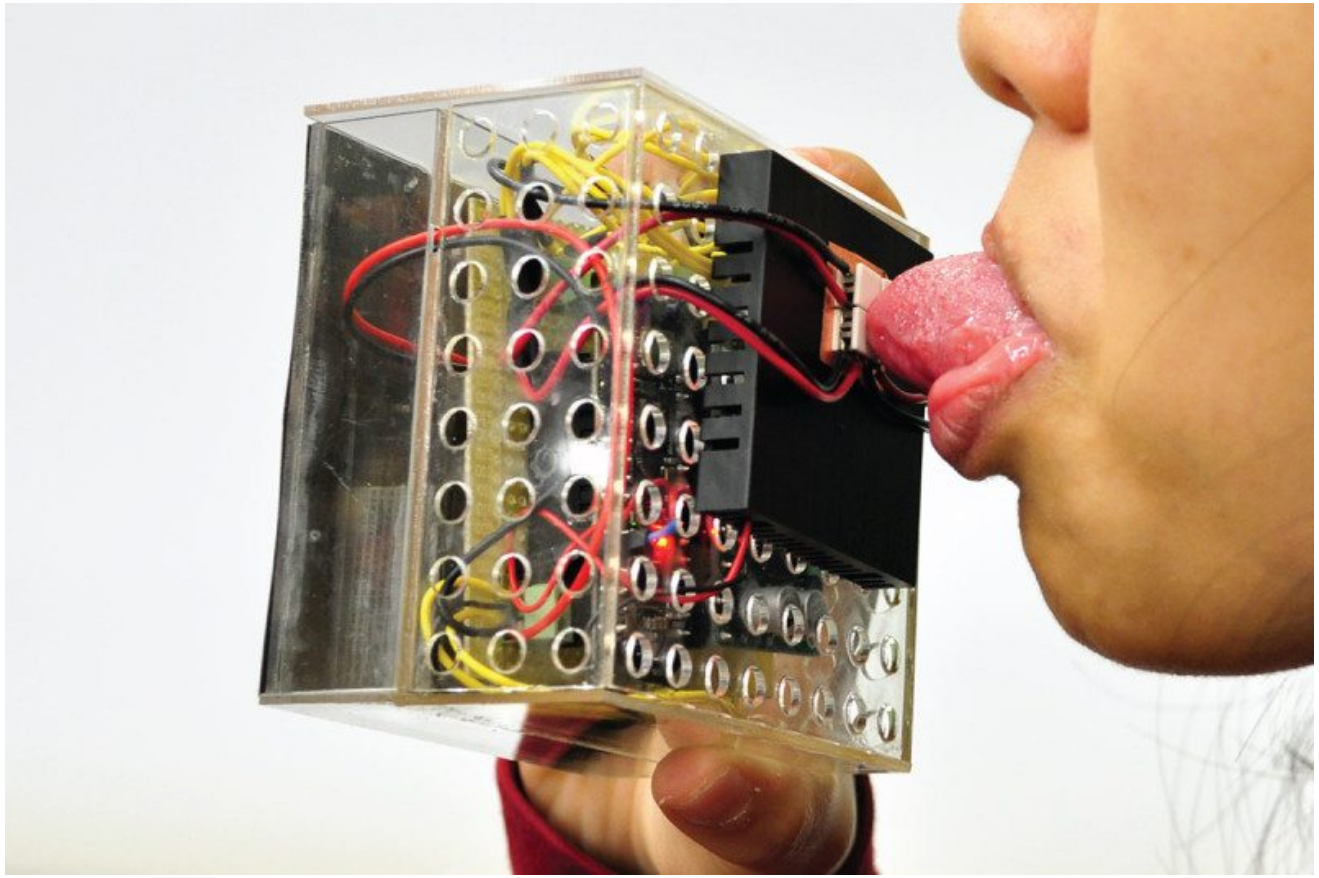
HTC/Valve Vive

Sony Morpheus

HTC Vive

- Room scale tracking
- Gesture input devices

Taste

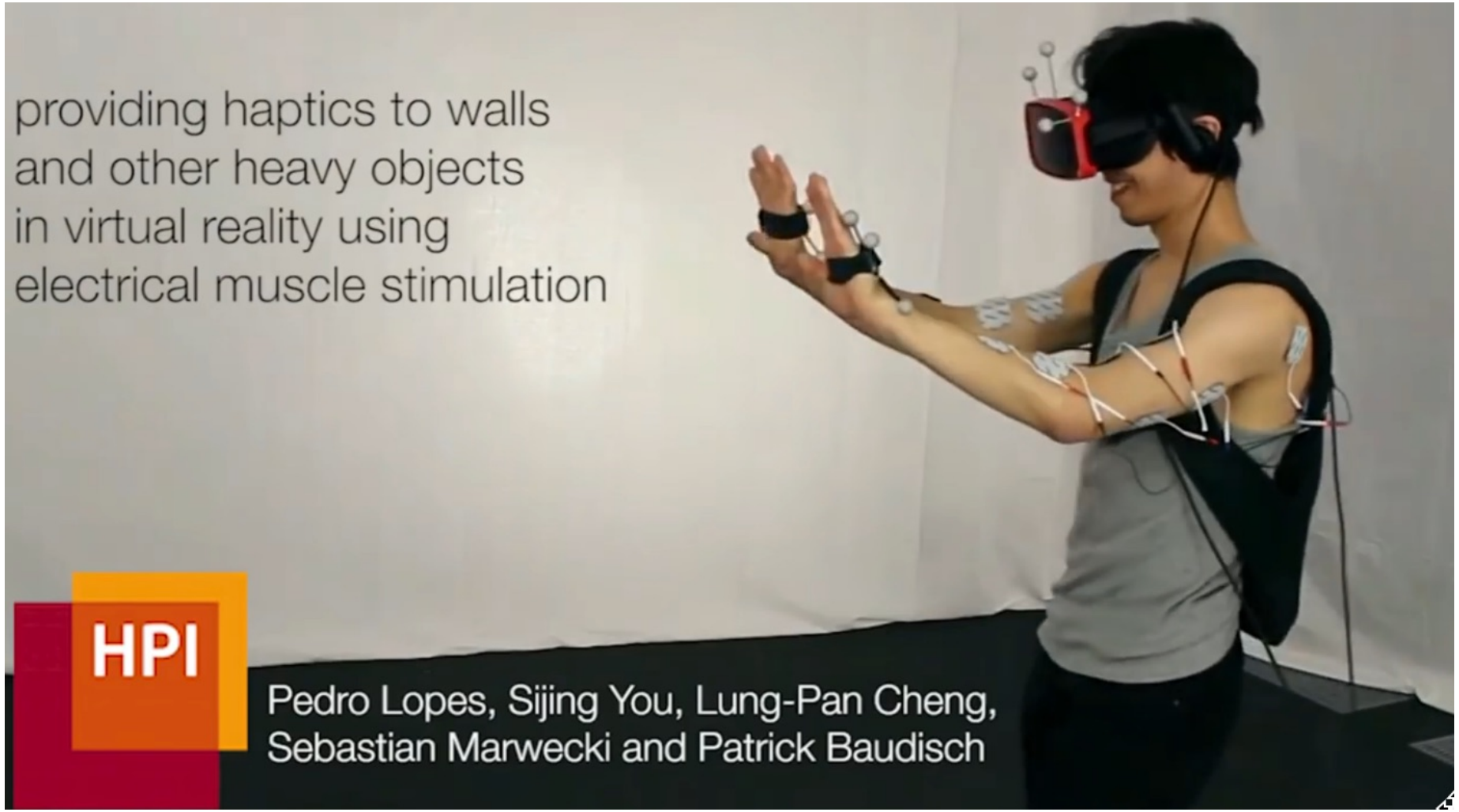


- Unreal: this tastes delicious Nimesha Ranasinghe, National University of Singapore

Smell

https://www.youtube.com/watch?v=Im6YxFw7apc

Touch



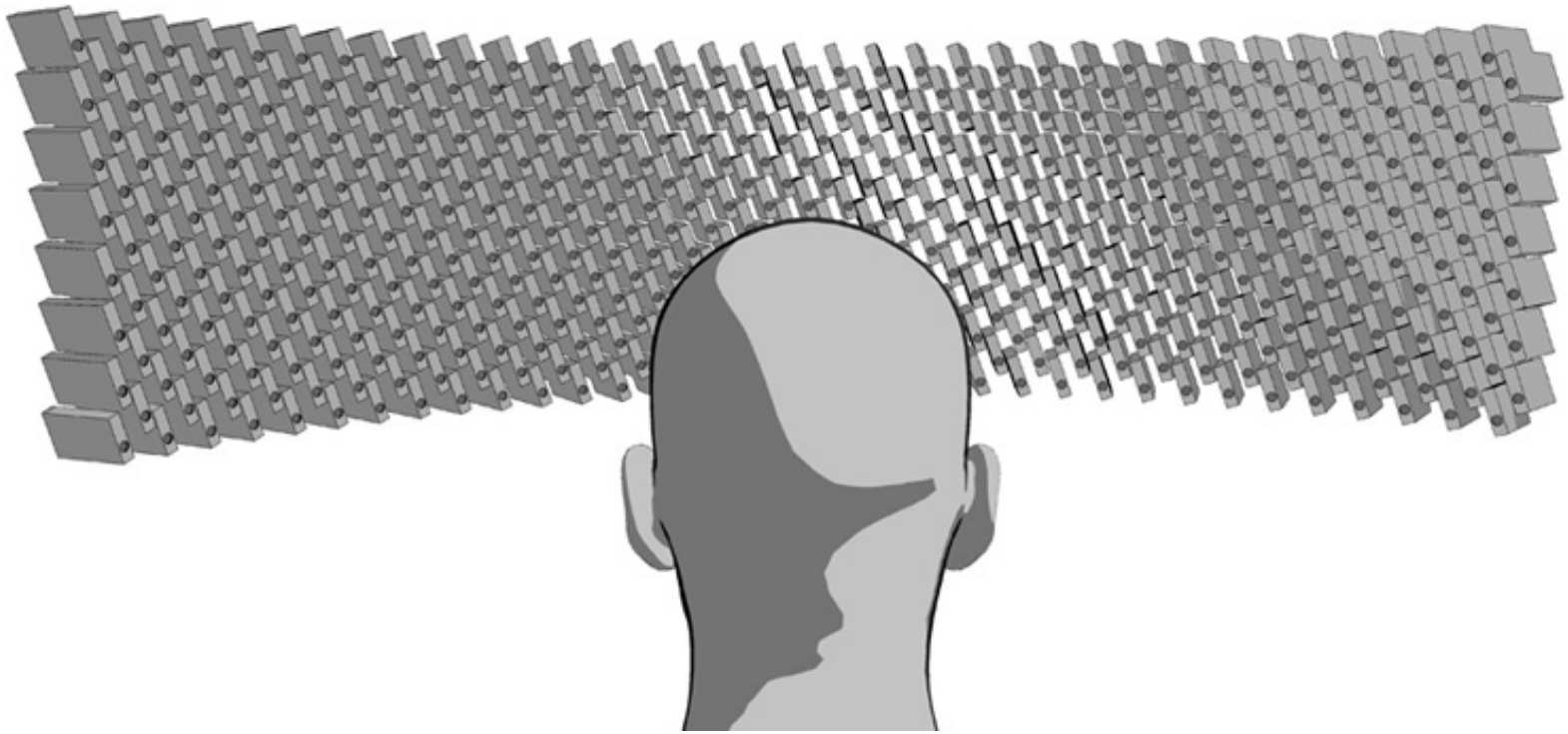
https://www.youtube.com/watch?v=MYH--QGUFn8

Sound

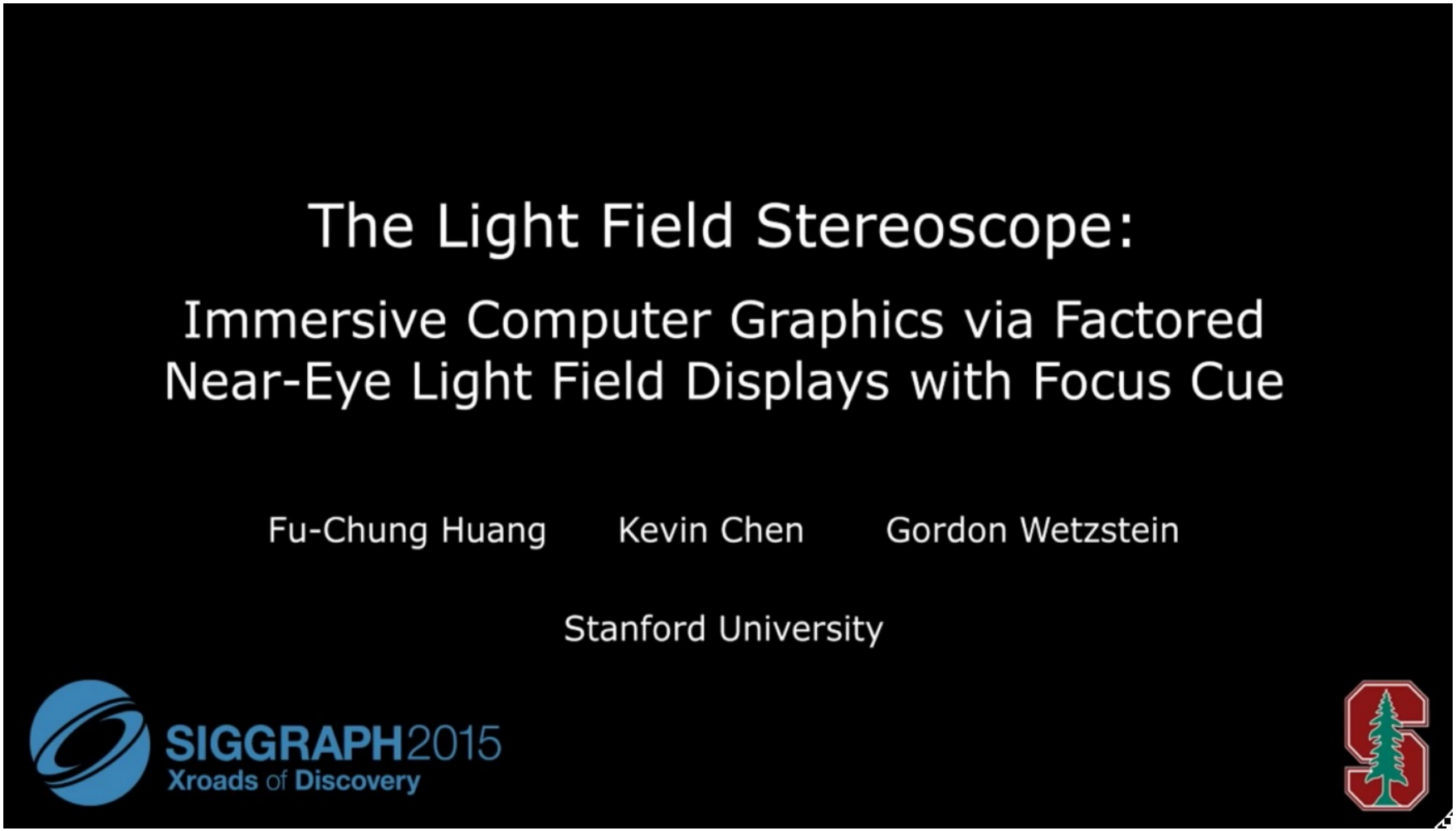
highfidelity.com

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

Light Field Displays

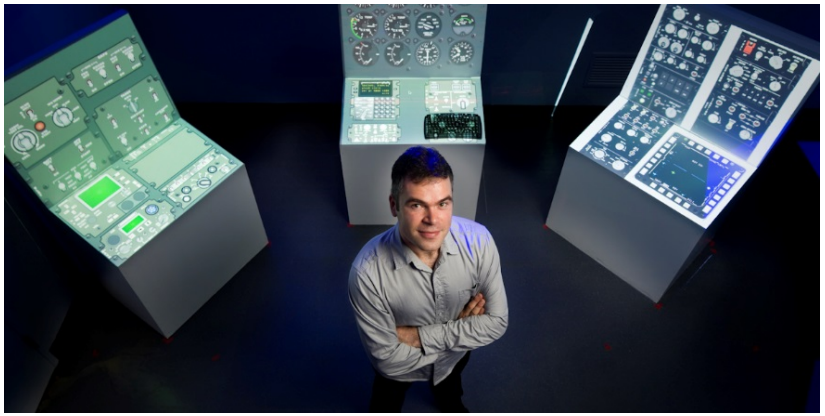


Light Field Display

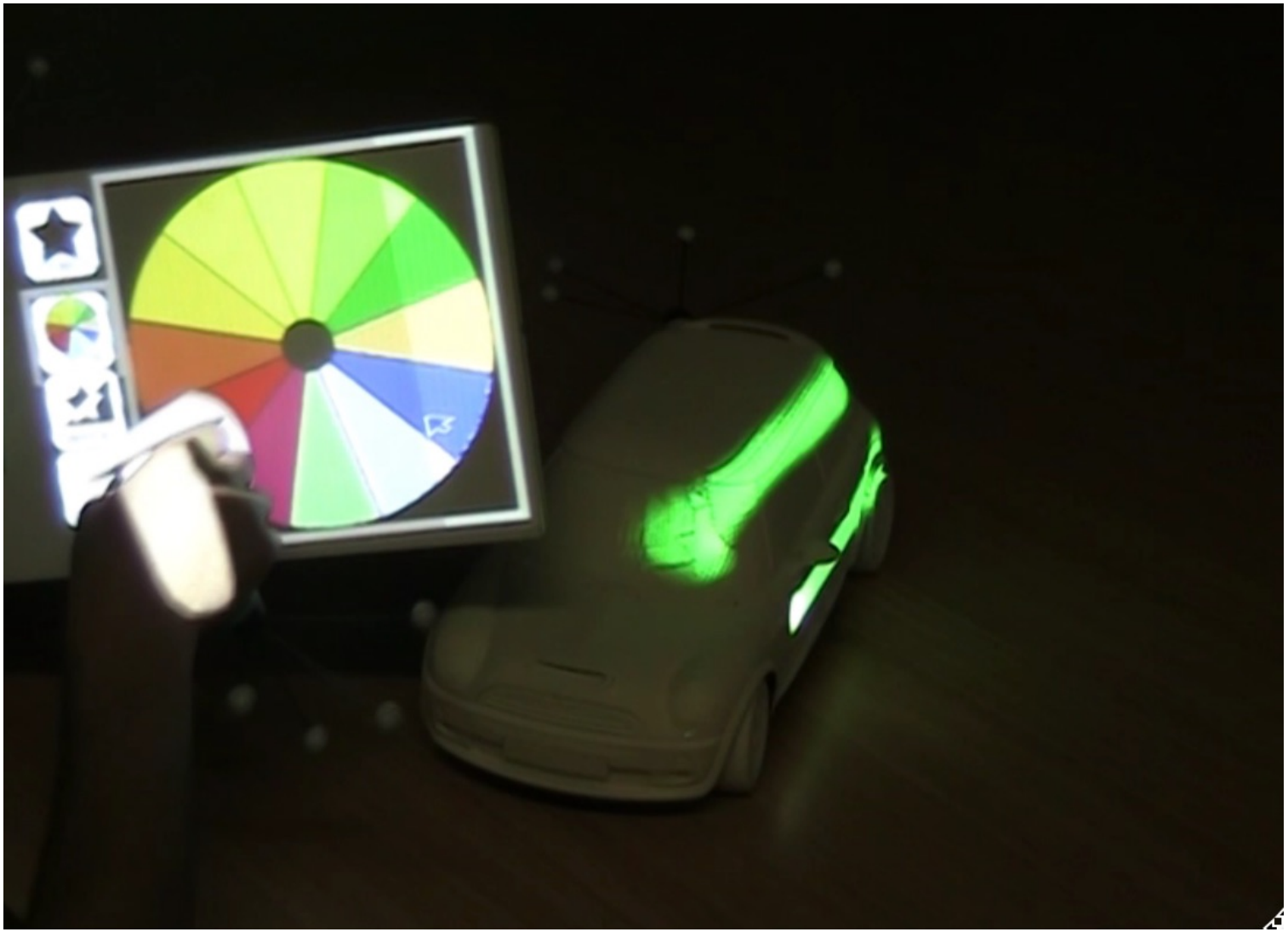


https://www.youtube.com/watch?v=YJdMPUF8cDM

Spatial Augmented Reality
University of South Australia



Projectors and Light



We are Well on Our Way to the Future!

AUGMENTED REALITY

Prof Mark Billinghurst
University of South Australia

Augmented Reality

1977 – Star Wars

Augmented Reality Characteristics

- Combines Real and Virtual Images
  - Both can be seen at the same time
- Interactive in real-time
  - The virtual content can be interacted with
- Registered in 3D
  - Virtual objects appear fixed in space

Azuma, R. T. (1997). A survey of augmented reality. Presence, 6(4), 355-385.

2008 - CNN

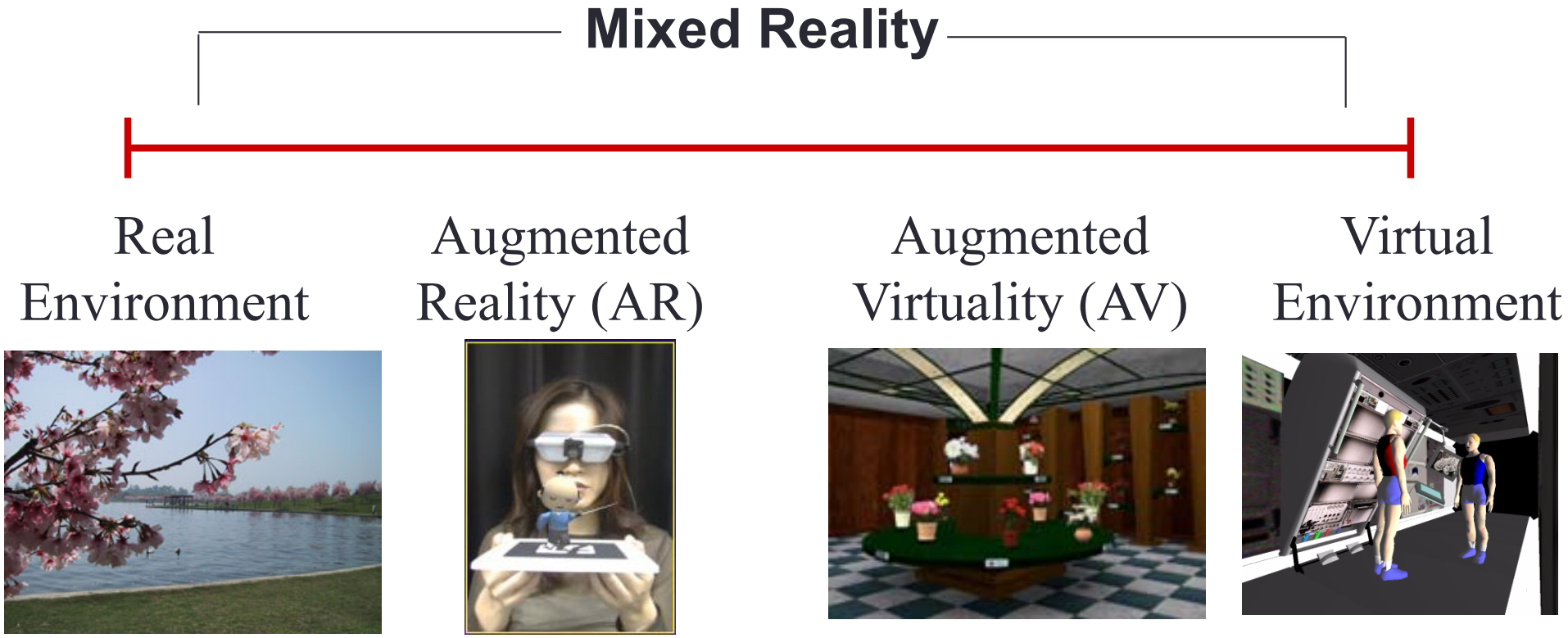
https://www.youtube.com/watch?v=v7fQ_EsMJMs

AR vs VR

	Virtual Reality *Replaces Reality*	**Augmented Reality** *Enhances Reality*
Scene Generation	Requires realistic images	Minimal rendering okay
Display Device	Fully immersive, wide field of view	Non-immersive, small field of view
Tracking	Low to medium accuracy is okay	The highest accuracy possible

Milgram's Reality-Virtuality continuum

"...anywhere between the extrema of the *virtuality continuum.*"

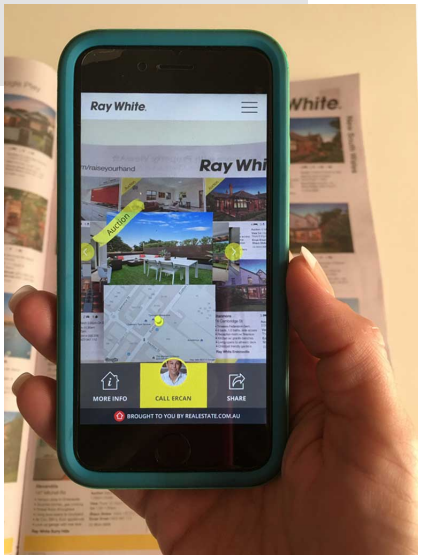


Reality - Virtuality (RV) Continuum

P. Milgram and A. F. Kishino, Taxonomy of Mixed Reality Visual Displays
IEICE Transactions on Information and Systems, E77-D(12), pp. 1321-1329, 1994.

Augmented Reality in 2017

- Large growing market
  - > $600 Million USD in 2016
- Many available devices
  - HMD, phones, tablets, HUDs
- Robust developer tools
  - Vuforia, ARToolKit, Unity, Wikitude, etc
- Large number of applications
  - > 150K developers, > 100K mobile apps
- Strong research/business communities
  - ISMAR, AWE conferences, AugmentedReality.org, etc



Typical AR Experiences

- Web based AR
  - Marketing, education
- Outdoor Mobile AR
  - Viewing Points of Interest
- Handheld AR
  - Marketing, gaming, education
- Location Based Experiences
  - Museums, point of sale, advertising

Example: Quiver

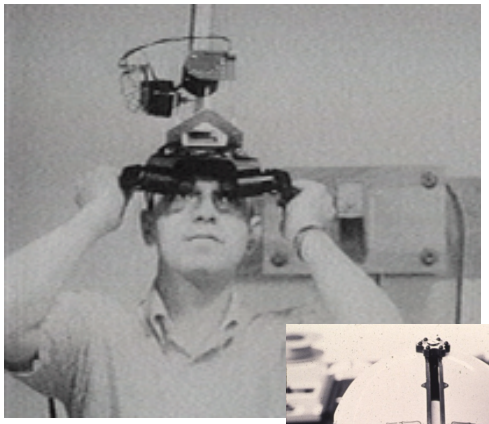
http://www.quivervision.com/

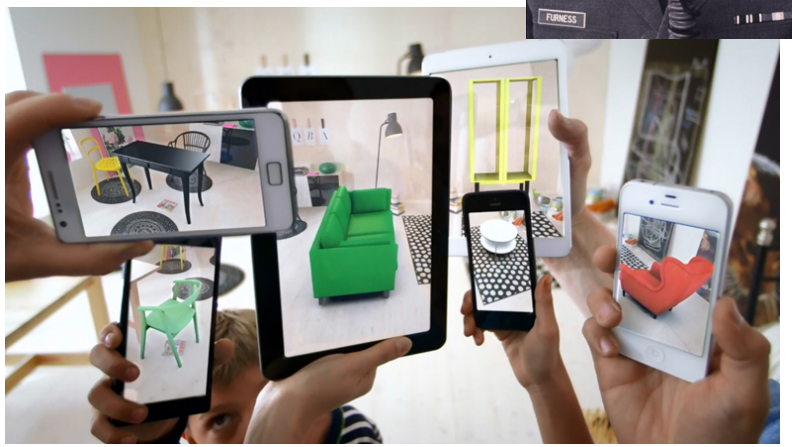
Key Enabling Technologies

1. Combines Real and Virtual Images
   - ➡ Display Technology
2. Interactive in real-time
   - ➡ Interaction Technologies
3. Registered in 3D
   - ➡ Tracking Technologies

Future Displays

- Past
  - Bulky Head mounted displays
- Current
  - Handheld, lightweight head mounted
- Future
  - Projected AR
  - Wide FOV see through
  - Retinal displays
  - Contact lens





Wide FOV See-Through (3+ years)

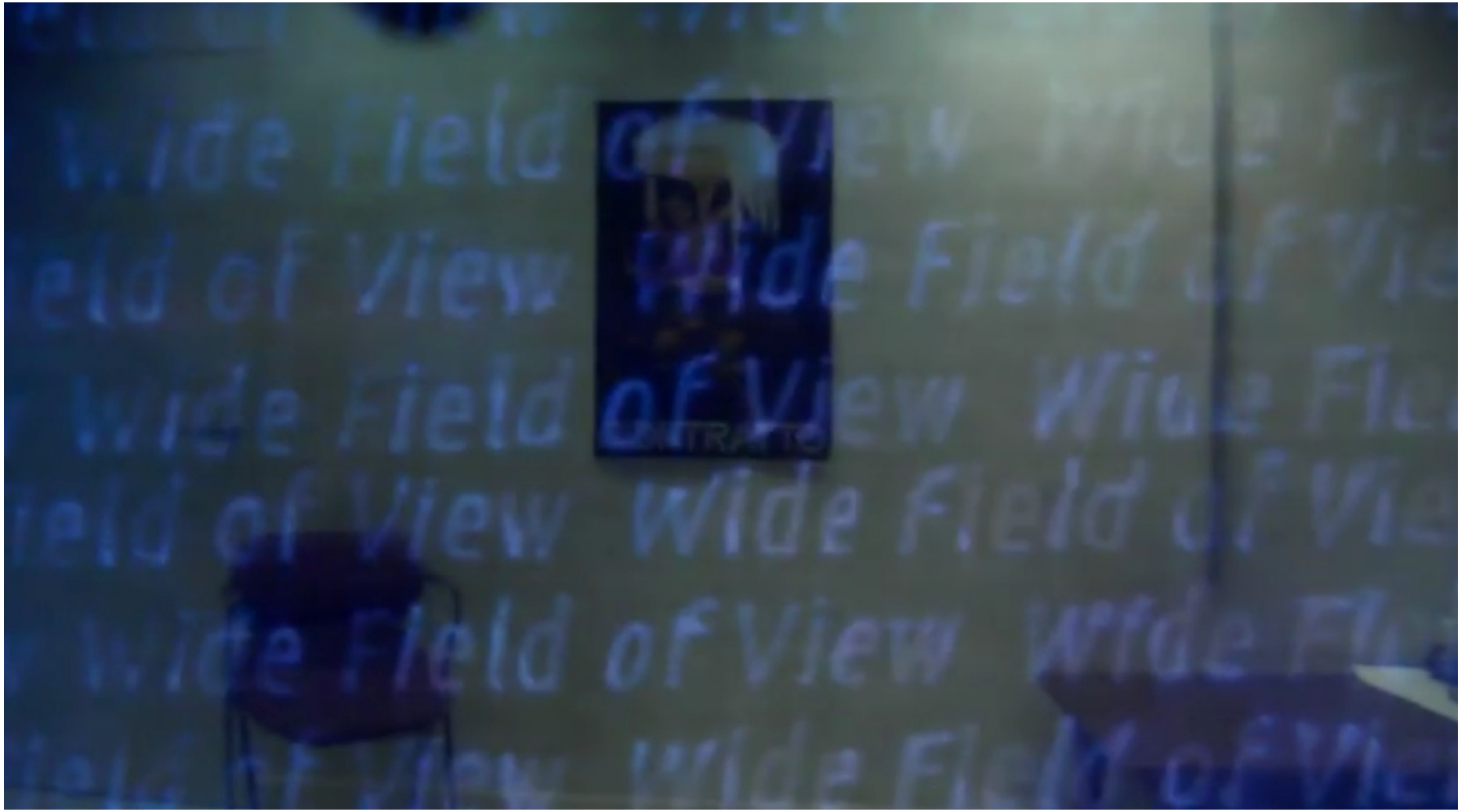
- Waveguide techniques
  - Thin, wider FOV
  - Socially acceptable

Lumus DK40

- Pinlight Displays
  - LCD panel + point light sources
  - 110 degree FOV

Maimone, A., Lanman, D., Rathinavel, K., Keller, K., Luebke, D., & Fuchs, H. (2014). Pinlight displays: wide field of view augmented reality eyeglasses using defocused point light sources. In *ACM SIGGRAPH 2014 Emerging Technologies* (p. 20). ACM.

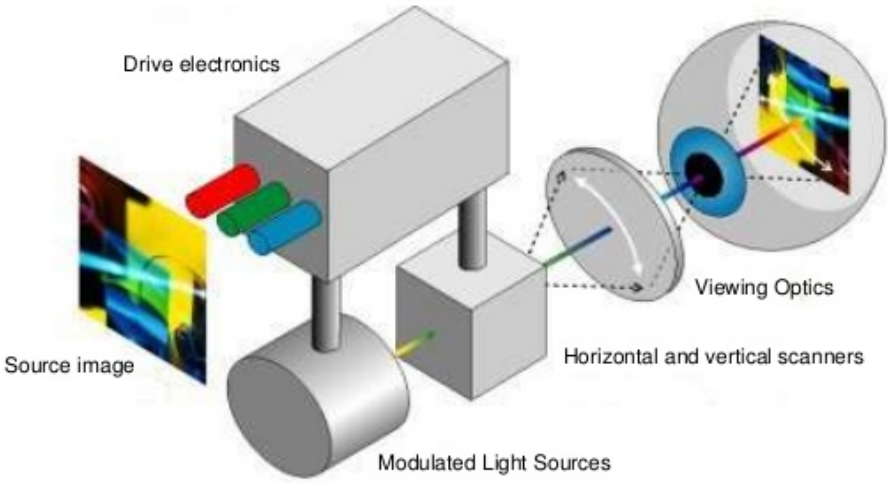
Pinlight Display Demo



https://www.youtube.com/watch?v=P407DFm0PFQ

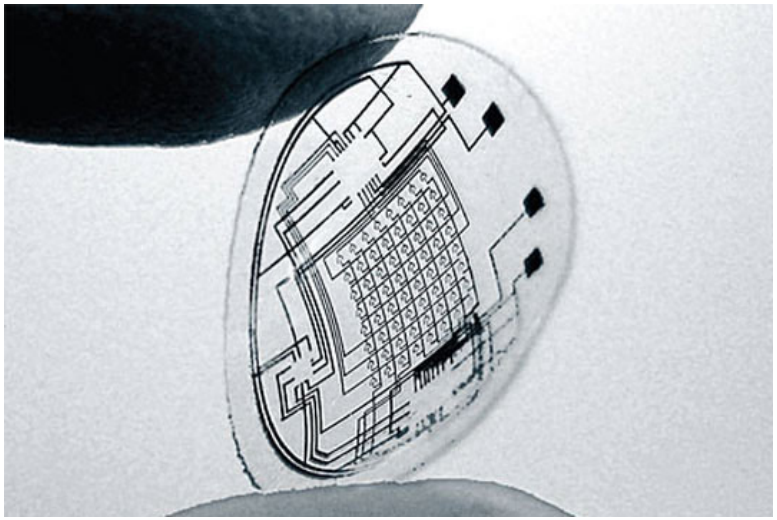
Retinal Displays (5+ years)

- Photons scanned into eye
  - Infinite depth of field
  - Bright outdoor performance
  - Overcome visual defects
  - True 3D stereo with depth modulation
- Microvision (1993-)
  - Head mounted monochrome
- MagicLeap (2013-)
  - Projecting light field into eye

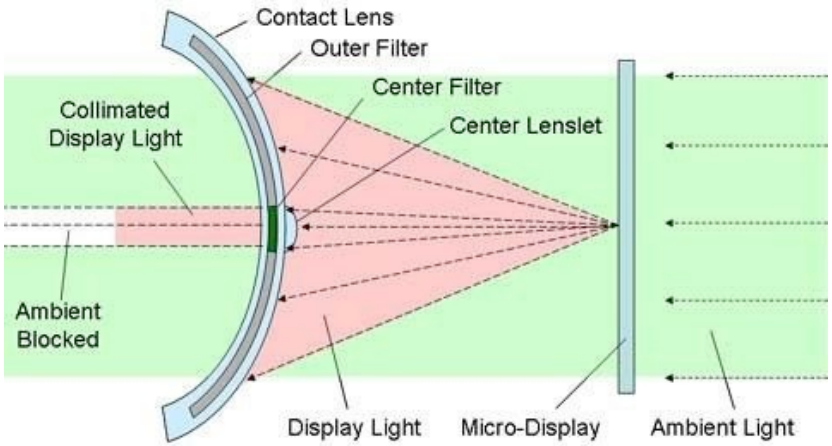


Contact Lens (10 – 15 + years)

- Contact Lens only
  - Unobtrusive
  - Significant technical challenges
    - Power, data, resolution
  - Babak Parviz (2008)



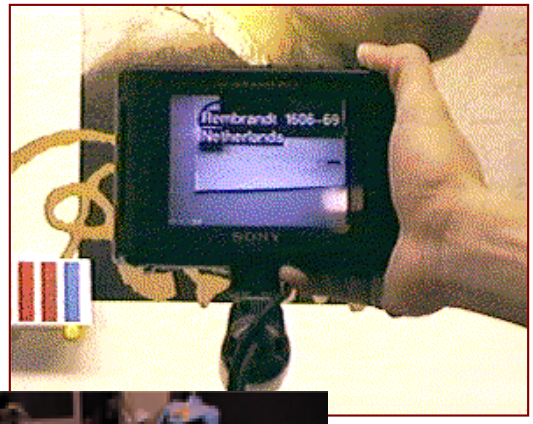
- Contact Lens + Micro-display
  - Wide FOV
  - socially acceptable
  - Innovega (innovega-inc.com)

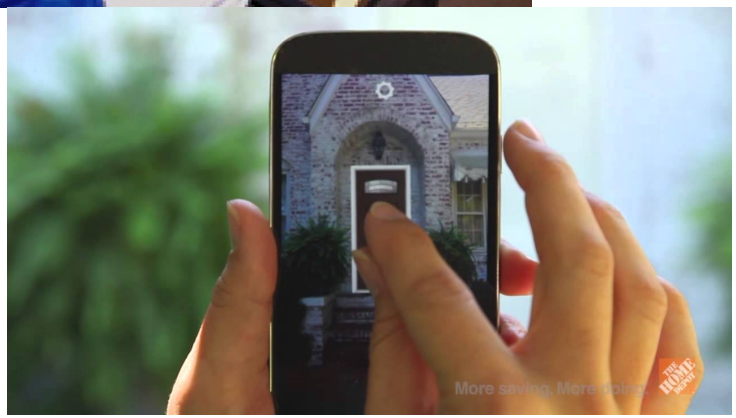


http://spectrum.ieee.org/biomedical/bionics/augmented-reality-in-a-contact-lens/

Evolution of Interaction

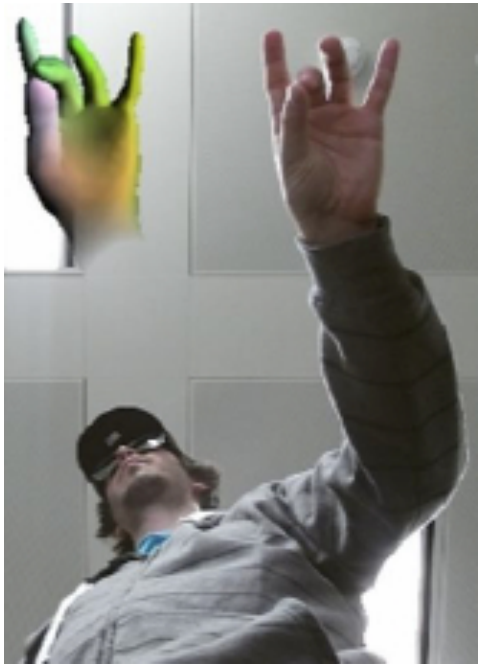
- Past
  - Limited interaction
  - Viewpoint manipulation
- Present
  - Screen based, simple gesture
  - tangible interaction
- Future
  - Natural gesture, Multimodal
  - Intelligent Interfaces
  - Physiological/Sensor based





Natural Gesture (2-5 years)

- Freehand gesture input
  - Depth sensors for gesture capture
  - Rich two handed gestures
- Eg Microsoft Research Hand Tracker
  - 3D hand tracking, 30 fps, single sensor
- Commercial Systems
  - Meta, MS Hololens, Occulus, Intel, etc



Sharp, T., Keskin, C., Robertson, D., Taylor, J., Shotton, J., Leichter, D. K. C. R. I., ... & Izadi, S. (2015, April). Accurate, Robust, and Flexible Real-time Hand Tracking. In *Proc. CHI* (Vol. 8).

Microsoft Hand Tracker

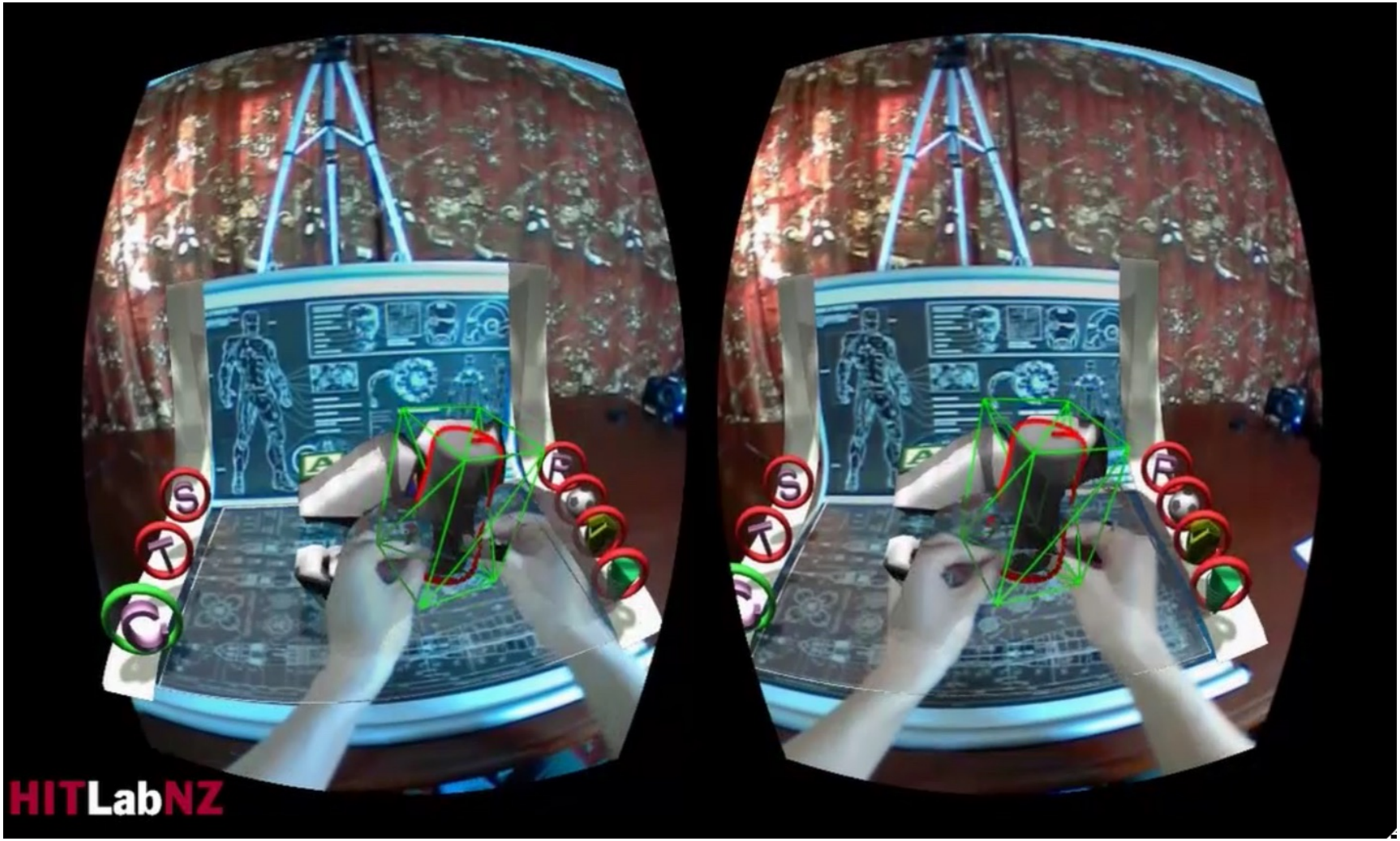
https://www.youtube.com/watch?v=A-xXrMpOHyc&t=7s

Multimodal Input (10-15+ years)

- Combine gesture and speech input
  - Gesture good for qualitative input
  - Speech good for quantitative input
  - Support combined commands
    - “Put that there” + pointing
- Eg HIT Lab NZ multimodal input
  - 3D hand tracking, speech
  - Multimodal fusion module
  - Complete tasks faster with MMI, less errors

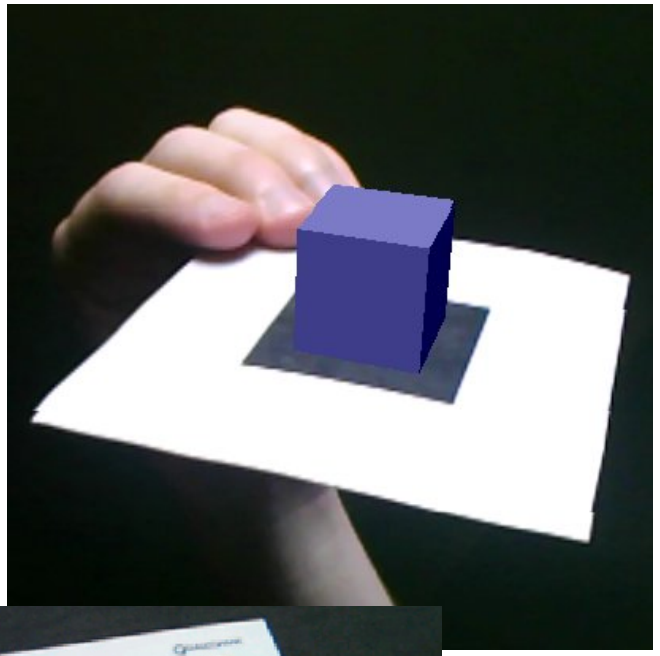
Billinghurst, M., Piumsomboon, T., & Bai, H. (2014). Hands in Space: Gesture Interaction with Augmented-Reality Interfaces. *IEEE computer graphics and applications*, (1), 77-80.

HIT Lab NZ Multimodal Input



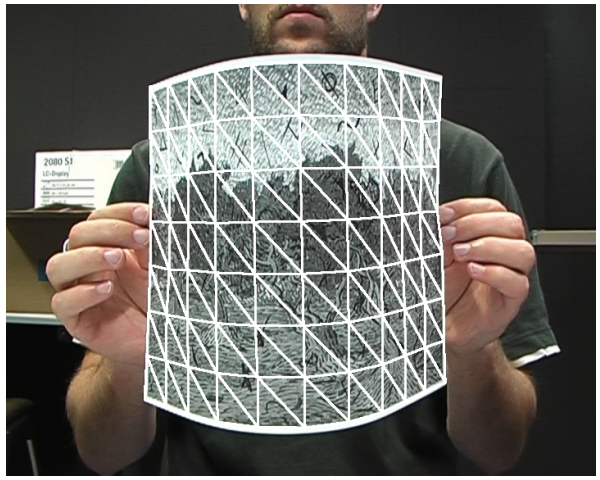
Evolution of Tracking

- Past
  - Location based, marker based,
  - magnetic/mechanical
- Present
  - Image based, hybrid tracking
- Future
  - Ubiquitous
  - Model based
  - Environmental



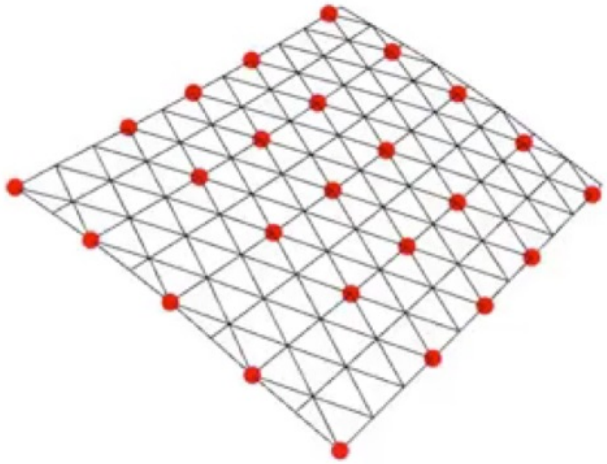
Model Based Tracking (1-3 yrs)

- Track from known 3D model
  - Use depth + colour information
  - Match input to model template
  - Use CAD model of targets
- Recent innovations
  - Learn models online
  - Tracking from cluttered scene
  - Track from deformable objects



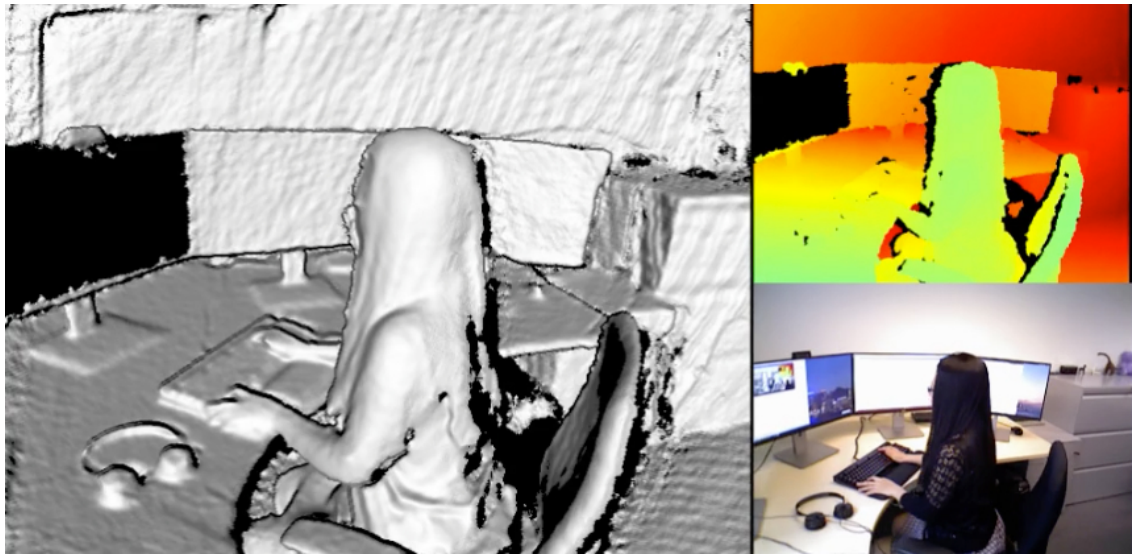
Hinterstoisser, S., Lepetit, V., Ilic, S., Holzer, S., Bradski, G., Konolige, K., & Navab, N. (2013). Model based training, detection and pose estimation of texture-less 3D objects in heavily cluttered scenes. In *Computer Vision–ACCV 2012* (pp. 548-562). Springer Berlin Heidelberg.

Deformable Object Tracking



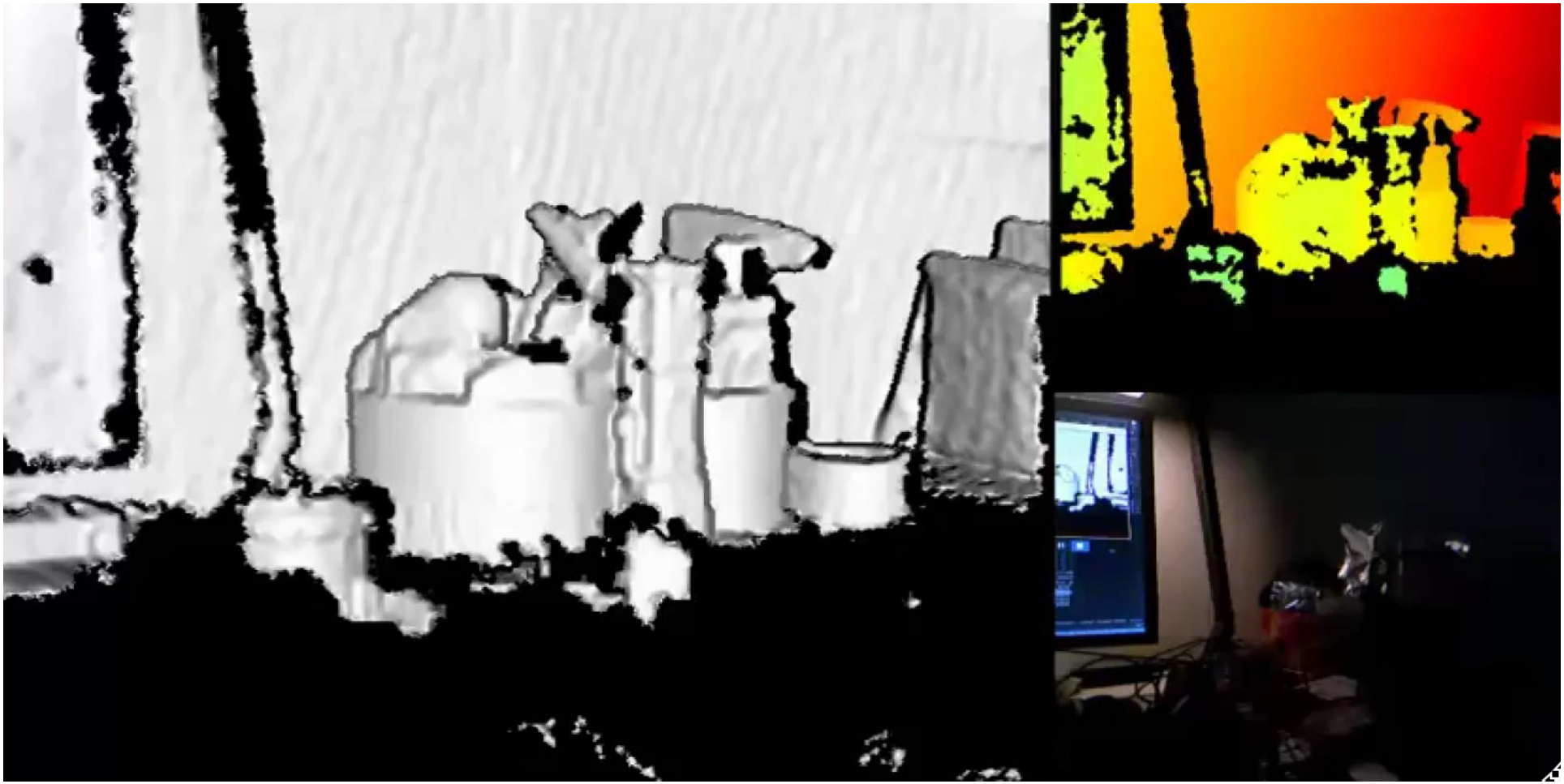
https://www.youtube.com/watch?v=t2vqsitWLKs

Environmental Tracking (3+ yrs)



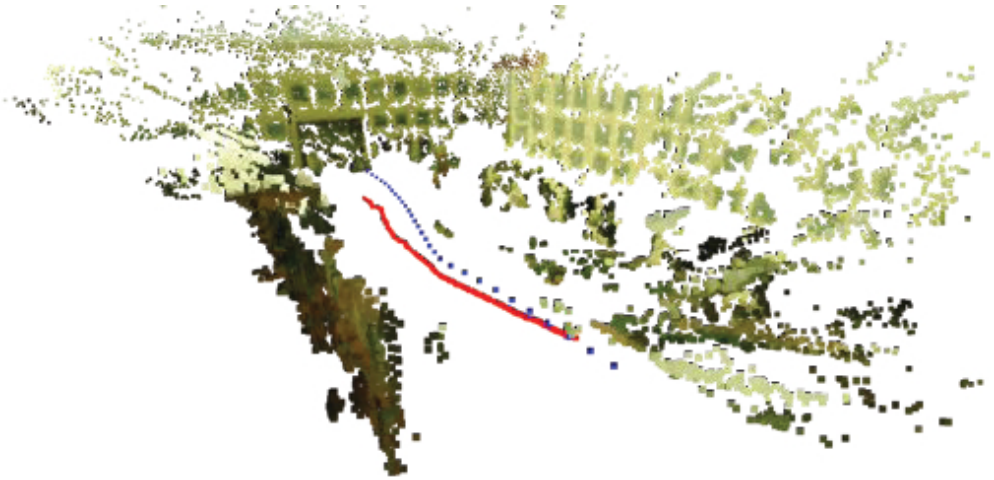
- Environment capture
  - Use depth sensors to capture scene & track from model
- InifinitAM (www.robots.ox.ac.uk/~victor/infinitam/)
  - Real time scene capture on mobiles, dense or sparse capture
  - Dynamic memory swapping allows large environment capture

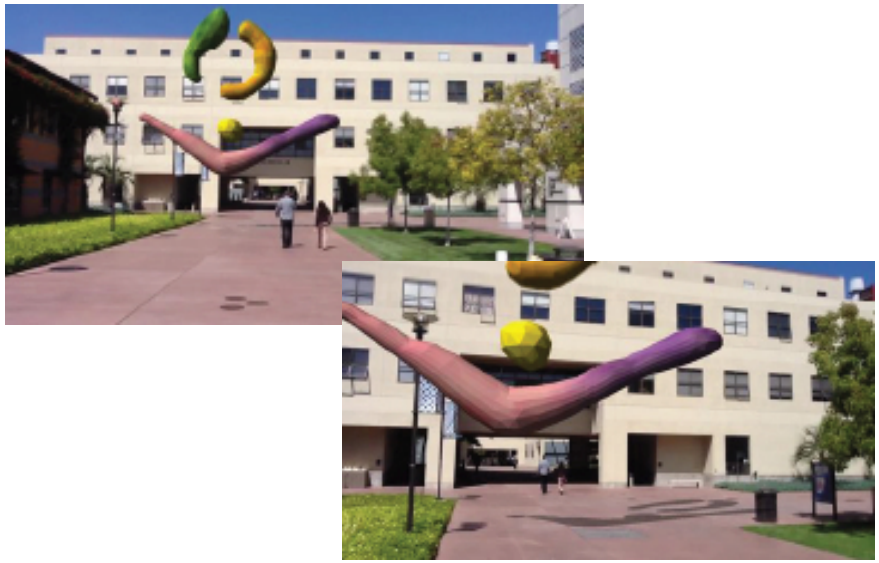
InfinitAM Demo



https://www.youtube.com/watch?v=47zTHHxJjQU

Wide Area Outdoor Tracking (10 + yrs)

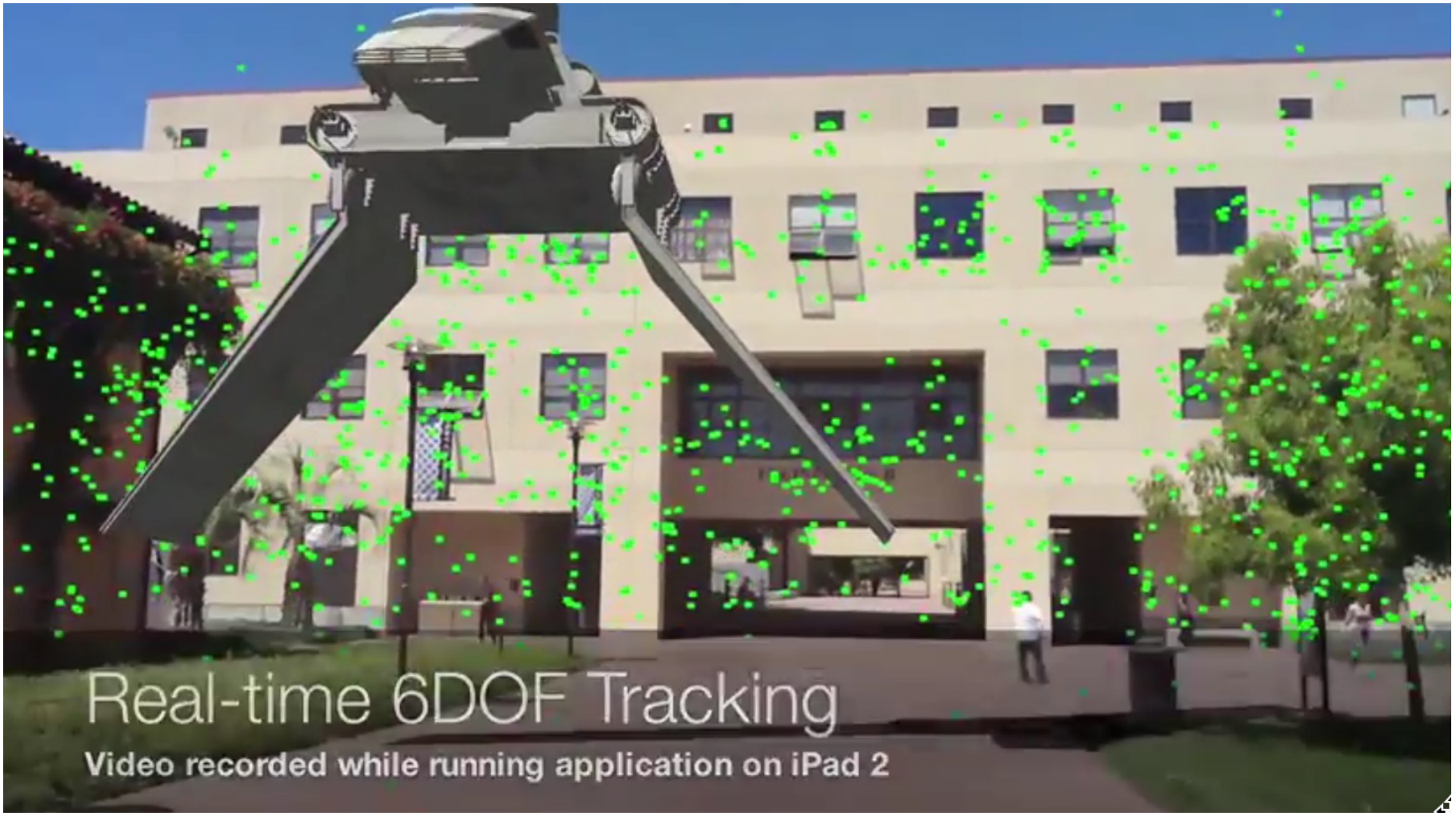




- Process
  - Combine panorama's into point cloud model (offline)
  - Initialize camera tracking from point cloud
  - Update pose by aligning camera image to point cloud
  - Accurate to 25 cm, 0.5 degree over very wide area

Ventura, J., & Hollerer, T. (2012). Wide-area scene mapping for mobile visual tracking. In *Mixed and Augmented Reality (ISMAR), 2012 IEEE International Symposium on* (pp. 3-12). IEEE.

Wide Area Outdoor Tracking



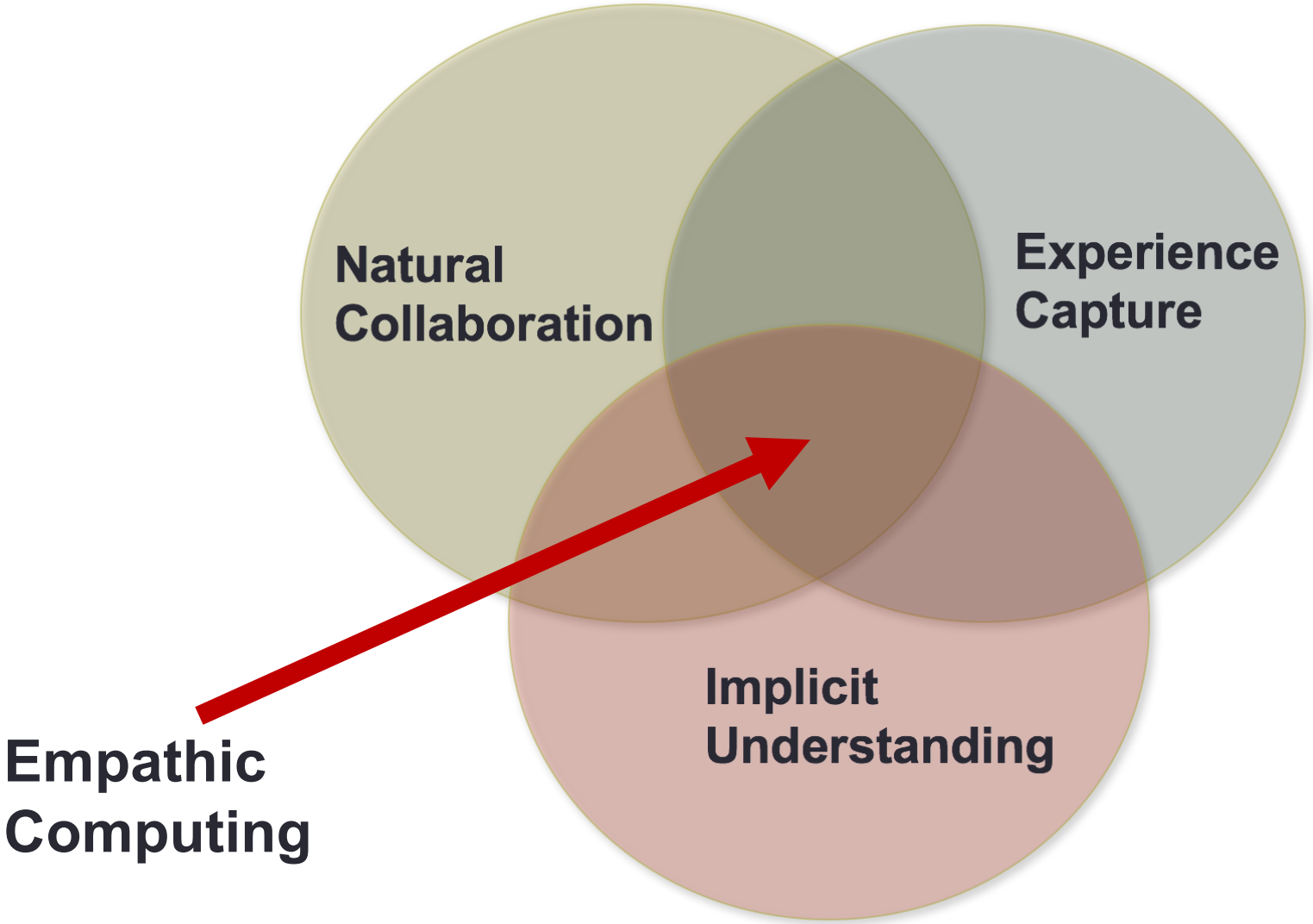
https://www.youtube.com/watch?v=8ZNN0NeXV6s

ENHANCED EXPERIENCE

Research Possible in Many Areas

- Collaborative Experiences
  - AR teleconferencing
- Social Acceptance
  - Overcome social problems with AR
- Cloud Services
  - Cloud based storage/processing
- AR Authoring Tools
  - Easy content creation for non-experts
- Etc..

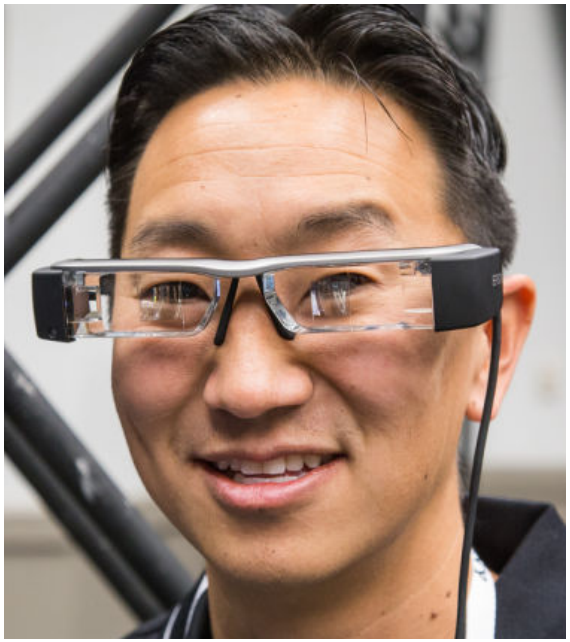
Next Generation Collaboration



Empathy Glasses (CHI 2016)

Pupil Labs

+



Epson BT-200

+

AffectiveWear

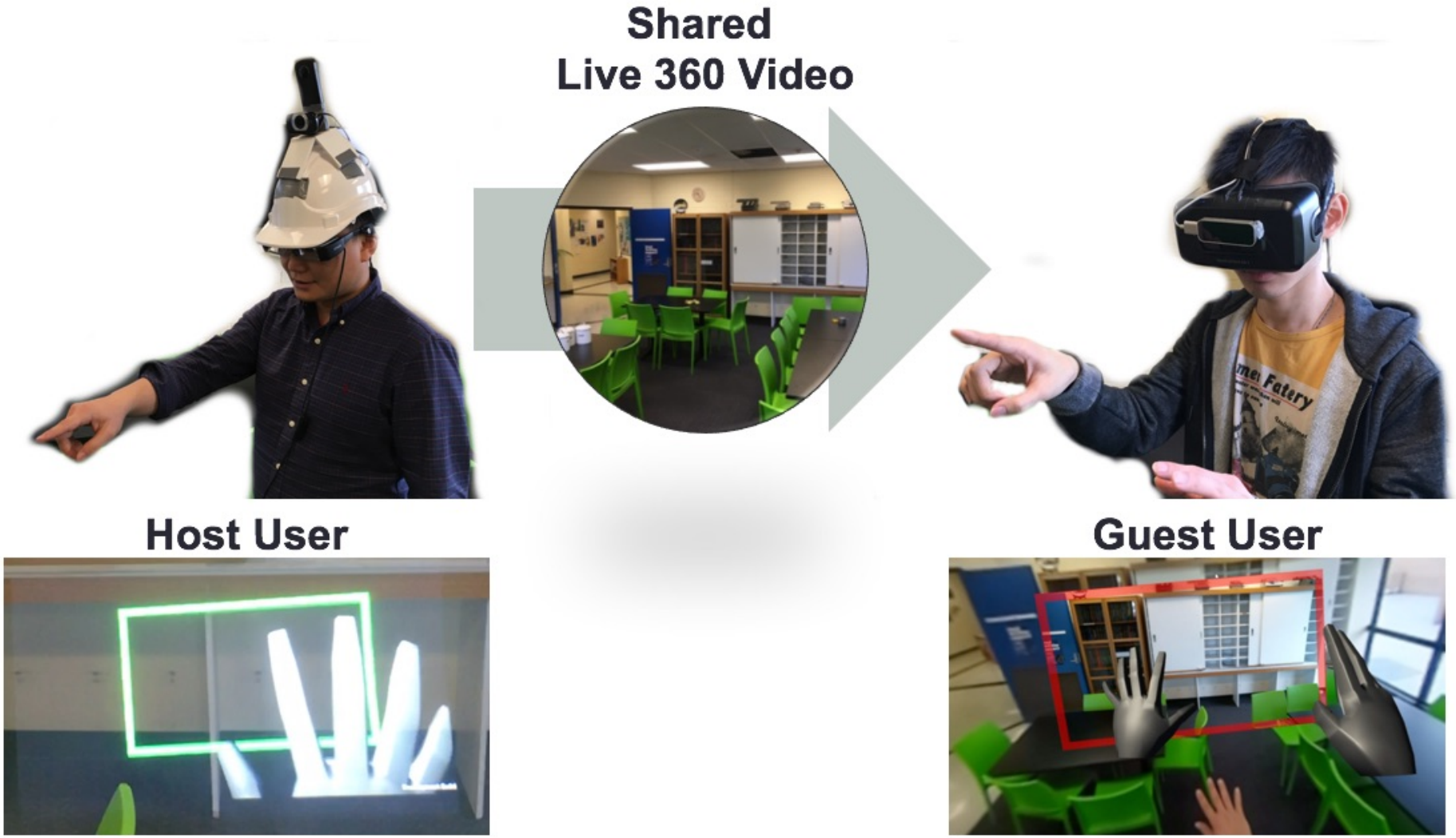
- Combine together eye-tracking, display, face expression
- Implicit cues – eye gaze, face expression

Masai, K., Sugimoto, M., Kunze, K., & Billinghurst, M. (2016, May). Empathy Glasses. In *Proceedings of the 34th Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*. ACM.

Empathy Glasses Demo

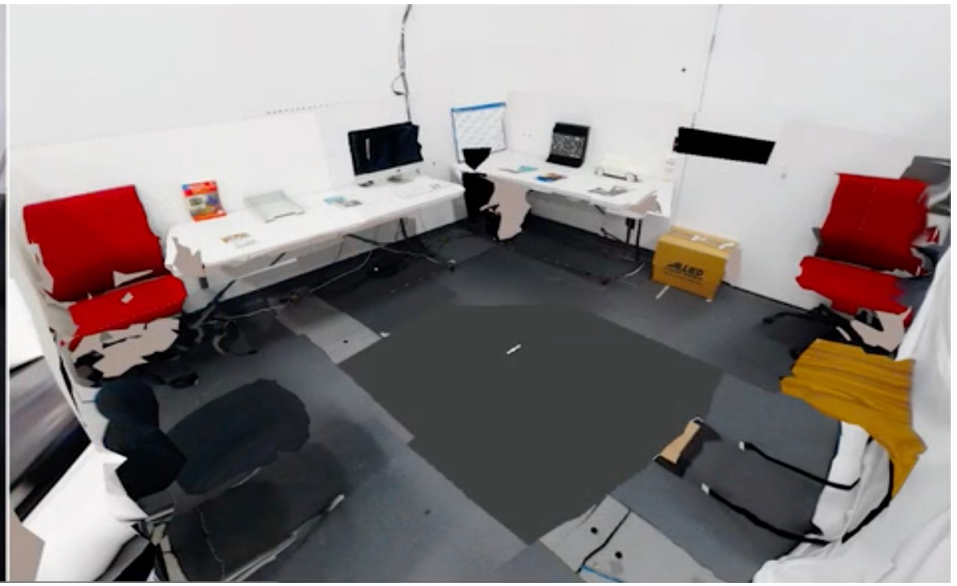
https://www.youtube.com/watch?v=CdgWVDbMwp4

Shared Sphere – 360 Video Sharing (2017)



Mixed Space Collaboration (2017)

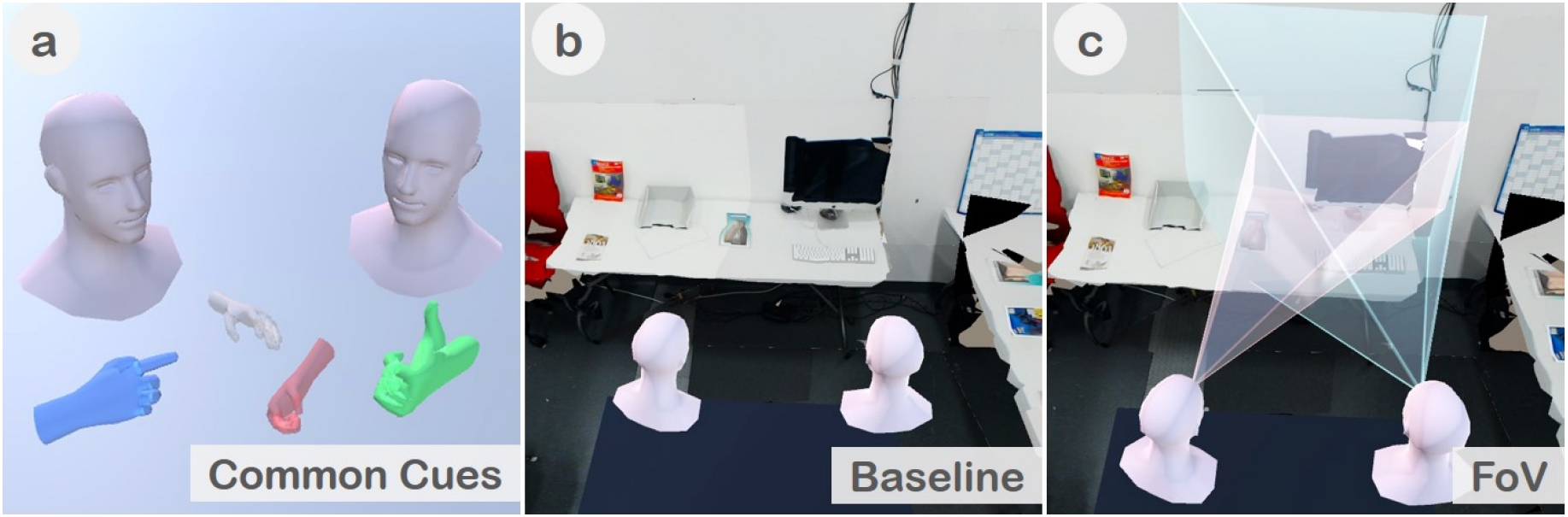
Real World



Virtual World

- Make 3D copy of real space
- Share virtual body cues
- AR/VR collaboration

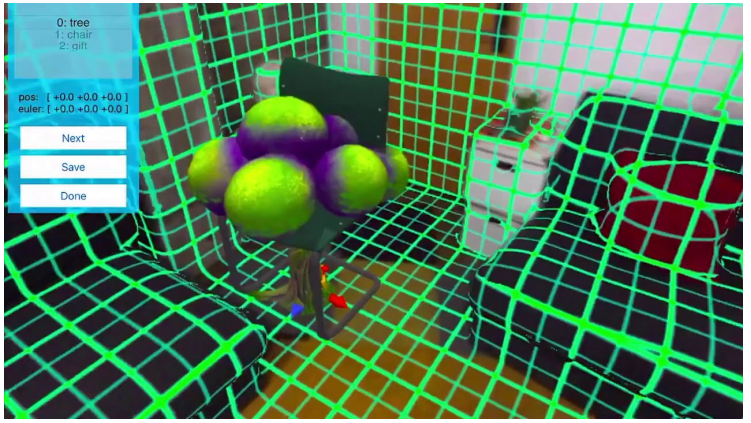
Virtual Body Cues

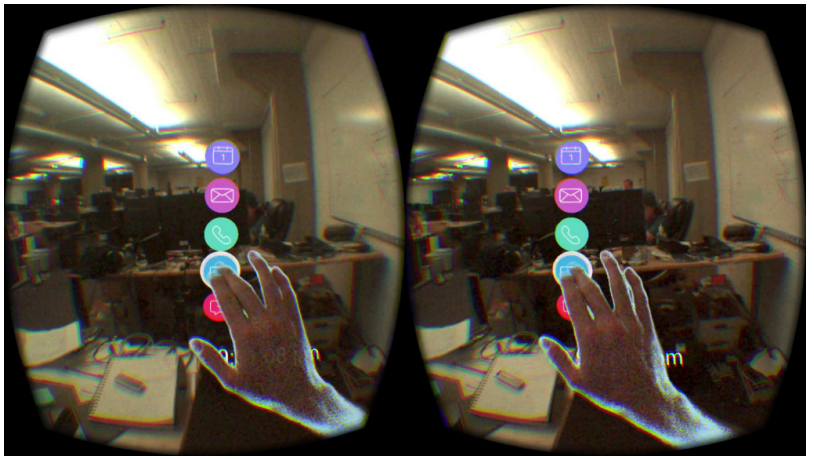


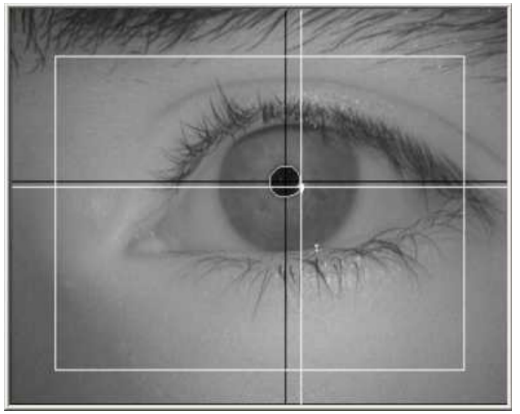
- Virtual head, hands
- View frustums – see where person looking

Technology Trends

- Advanced displays
  - Wide FOV, high resolution
- Real time space capture
  - 3D scanning, stitching, segmentation
- Natural gesture interaction
  - Hand tracking, pose recognition
- Robust eye-tracking
  - Gaze points, focus depth
- Emotion sensing/sharing
  - Physiological sensing, emotion mapping



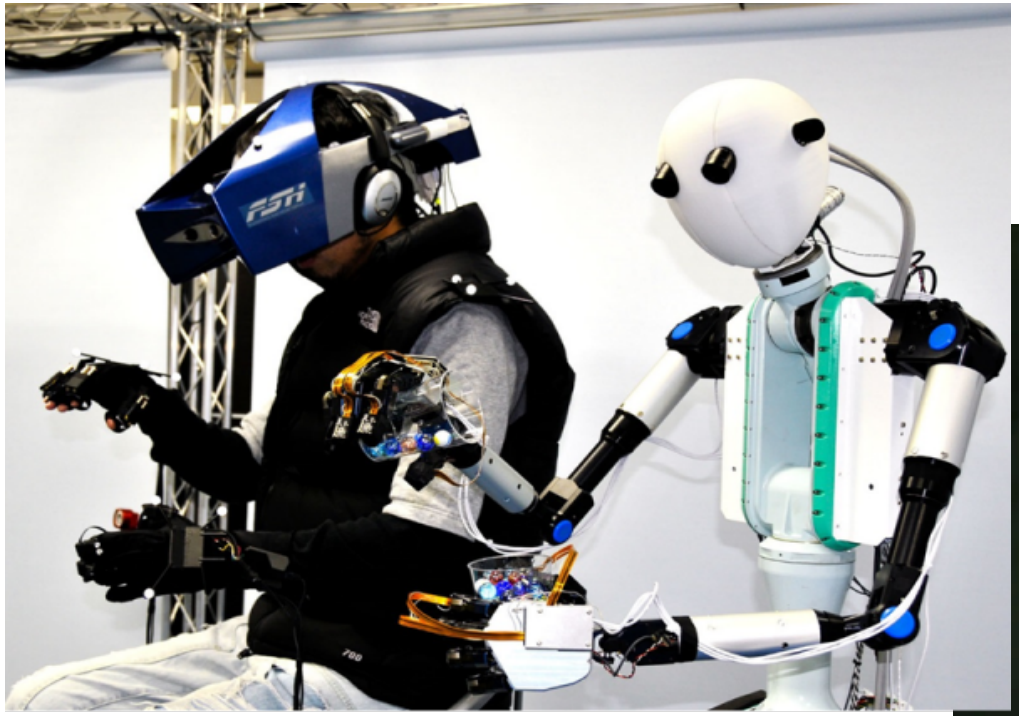


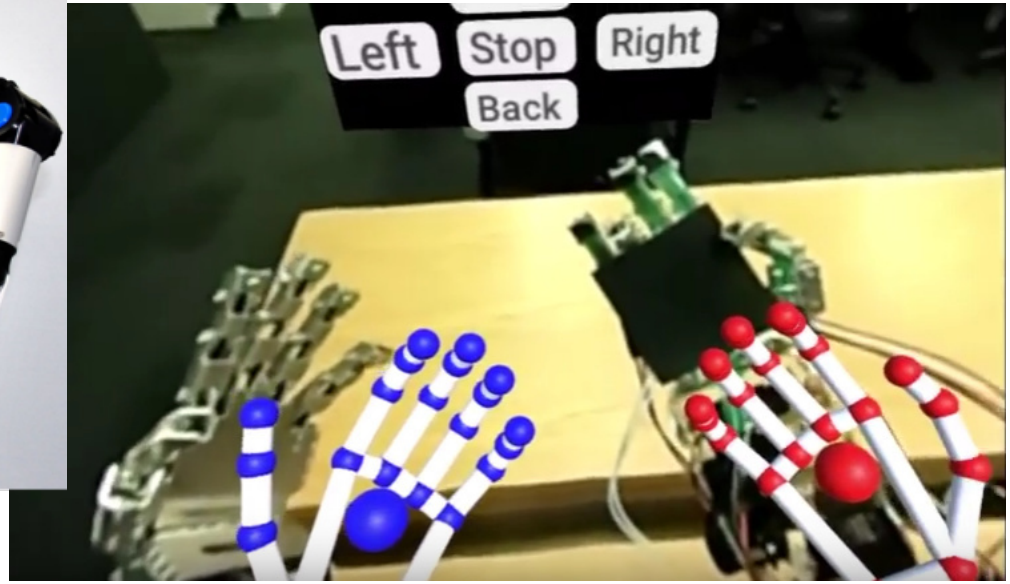


- Advanced displays
- Real time space capture
- Natural gesture interaction
- Robust eye-tracking
- Emotion sensing/sharing

Empathic
Tele-Existence

Empathic Tele-Existence (10+ years)





- Know what someone is seeing, hearing, feeling
- Feel that you are in the same environment with them
- Seeing virtual people with you in your real world

Surrogates (2009)

https://www.youtube.com/watch?v=KC5TrKNIDHQ

Conclusions

- AR is becoming commonly available
- In order to achieve significant growth AR needs to
  - Expand into new markets
  - Move onto new platforms
  - Create new types of applications
- New AR technologies will enable this to happen
  - Display, Interaction, Tracking technologies
- However there are still significant areas for research
  - Social Acceptance, Cloud Services, AR authoring tools, Etc

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