LECTURE 11: EXAMPLE AR APPLICATIONS

COMP 4010 – Virtual Reality
Semester 5 – 2017

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October 26th 2017

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AR Business Today

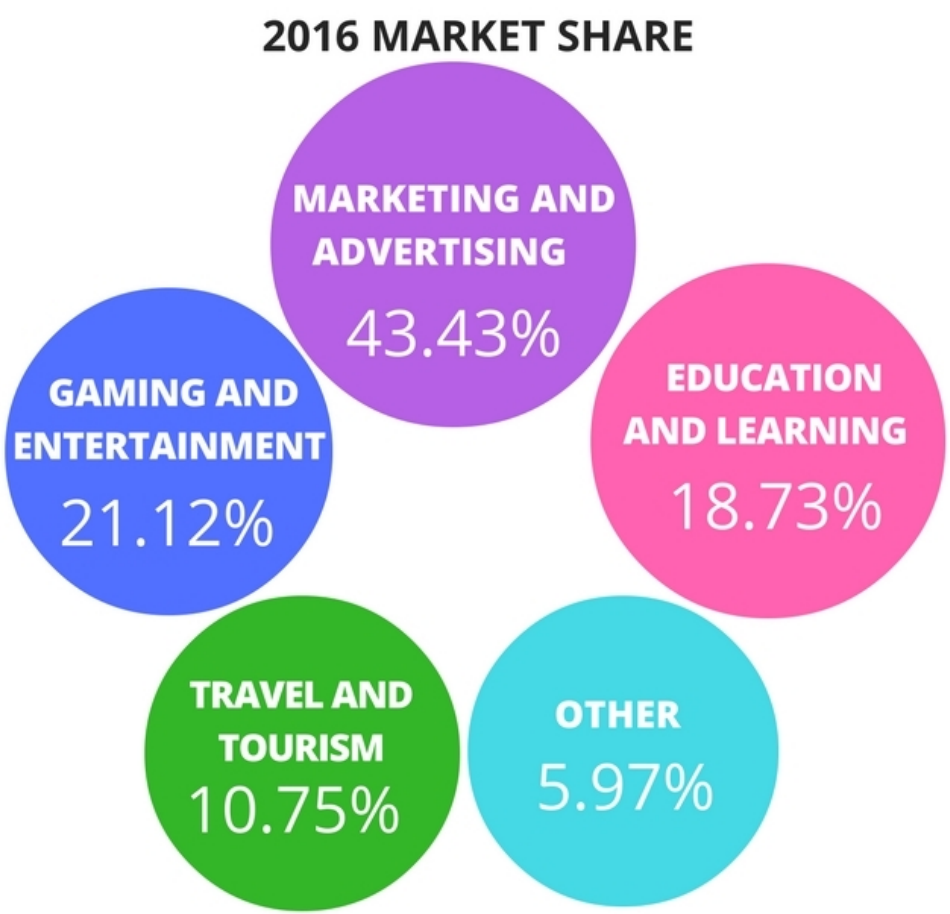
- Around $600 Million USD in 2014 (>$2B 2016)
- 70-80+% Games and Marketing

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

GLOBAL MOBILE AUGMENTED REALITY (AR) MARKET BY APPLICATION

APPLICATION	REVENUE 2016
MARKETING AND ADVERTISING	$1.09 billion
GAMING AND ENTERTAINMENT	$0.53 billion
EDUCATION AND LEARNING	$0.47 billion



technavio

THE VR FUND Q2 2017 AR INDUSTRY LANDSCAPE

INFRASTRUCTURE ▲ TOOLS/PLATFORM ▲ APPLICATIONS

APPLICATIONS

GAMES/ENTERTAINMENT

Microsoft, magic leap, Disney, Funomena, SCHELL GAMES, HADO, FATHER.IO, ASOBO STUDIO, ILMxLAB, CLIMAX STUDIOS, WETA WORKSHOP, FLARB, NIANTIC, WINGNUT FILMS, WITHIN

CONSUMER

Microsoft, facebook, MODSY, HUTCH, wayfair, LEGO, L'ORÉAL, IKEA, LOWE'S, QuiverVision

ENTERPRISE

Microsoft, UPSKILL, ZEBRA, RE'FLEKT, MODIFACE, DASSAULT SYSTEMES, IBM, SCOPE AR, xmreality, CN2, Loook, vuforia, Trimble, CivicAR Mobile Platform, object theory, AUGMENT, hyperindustry, FINGER FOOD, AUGMATE, DAQRI, HUDWAY

HEALTHCARE

Microsoft, AUGMEDIX, 3D4MEDICAL, Medical Realities, evena MEDICAL, SCOPIS medical

EDUCATION

Microsoft, Lifeliqe, EvoBooks, NEOBEAR 小熊尼奥·创意科技儿童品牌, CURISCOPE

TOOLS/PLATFORM

DISTRIBUTION

Microsoft, magic leap, Google, Meta AUGMENTED REALITY

SDK

Microsoft, vuforia, blippAR, Google, wikitude, occipital, AURASMA, kudan AUGMENTED REALITY, SONY, AR-media SDK, ARTOOLKIT, Total Immersion, zappar, augmenta AMPLIFY LIFE, EasyAR, DAQRI, BOSCH

3D TOOLS (ENGINES/AUDIO)

unity, UNREAL ENGINE, NVIDIA, RE'FLEKT ONE, facebook, Microsoft, skylight, waking app, AMD, RealSpace3D Audio, DOLBY ATMOS, Google, facebook, DYSONICS, Mach 1™

3D REALITY CAPTURE

PHOTOGRAMMETRY: Agisoft, AUTODESK, Microsoft, matterport, CapturingReality, INDOOR REALITY, itSeez3D, occipital

VOLUMOGRAPHY/LIGHTFIELD: Microsoft, LYTRO, otoy

INFRASTRUCTURE

DEVICES (MR HMD/AR HMD/HANDHELD MR)

Microsoft HoloLens, magic leap, ODG, DAQRI, Lenovo, Meta AUGMENTED REALITY, occipital, SULON, IMMY, Canon, INFINITY augmented reality, VRVANA, SHADOW CREATOR, DreamWorld, mira

Google, SONY, EPSON, VUZIX, ATHEER, recon, solos, realwear, EVERYSIGHT

Google, ASUS, Lenovo

COMPONENTS (DISPLAY/3D CAMERAS/INPUT/COMPUTER VISION)

magic leap, ODG, LUMUS, KOPIN, AVEGANT, DIGILENS, EyeWay, emacula, WaveOptics, THALMICLABS

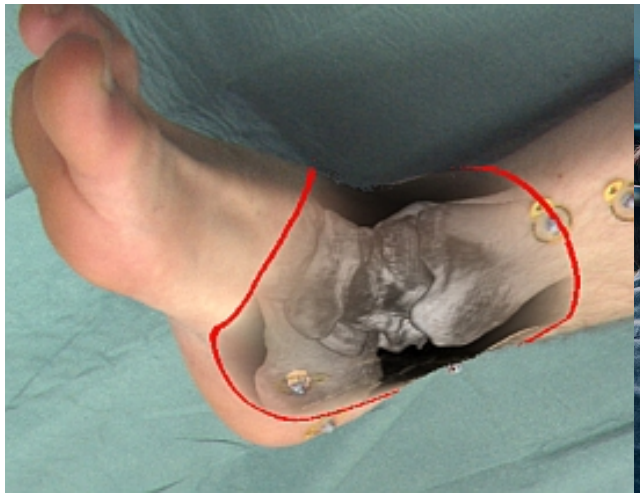
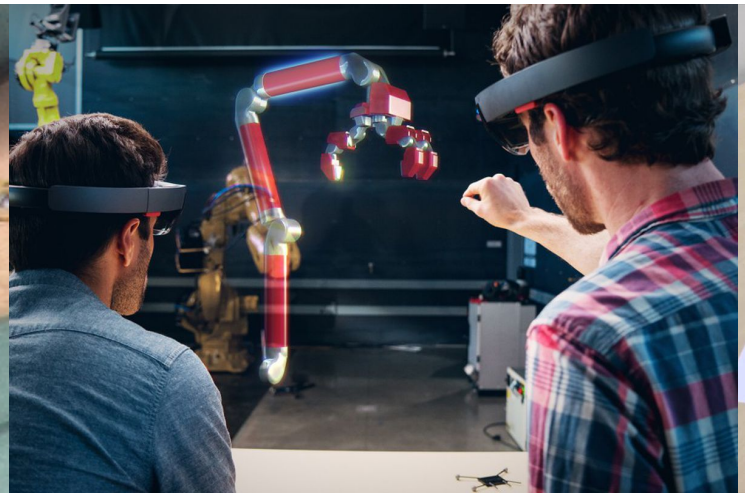
intel REALSENSE TECHNOLOGY, Microsoft, mantis vision, pmd, SONY, occipital, STEREOLABS, FOTONIC, ORBBEC, AIRY:3D

Microsoft, Google, Meta AUGMENTED REALITY, LEAP MOTION, gestigon, SONY, uSens Inc, nod, SIXENSE, THALMICLABS, XIMMERSE, NAVISENS, tobii, oculus, IBM Watson

Microsoft, magic leap, Google, SONY, Meta AUGMENTED REALITY, EONITE PERCEPTION, AUGMENTED PIXELS, wrnch, perceptive io, oculus

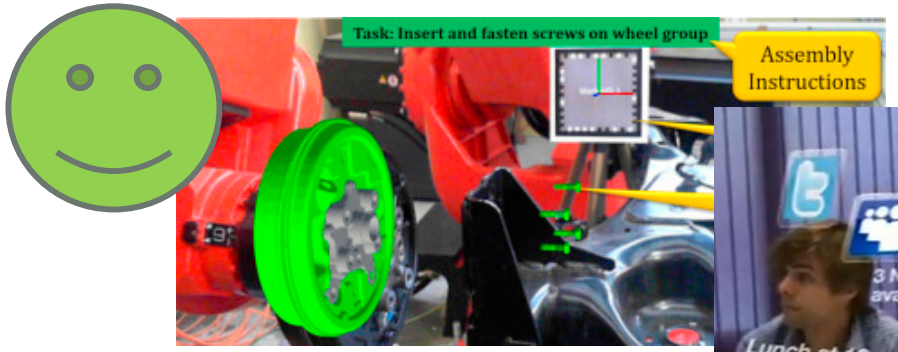
BY TIPATAT@THEVRFUND.COM

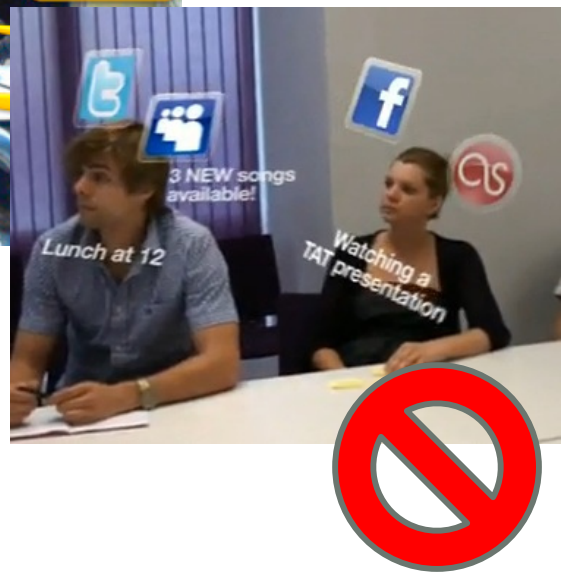
What types of AR Applications in Future?


- Applications suitable for AR
  - Involve 3D spatial data
  - Require physical interaction
  - Involve connection between real and digital worlds
  - Require collaboration, connecting between people
- Focus on Intelligence Augmentation (IA not AI)
  - Enhancing people performing real world tasks

Examples



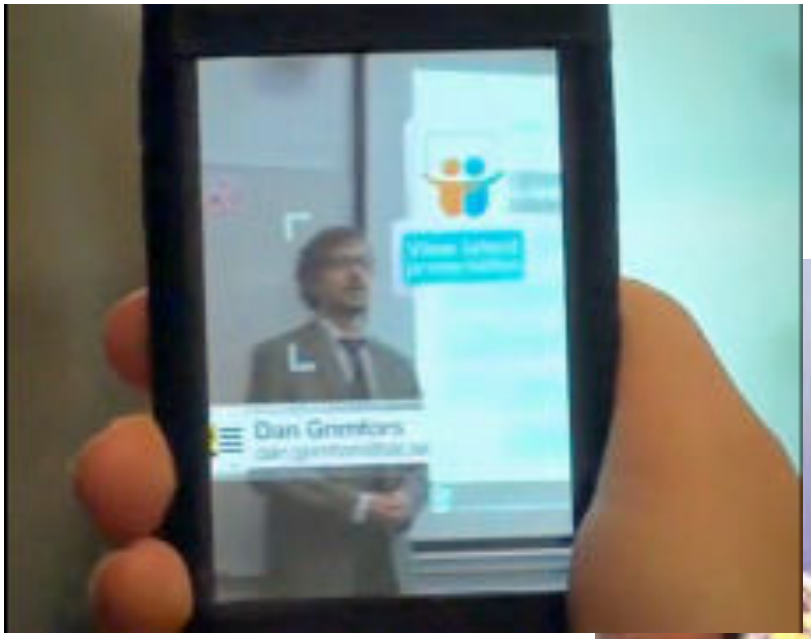


- Good for AR
  - Sharing virtual masks
  - Medical visualization on real body
  - CAD model on real printed manual
  - AR assembly instructions shown on real model
- Bad for AR
  - ATM locations overlaid on camera view (use map instead)
  - AR tower defense game (better than non-AR version?)
  - Language learning with AR flip cards (why AR?)
  - AR names on faces (social acceptance, not better than 2D)

Example: Social Acceptance

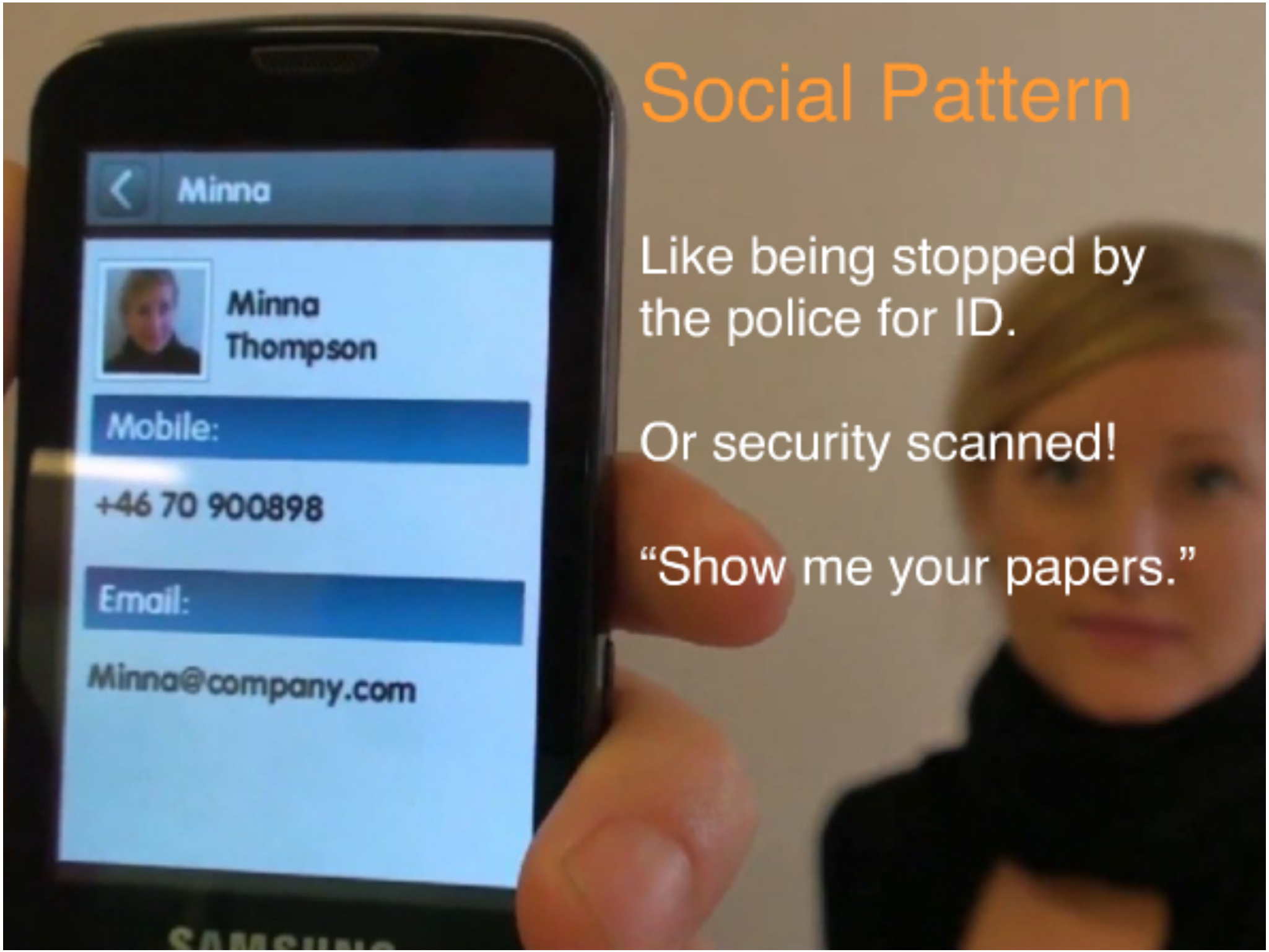
- People don't want to look silly
  - Only 12% of 4,600 adults would be willing to wear AR glasses
  - 20% of mobile AR browser users experience social issues
- Acceptance more due to Social than Technical issues
  - Needs further study (ethnographic, field tests, longitudinal)

TAT Augmented ID



TAT AugmentedID

https://www.youtube.com/watch?v=tb0pMeg1UN0

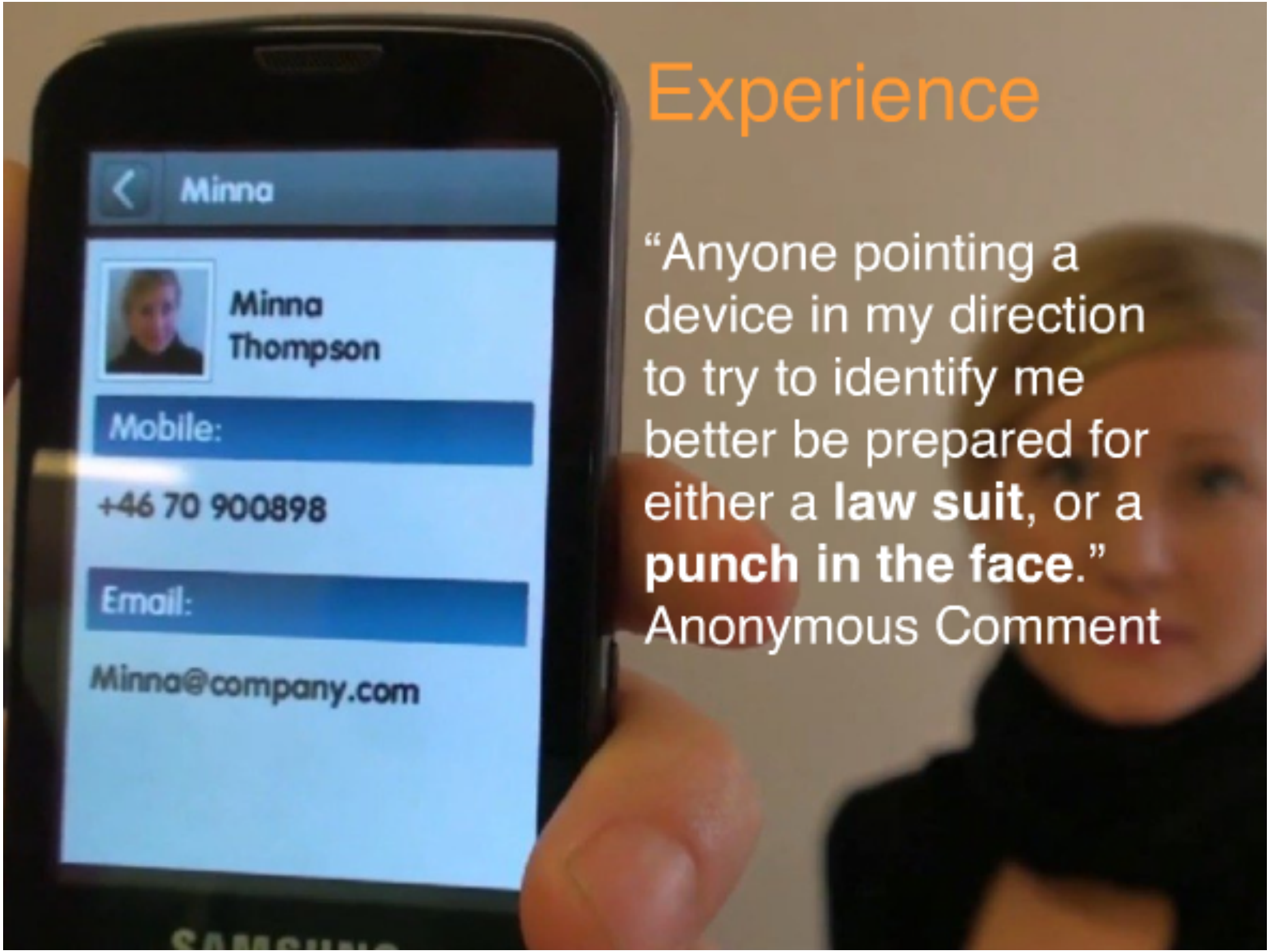


Social Pattern

Like being stopped by the police for ID.

Or security scanned!

“Show me your papers.”



Experience

"Anyone pointing a device in my direction to try to identify me better be prepared for either a **law suit**, or a **punch in the face**."
Anonymous Comment

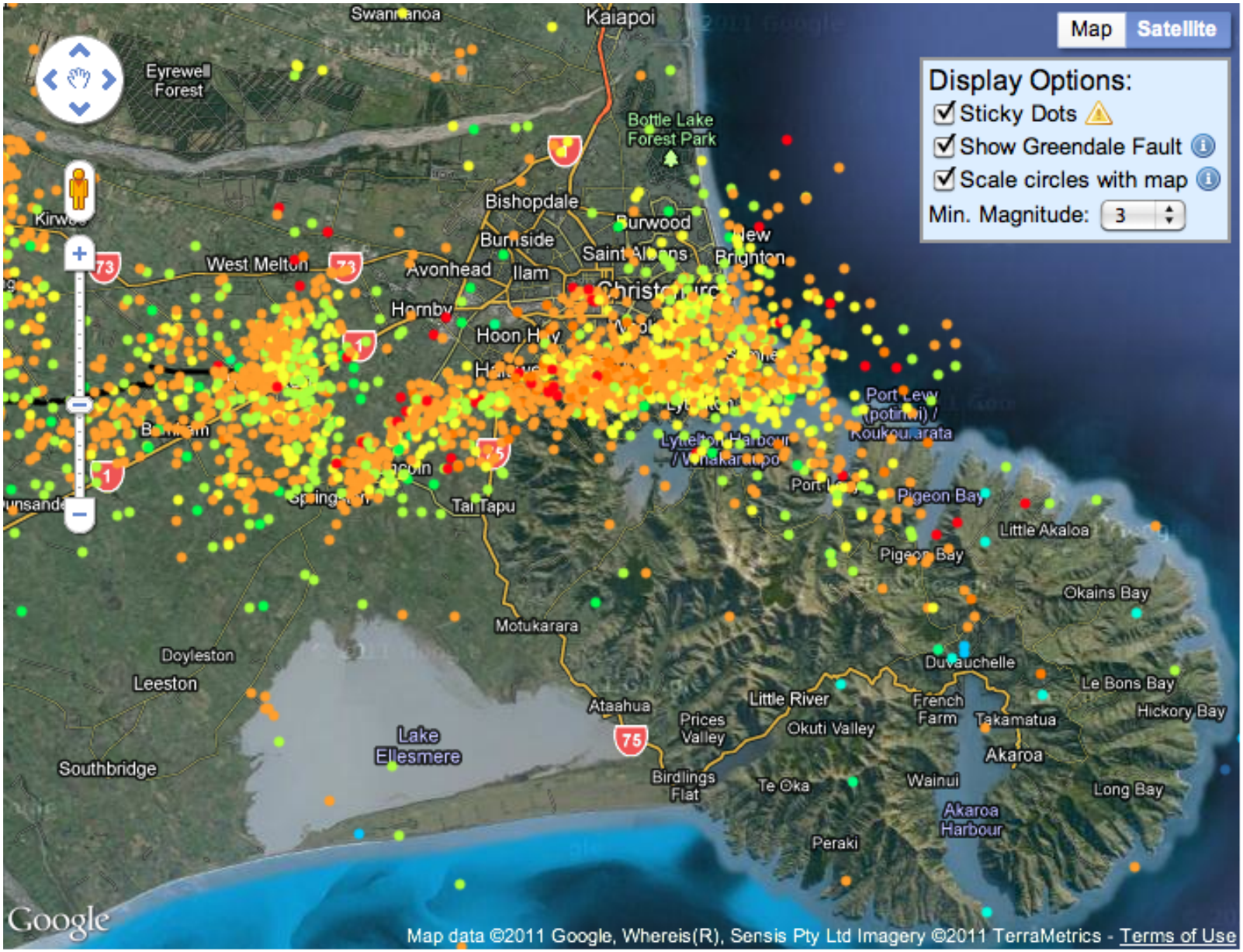
Other Important AR Application Domains

- Education
  - Learning on real world tasks
- Visualization
  - Enhancing real world view
- Conferencing
  - Face to face and remote collaboration
- Empathic Computing
  - Sharing Understanding

VISUALISATION


the daily bagel

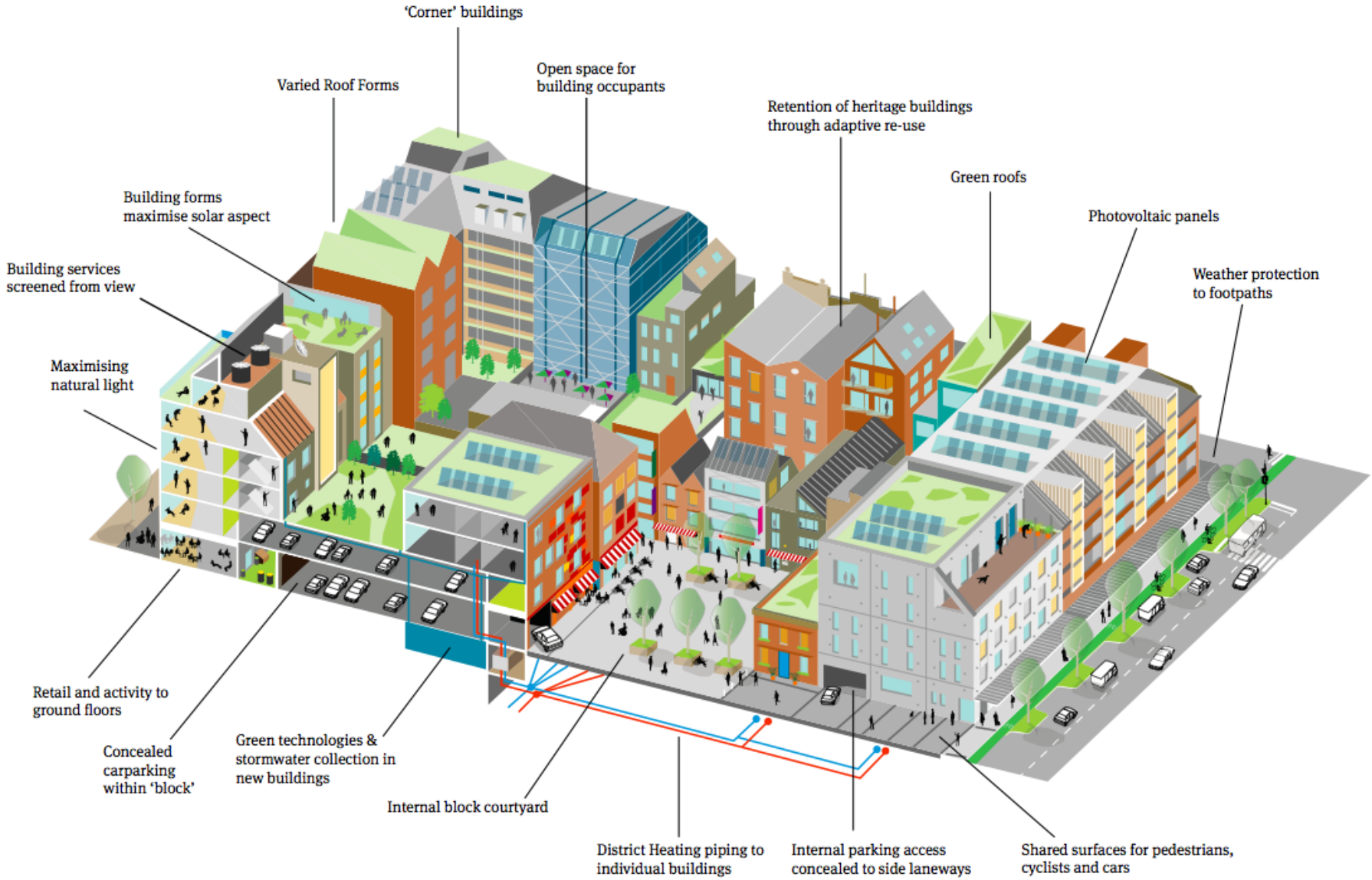
Christchurch Earthquakes (2011 onwards)



Christchurch Before and After

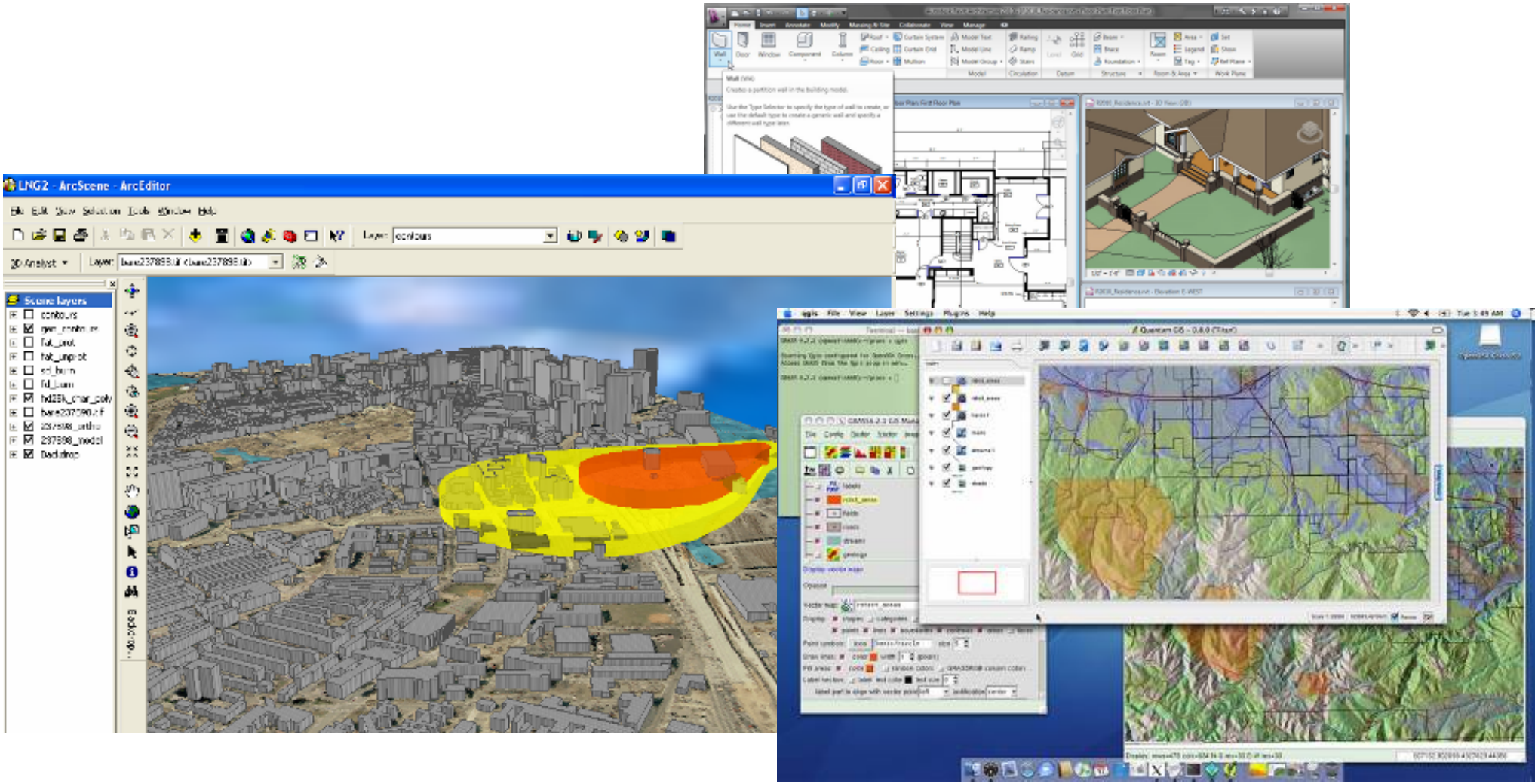
Typical Main Street views- before and after

After - Victoria Street


'Corner' buildings
Varied Roof Forms
Open space for building occupants
Retention of heritage buildings through adaptive re-use
Green roofs
Photovoltaic panels
Weather protection to footpaths
Building forms maximise solar aspect
Building services screened from view
Maximising natural light
Retail and activity to ground floors
Concealed carparking within 'block'
Green technologies & stormwater collection in new buildings
Internal block courtyard
District Heating piping to individual buildings
Internal parking access concealed to side laneways
Shared surfaces for pedestrians, cyclists and cars

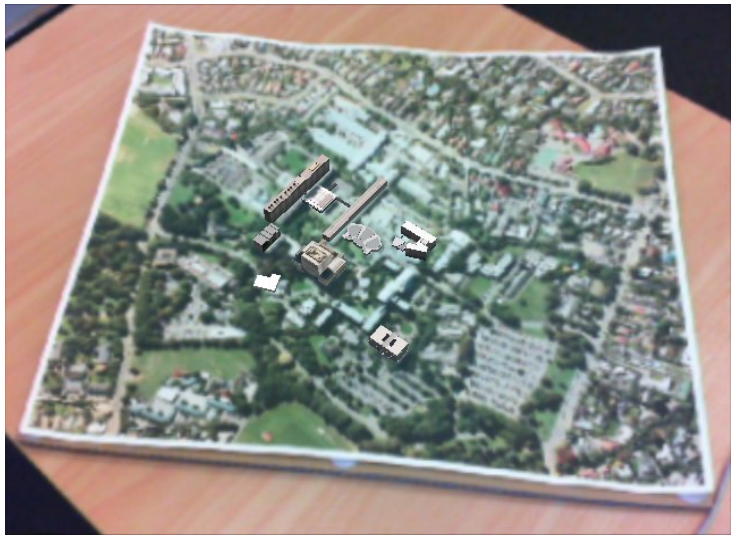
GIS Desktop Visualization Tools

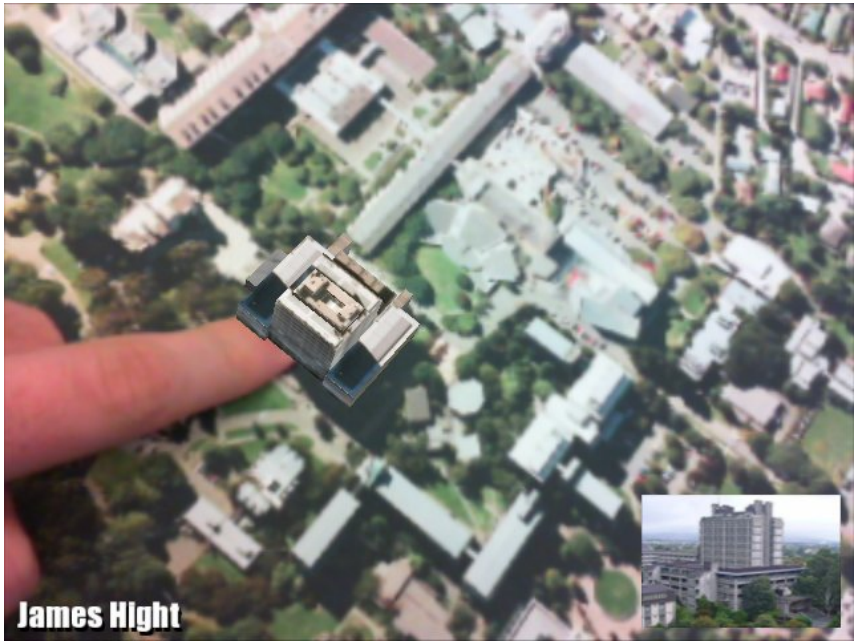
- Professional solutions available
  - Autodesk REVIST, ESRI ArcGIS, Grass,etc



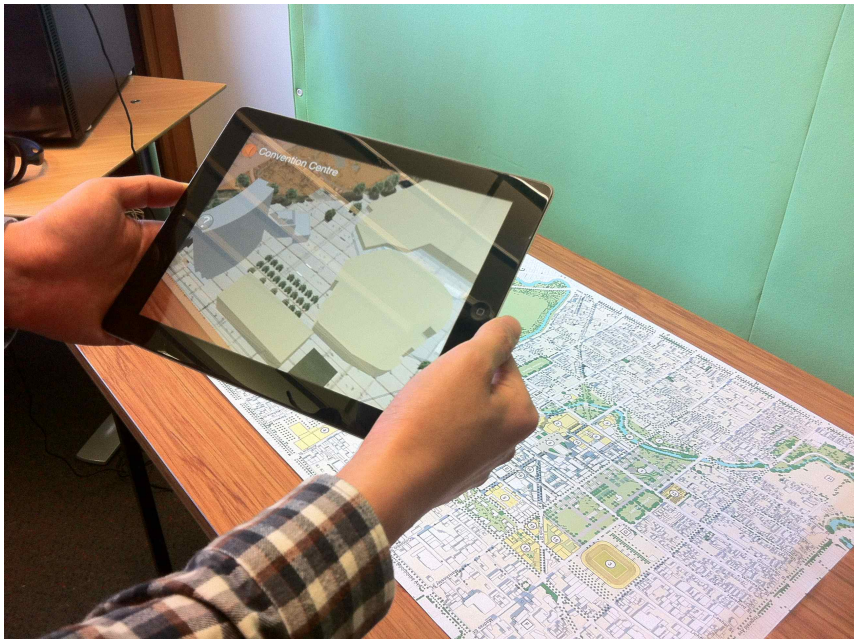
Interactive AR Maps

- Markerless tracking
- 3D model overlay
- Gesture input





Enhanced City Plans



- CERA – CCDU Plan
  - Using tablet to track off printed maps
  - Overlay 3D city models onto real maps

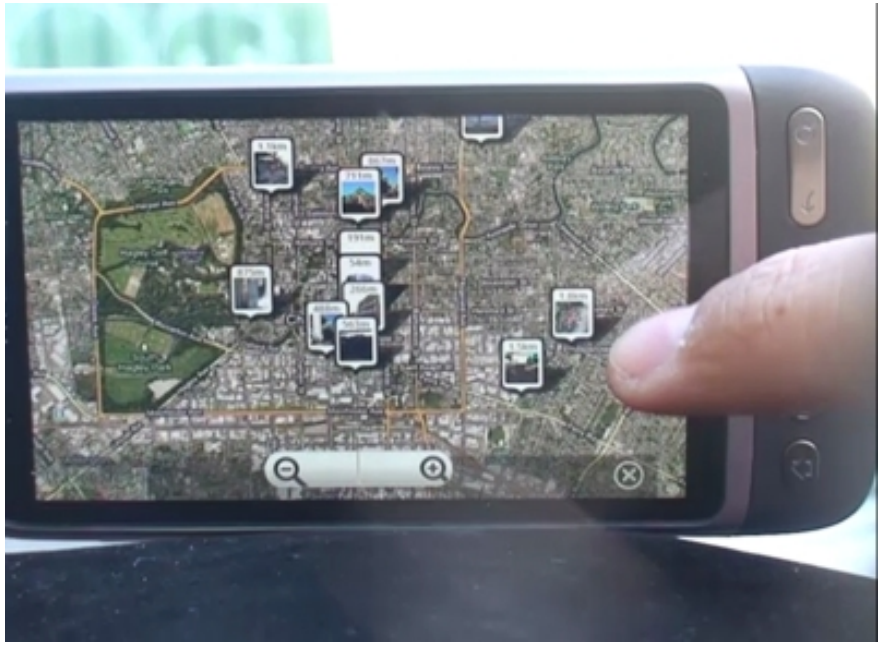
Earthquake AR Project

- Goal:
  - To allow people to see Christchurch as it was
  - To provide a tool for visualizing the city as it could be
- Technology
  - Mobile AR platform
  - Smart phone hardware
  - 3D content

HIT Lab NZ Outdoor AR Platform

- Cross platform
  - Android, iPhone
- 3D onsite visualization
  - Intuitive user interface
- Positions content in space
  - Camera, GPS, compass
- Client/Server software architecture
- Targeting museum guide/outdoor site applications

Earthquake Reconstruction

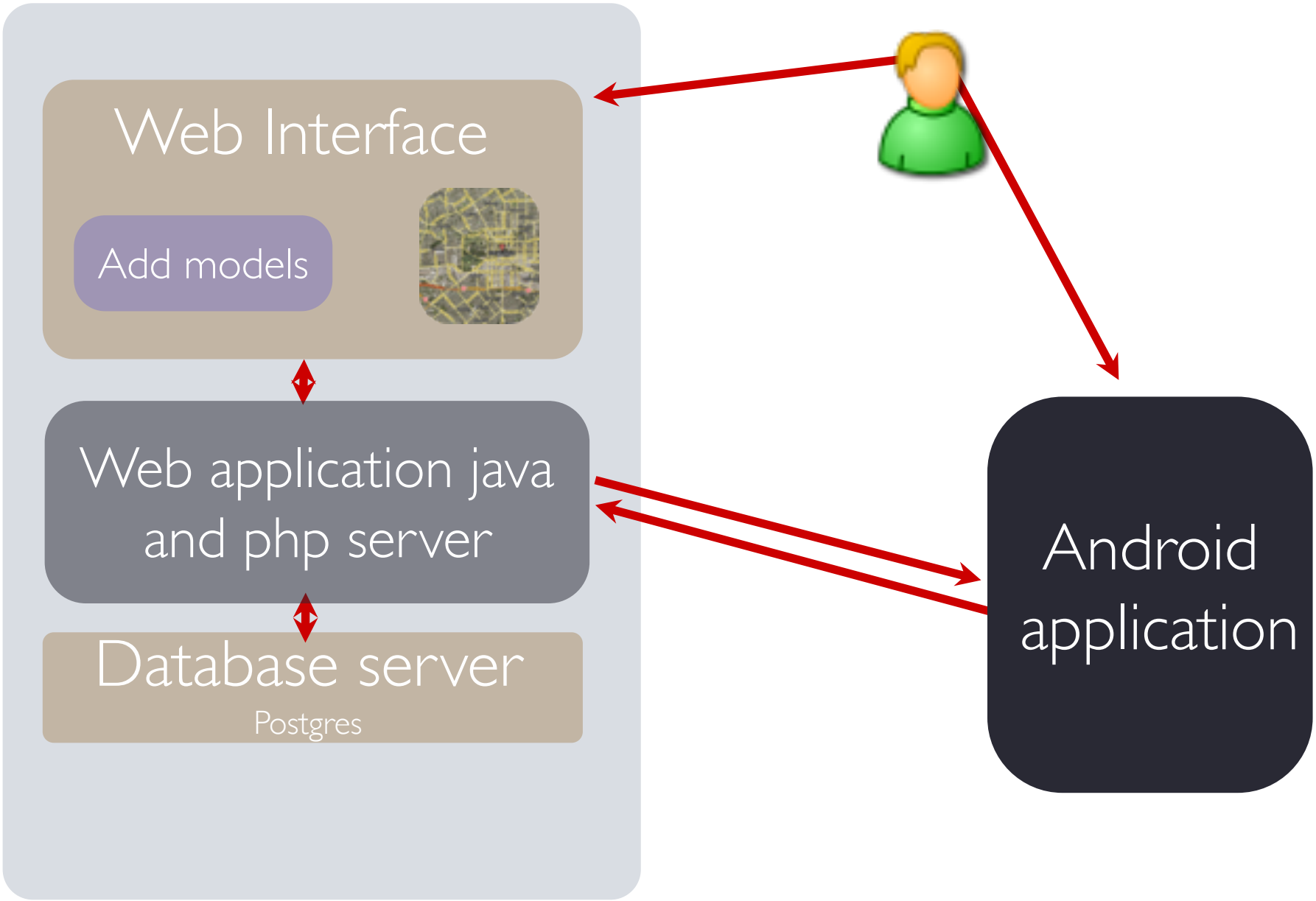


- See past, present and future building designs
- Earthquake survivor stories shown on map view
- Collect user comments
- Android platform

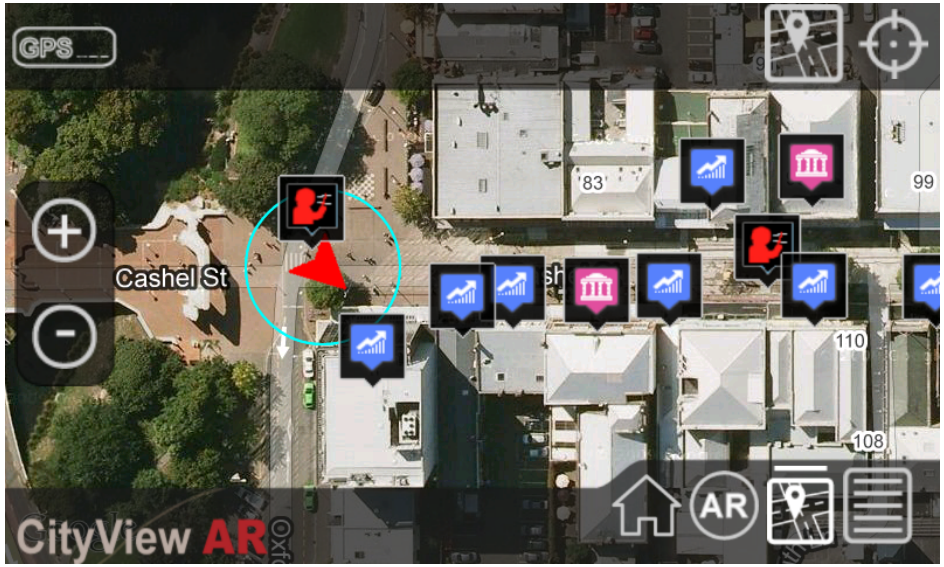
Demo

https://www.youtube.com/watch?v=vFFUKJzxTH4

Architecture

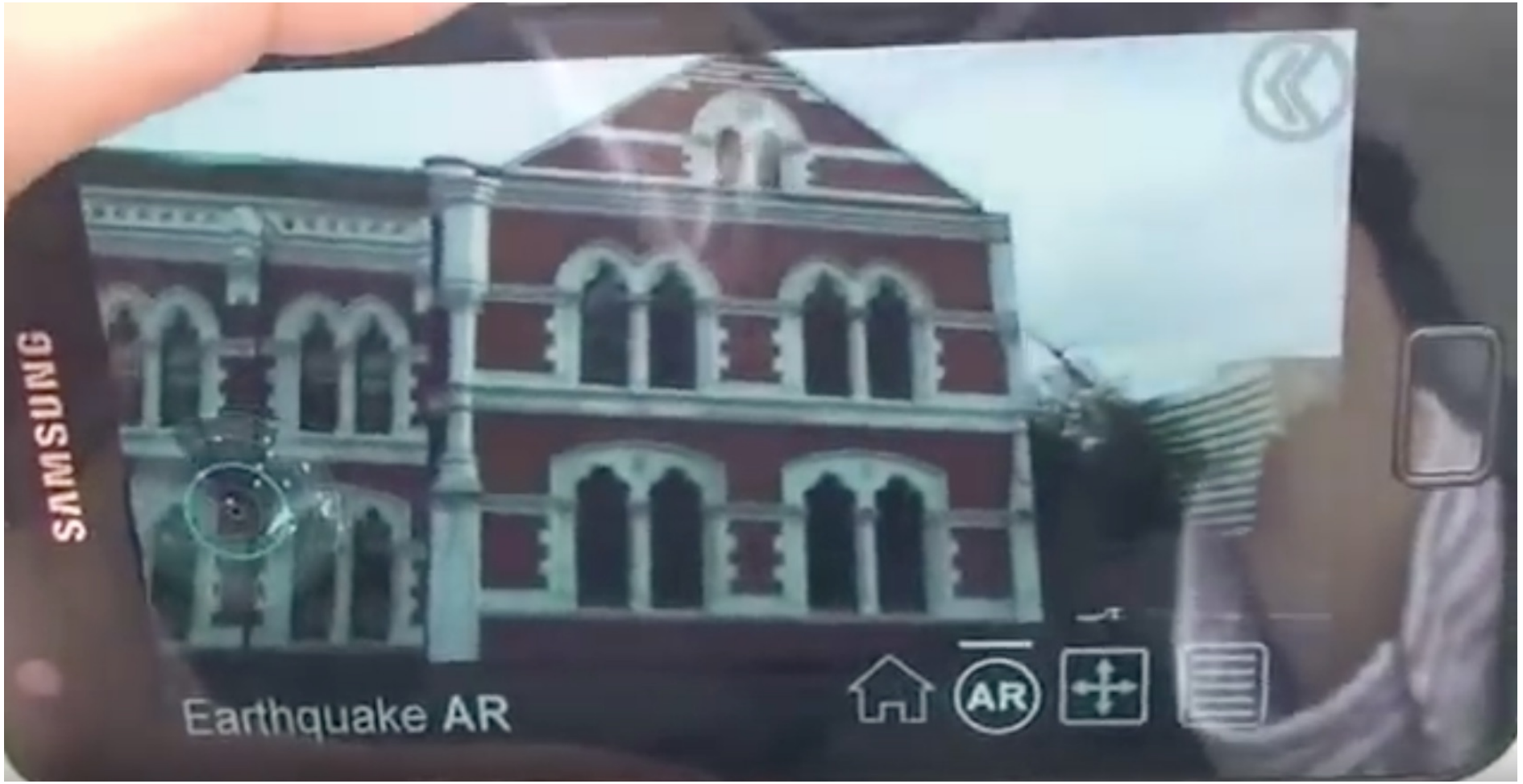


CityViewAR



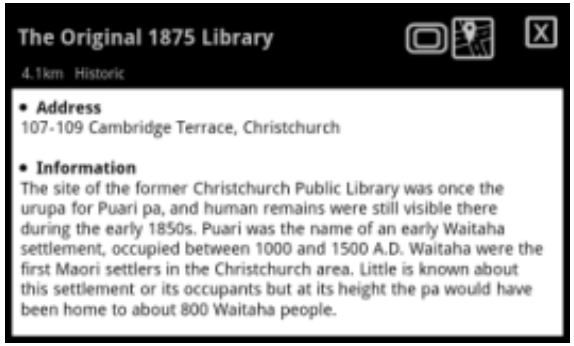
- Using AR to visualize Christchurch city buildings
  - 3D models of buildings, 2D images, text, panoramas
  - AR View, Map view, List view
  - Available on Android market

CityViewAR Demo



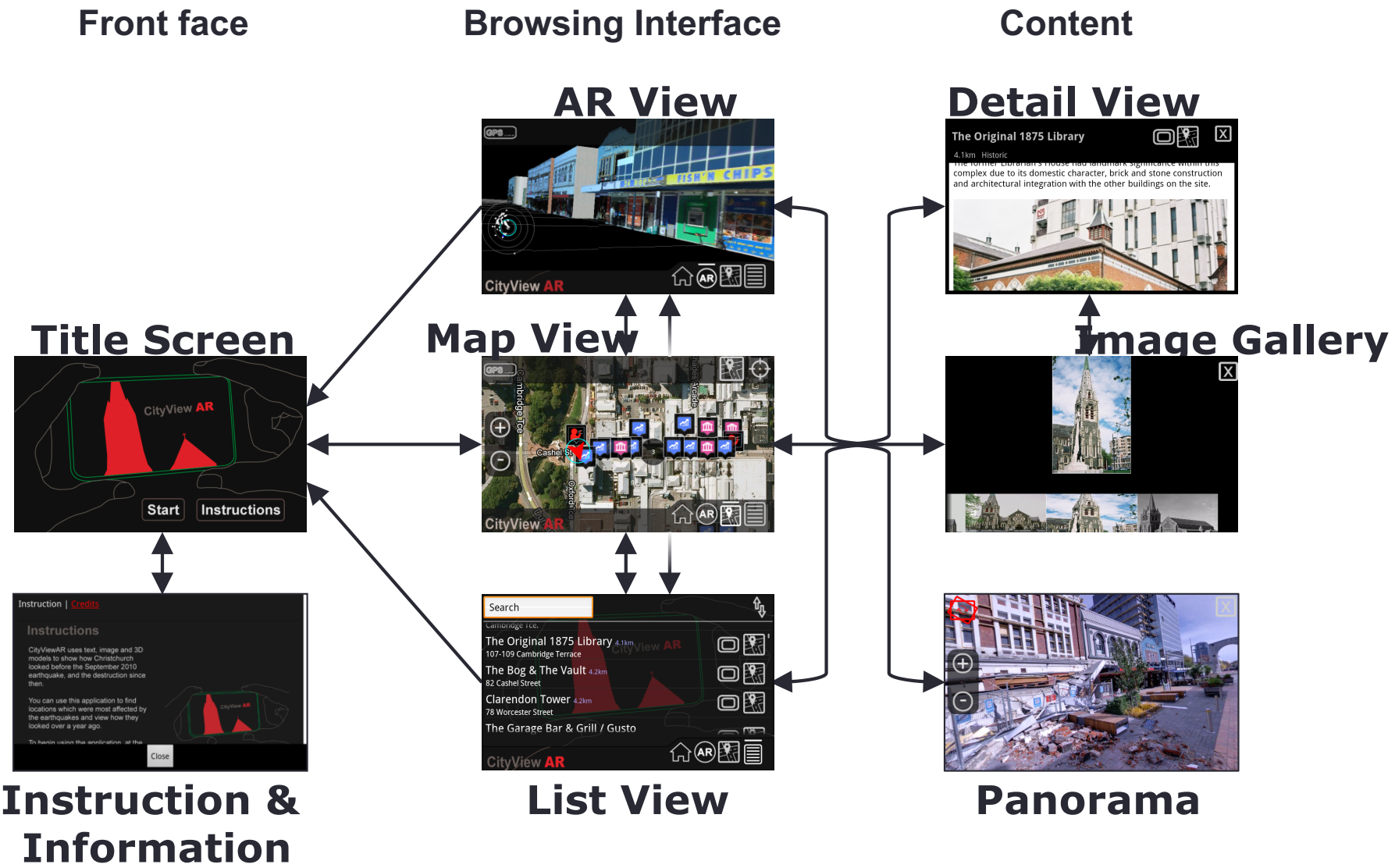
https://www.youtube.com/watch?v=fdgrXxJx4SE

User Experience



- While walking in the real world people can see text, 2D images and 3D content on their own phones

Interface Design (1/2)



Examples for Situated Visualization

Textual labels for architectural sights

Image: Raphael Grasset

Pollution levels on the street

Image: Sean White and Steve Feiner

Hydrological Data Visualization

Hydrosys displays locations of stations in a global sensor network as well as interpolated temperature plotted as geodesic contours

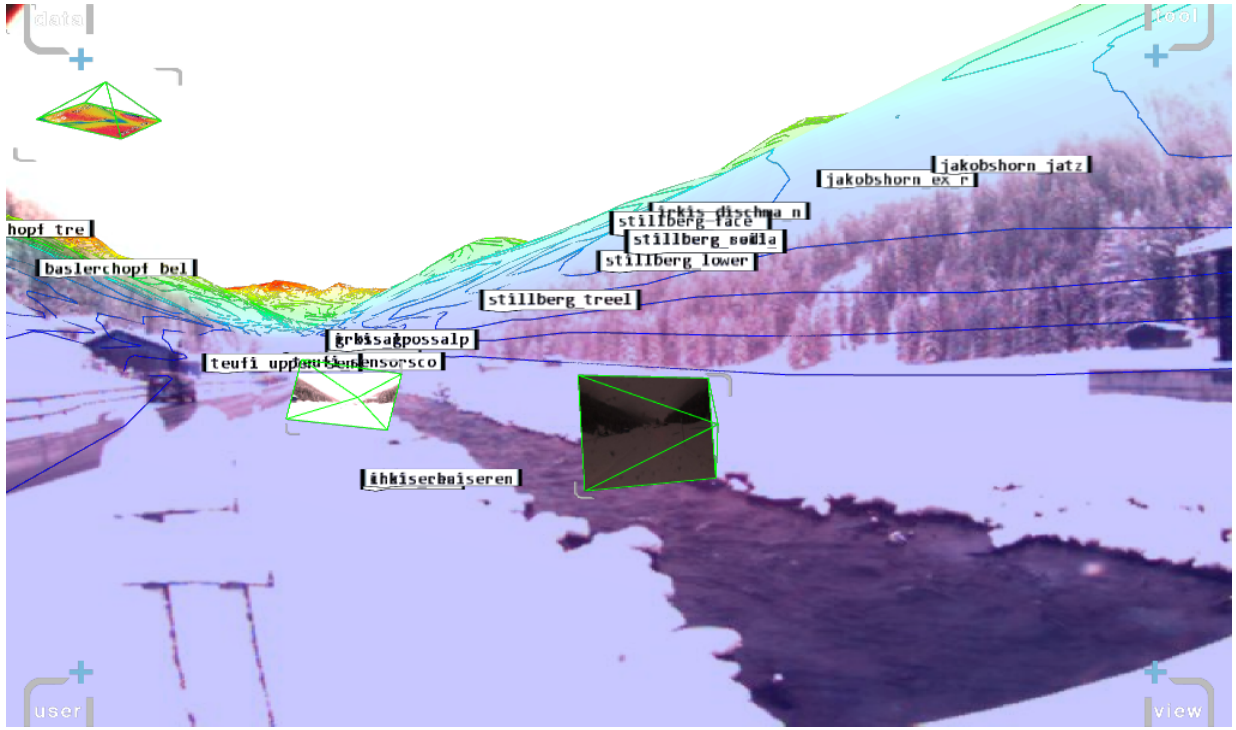
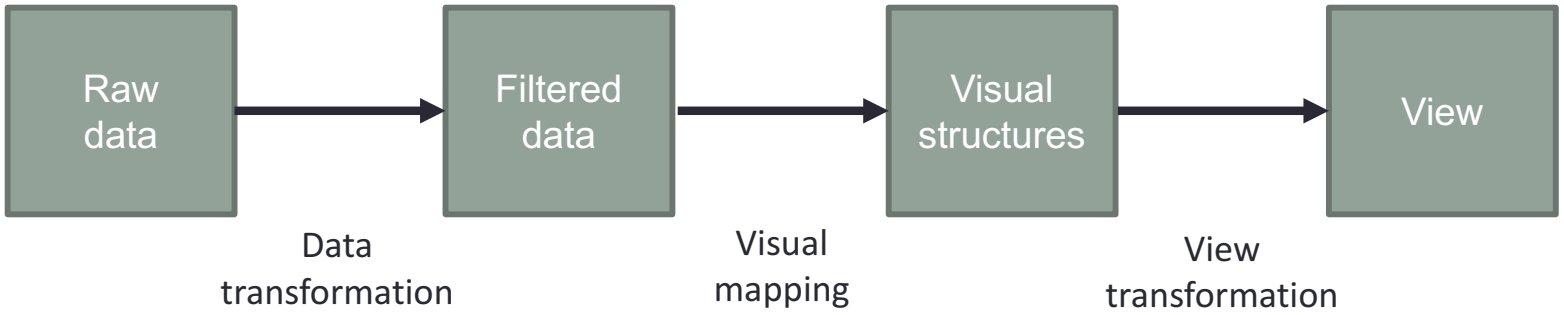


Image: Eduardo Veas and Ernst Kruijff

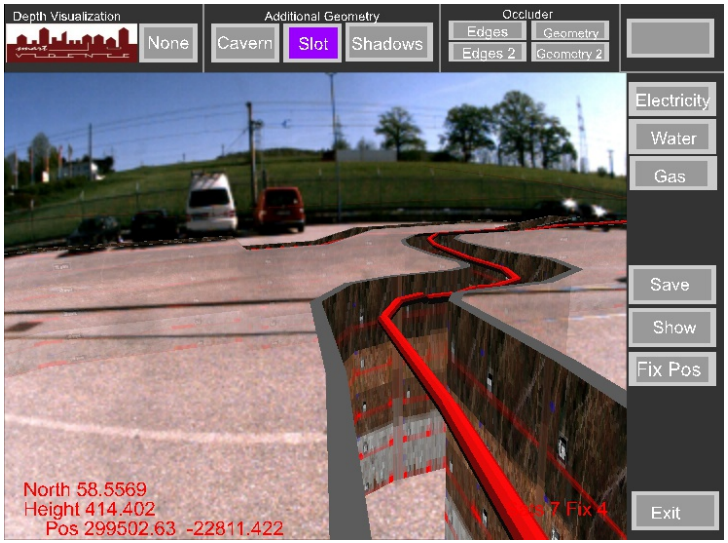
Visualization Pipeline

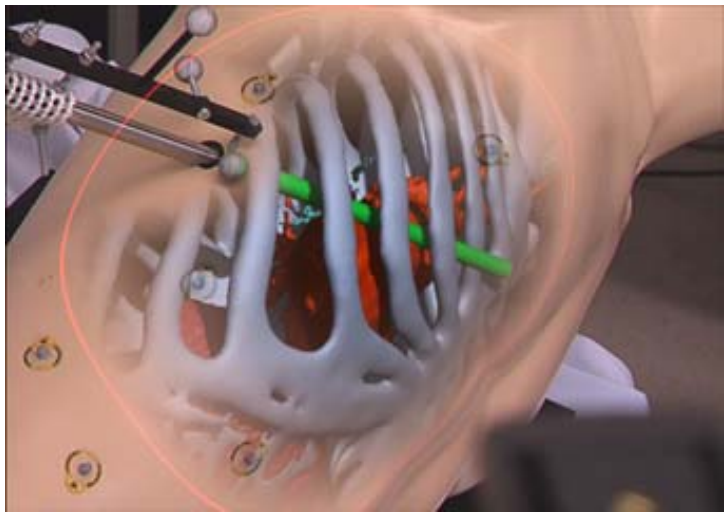


The visualization pipeline includes three stages:
data transformation, visual mapping, and view transformation

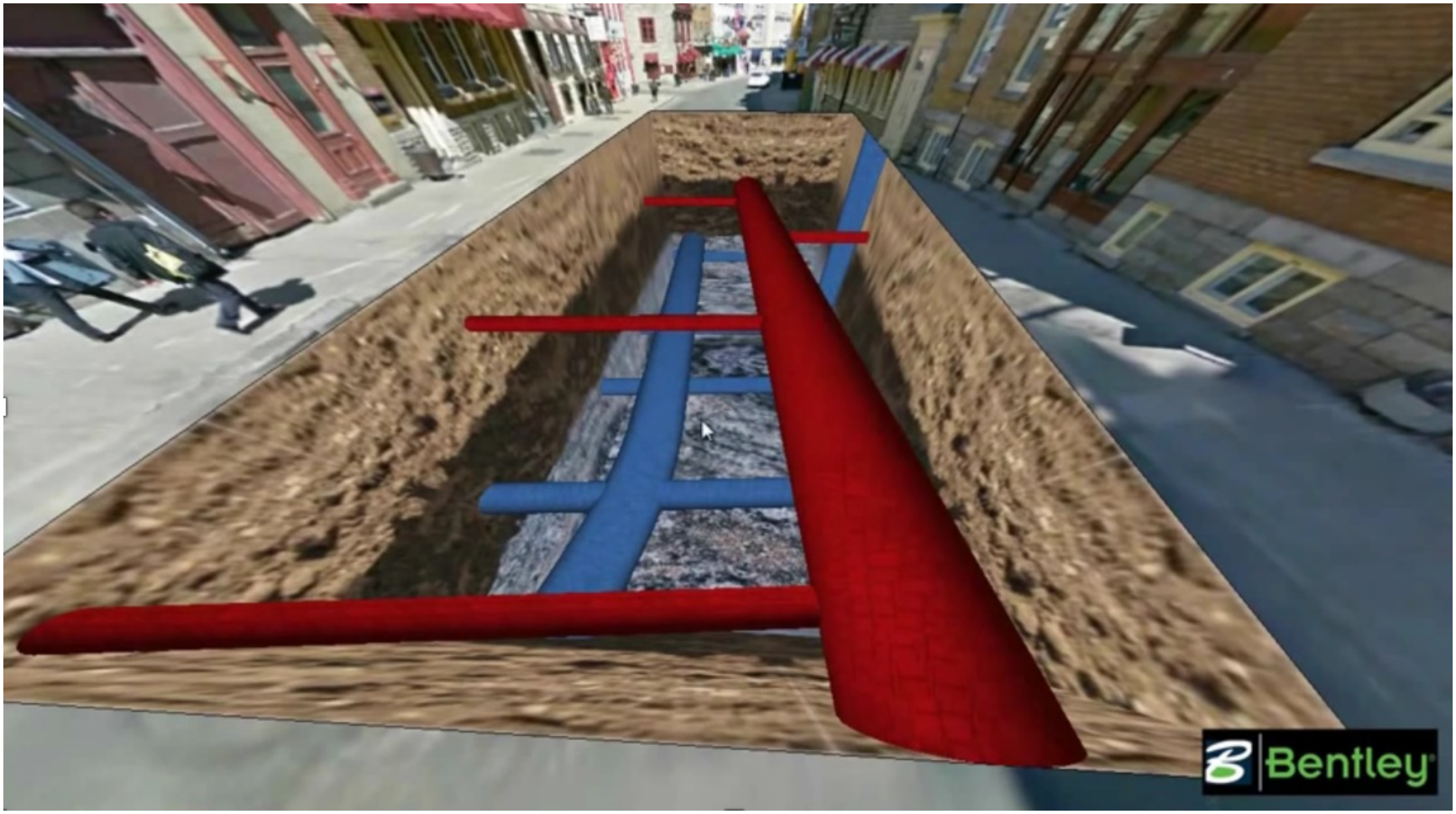
Making the Invisible Visible

- Hidden structures & information
- Supermans X-Ray Vision
- Spatial arrangement problem





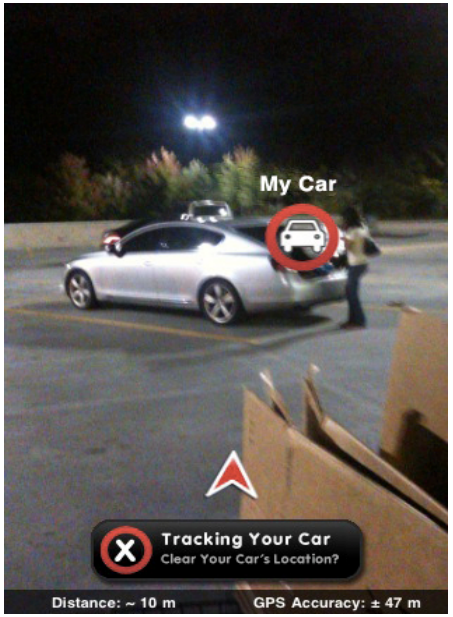
Example: Bently Systems



https://www.youtube.com/watch?v=KS_5OHoHHuo

AR Navigation

- Many commercial AR browsers
  - Information in place
  - How to navigate to POI



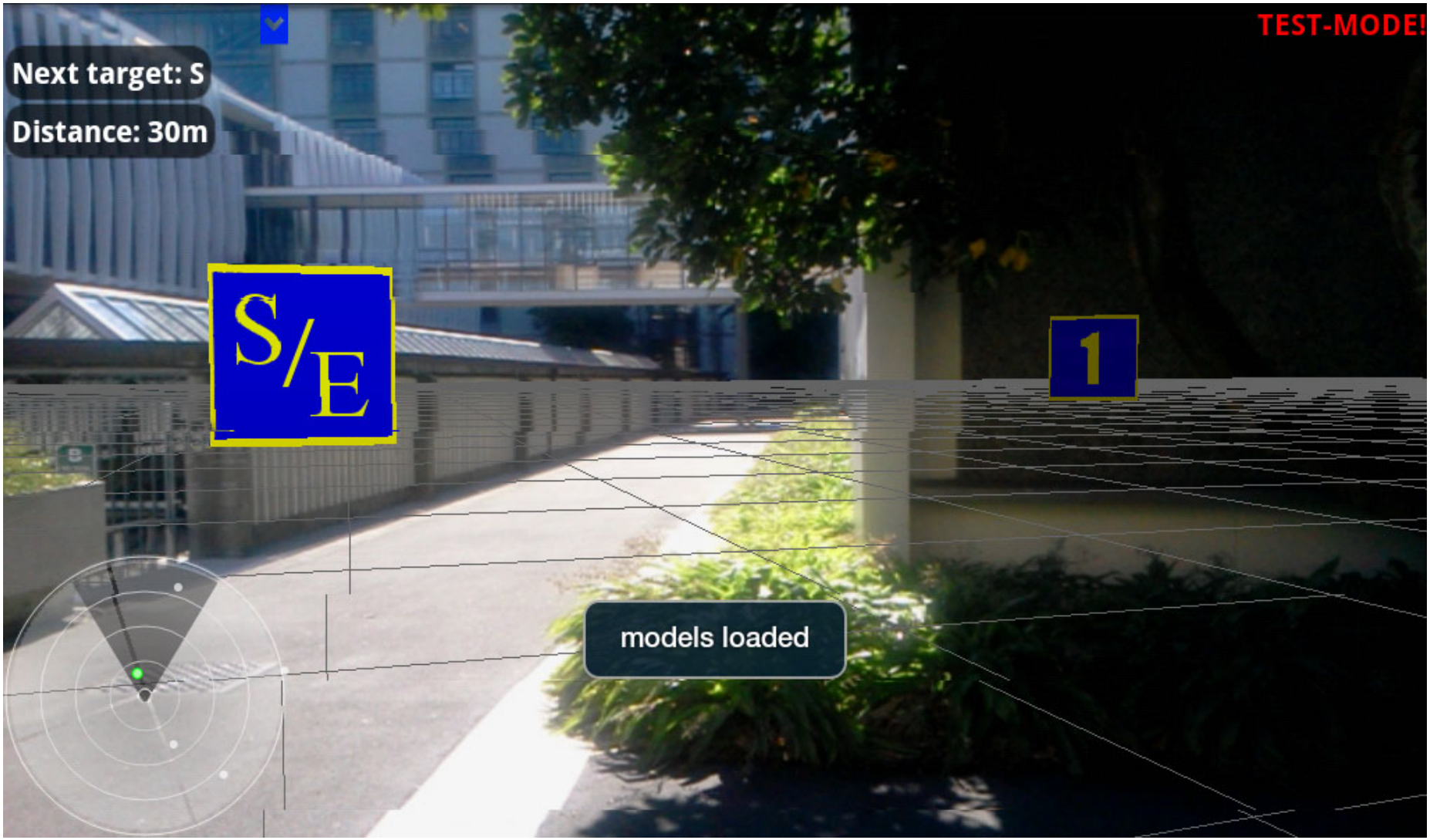
2D vs. AR Navigation?

VS

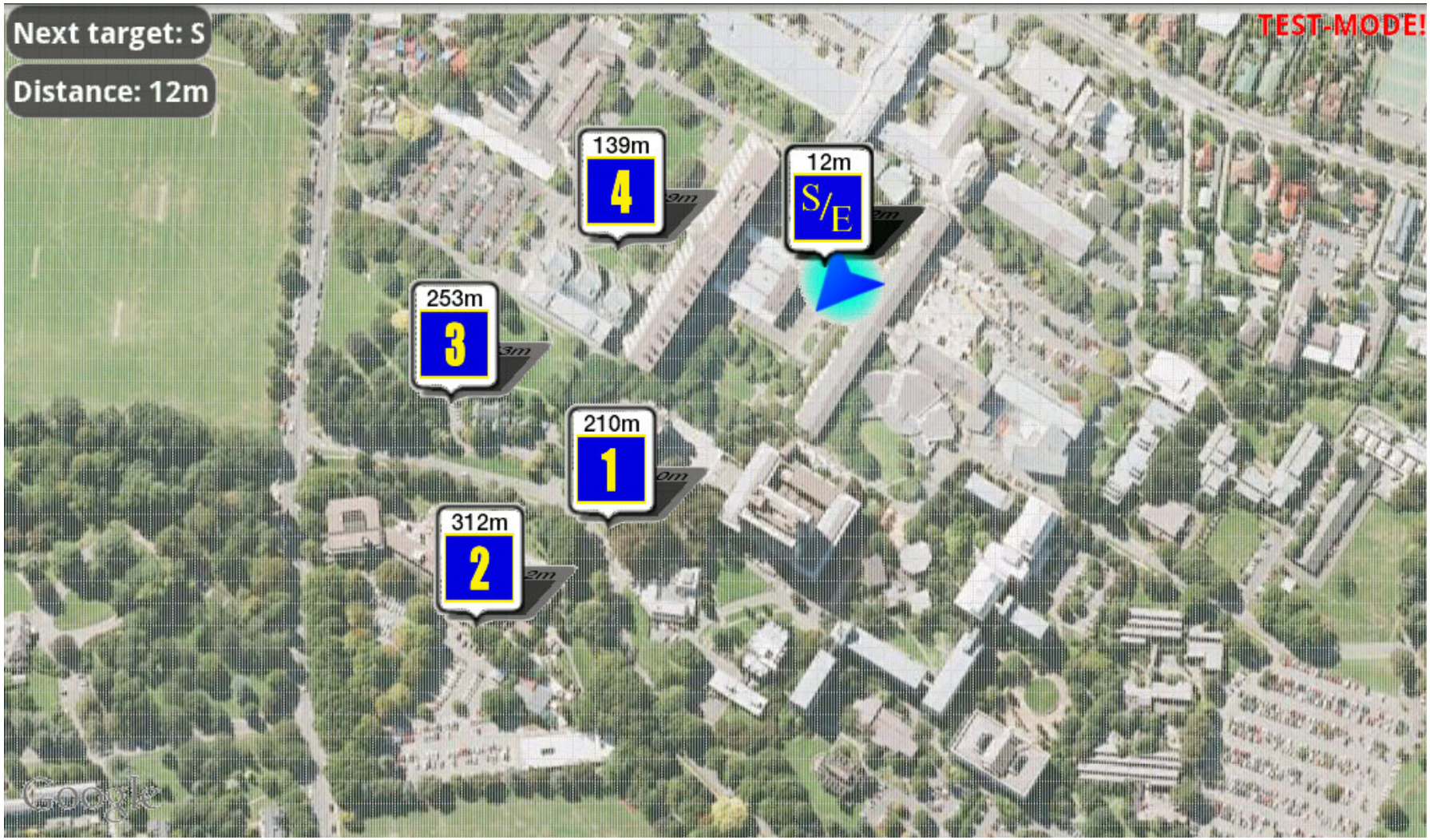
AR Navigation Study

- Users navigate between Points of Interest
- Three conditions
  - **AR:** Using only an AR view
  - **2D-map:** Using only a top down 2D map view
  - **AR+2D-map:** Using both an AR and 2D map view
- Experiment Measures
  - *Quantitative*
    - Time taken, Distance travelled
  - *Qualitative*
    - Experimenter observations, Navigation behavior, Interviews
    - User surveys, workload (NASA TLX)

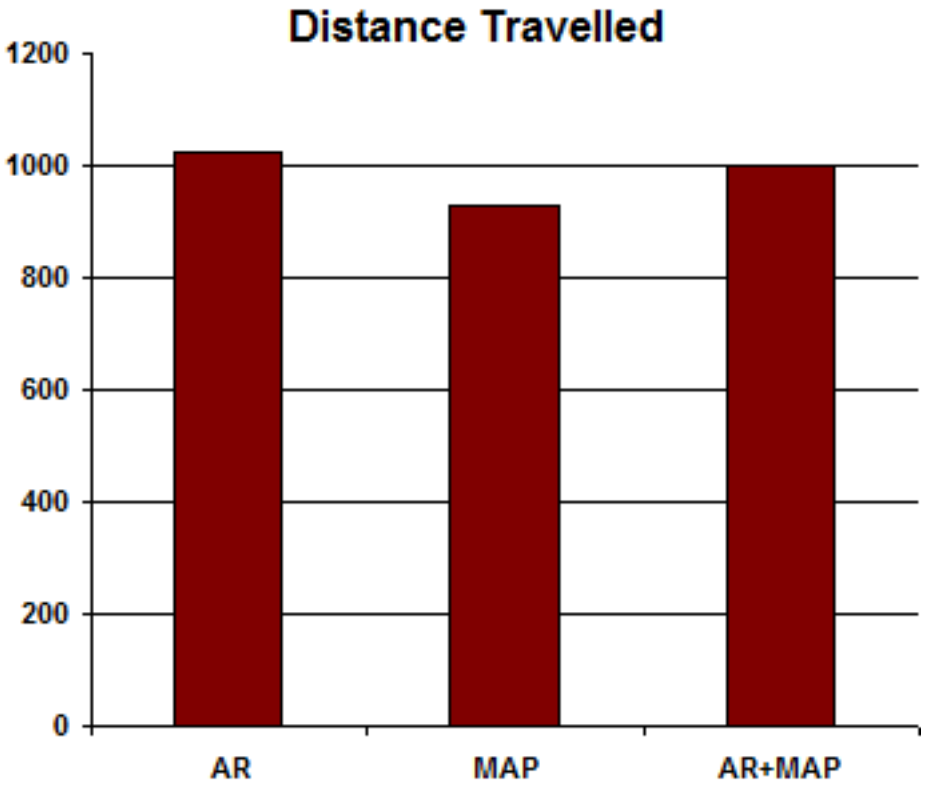
HIT Lab NZ Test Platform – AR View

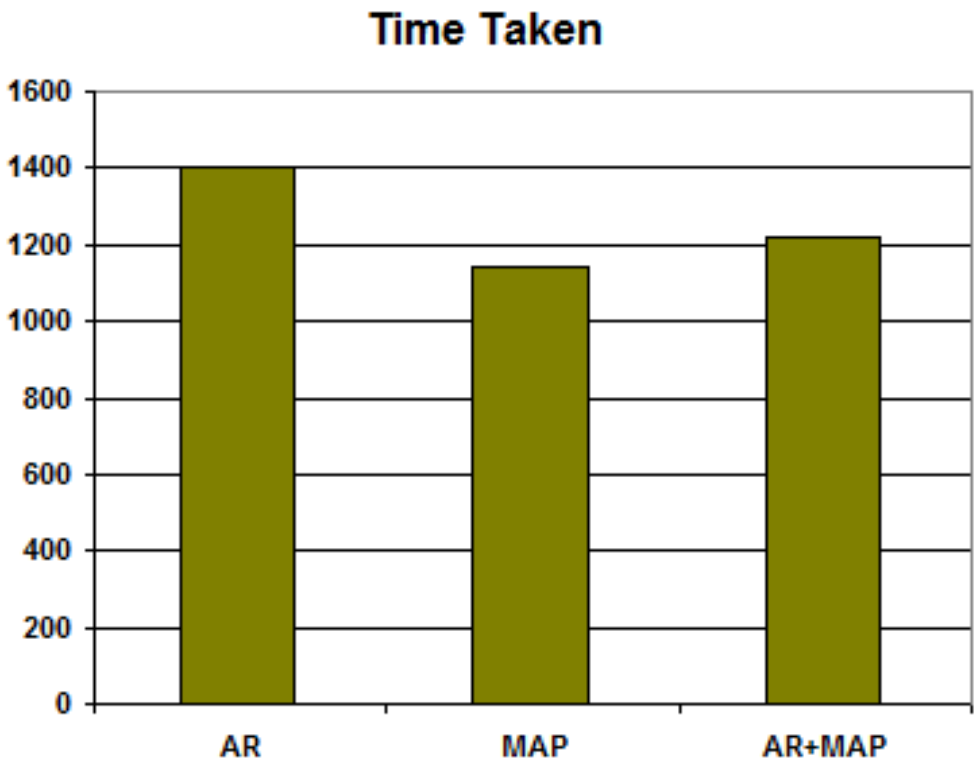


HIT Lab NZ Platform – Map View



Distance and Time



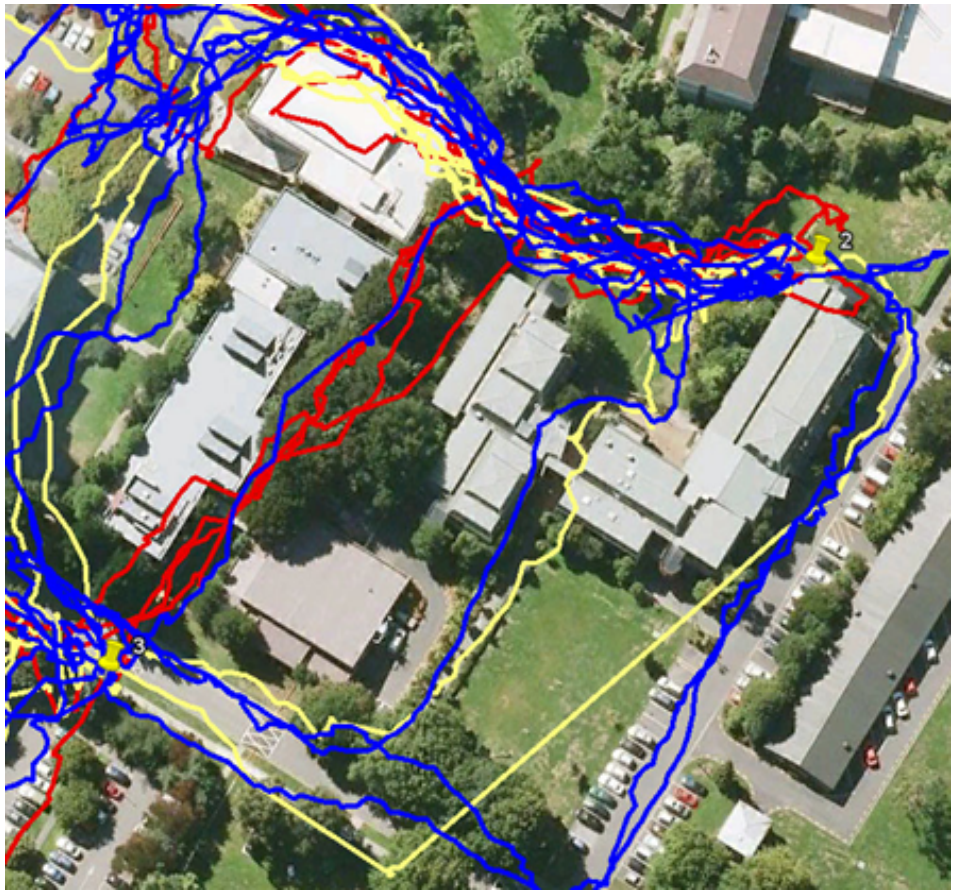


No significant differences

Paths Travelled

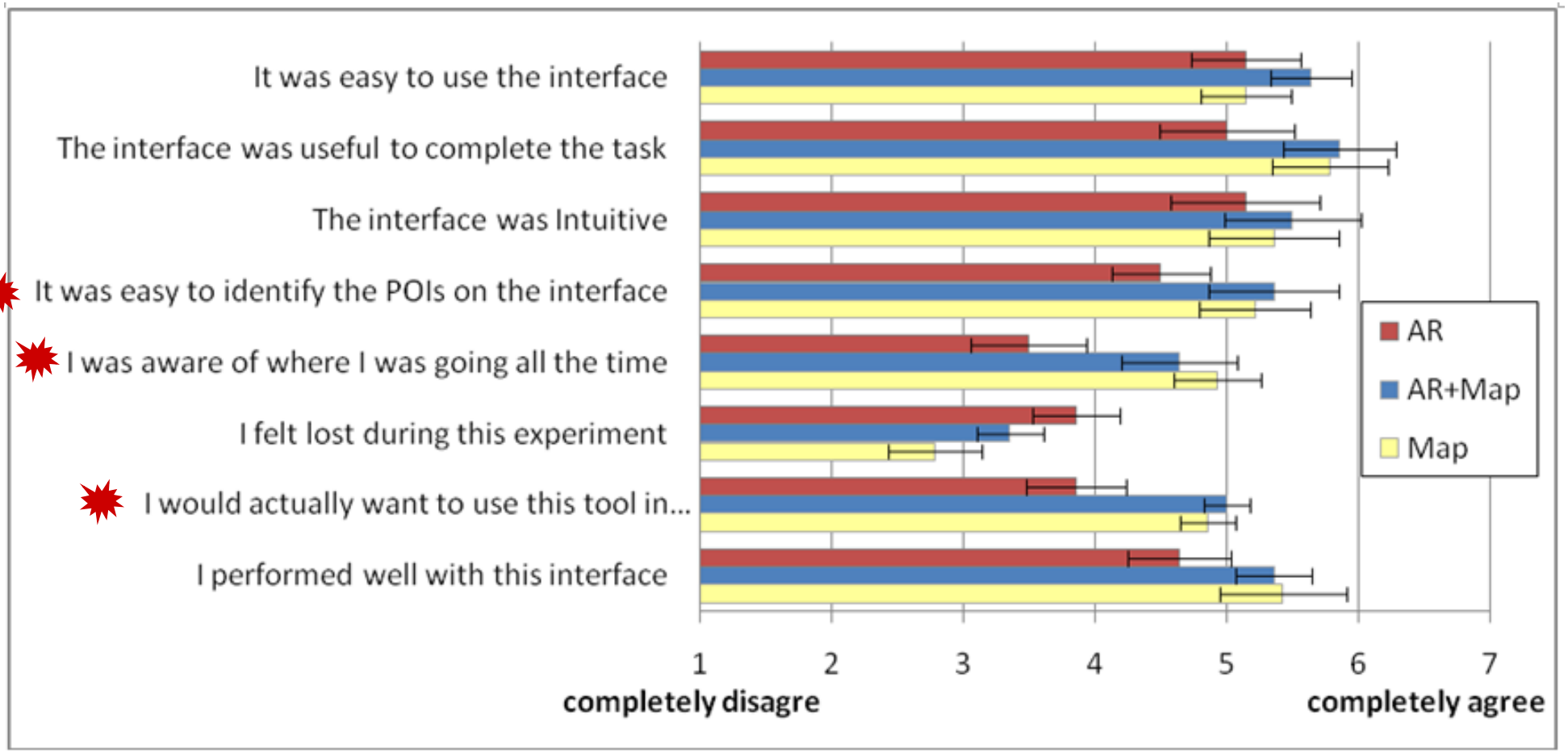
- Red – AR
- Blue – AR + Map
- Yellow - Map

Navigation Behaviour



- Depends on interface
  - Map doesn’t show short cuts

Survey Responses



User Comments

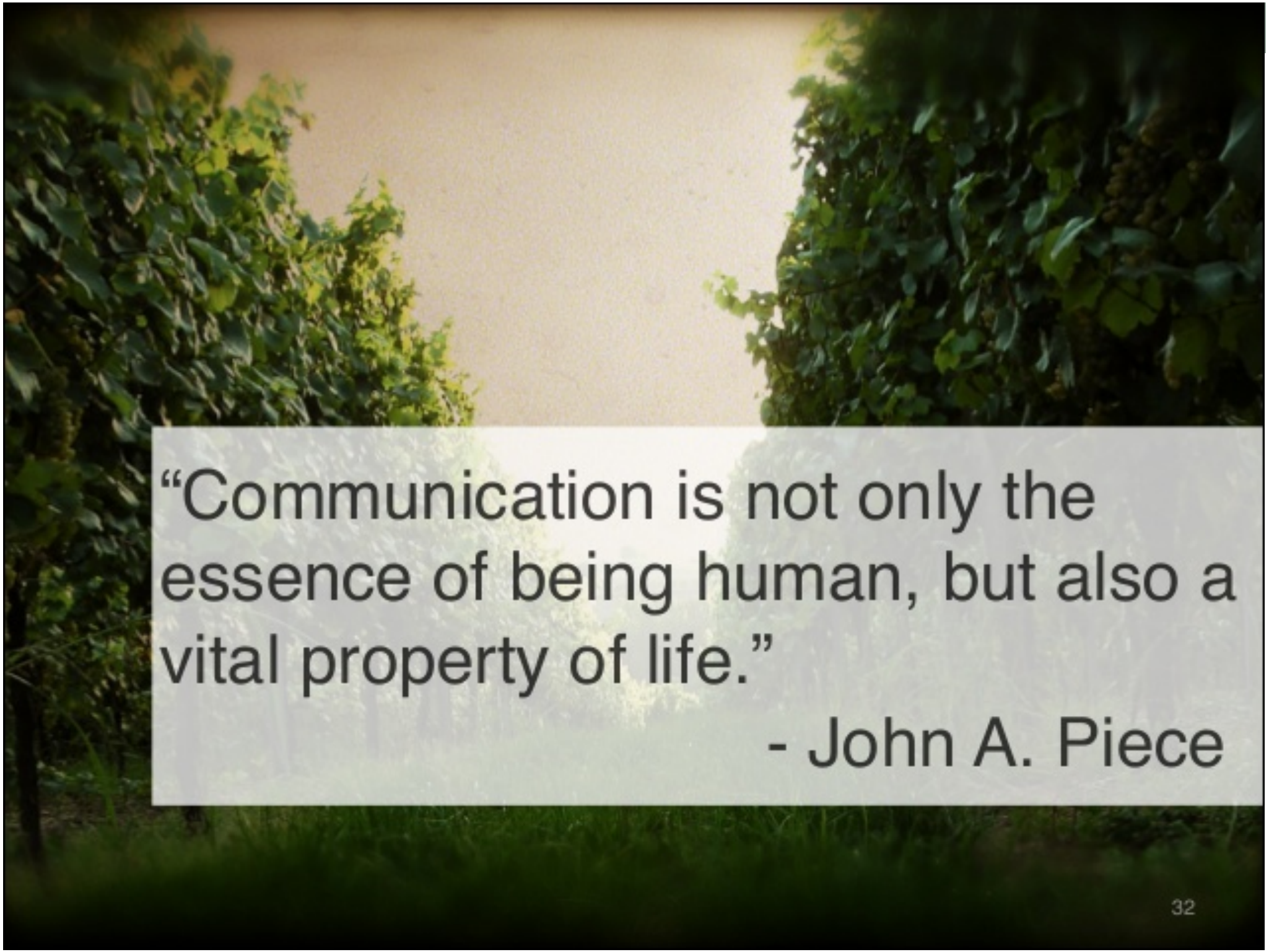
- AR
  - *“you don't know exactly where you are all of the time.”*
  - *“using AR I found it difficult to see where I was going”*
- Map
  - *“you were able to get a sense of where you were”*
  - *“you are actually able to see the physical objects around you”*
- AR+MAP
  - *“I used the map at the beginning to understand where the buildings were and the AR between each point”*
  - *“You can choose a direction with AR and find the shortest way using the map.”*

Lessons Learned

- User adapt navigation behaviour to guide type
  - AR interface shows shortcuts
  - Map interface good for planning
- Include map view in AR interface
  - 2D exocentric, and 3D egocentric
- Allow people to easily change between views
  - May use Map far away, AR close
- Difficult to accurately show depth

Dünser, A., Billinghurst, M., Wen, J., Lehtinen, V., & Nurminen, A. (2012). Exploring the use of handheld AR for outdoor navigation. *Computers & Graphics*, *36*(8), 1084-1095.

CONFERENCING


“Communication is not only the essence of being human, but also a vital property of life.”
- John A. Piece
32

Face to Face Communication

A wide variety of communication cues used.

Audio

Speech
Paralinguistic
Para-verbals
Prosodics
Intonation

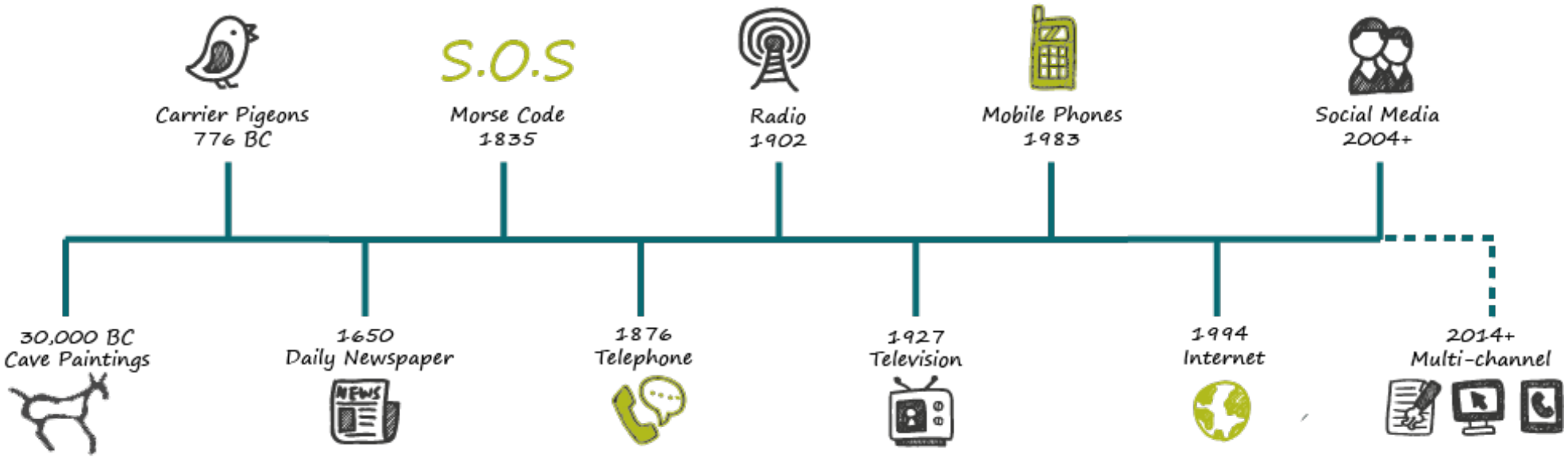
Visual

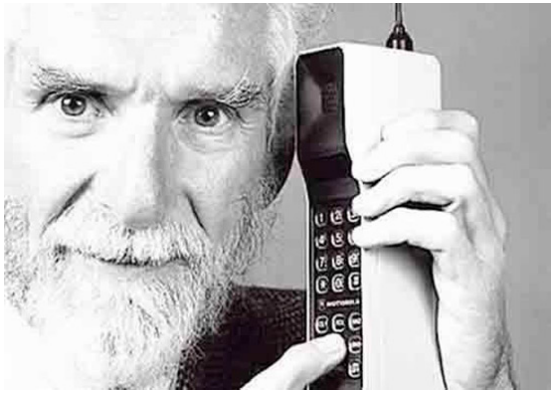
Gaze
Gesture
Face Expression
Body Position

Environmental

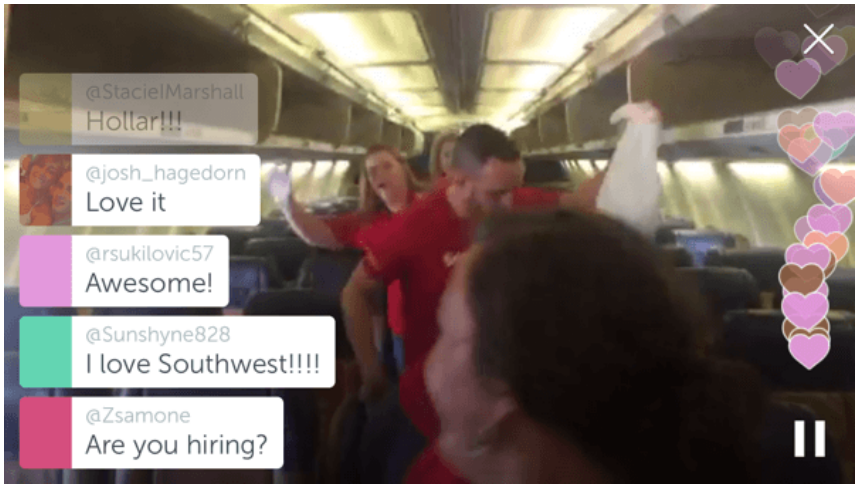
Object Manipulation
Writing/Drawing
Spatial Relationship
Object Presence

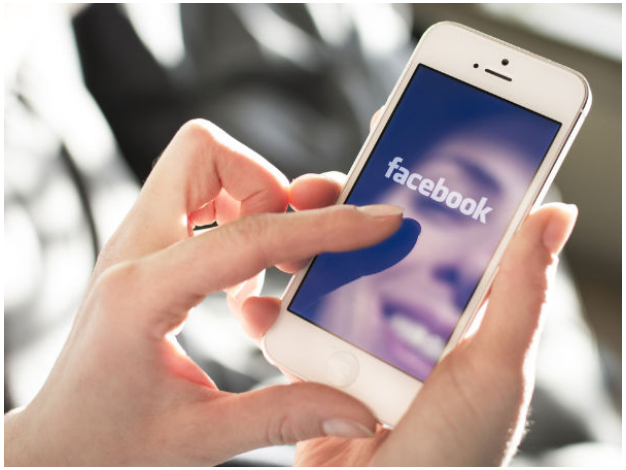
Evolution of Communication Tools



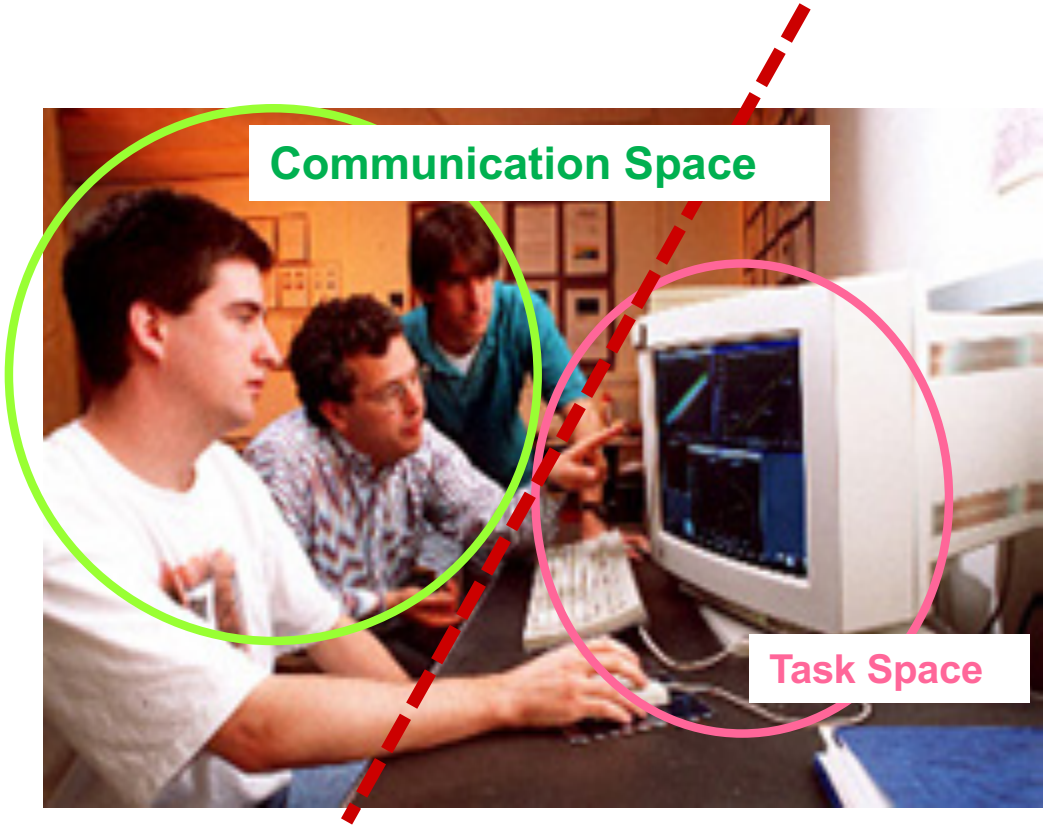


Communication Today

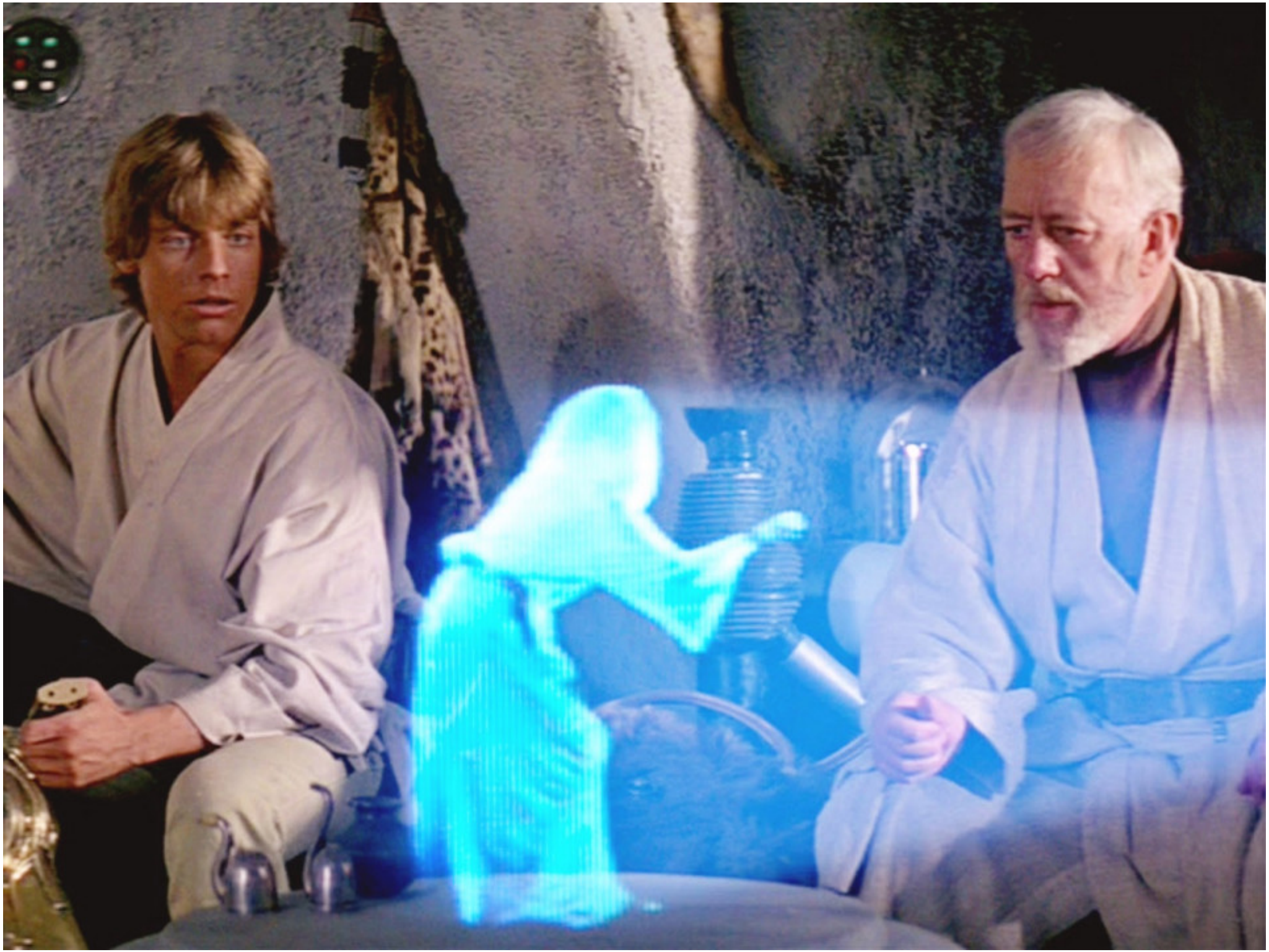




Communication Seams



- Technology creates artificial seams in communication
  - Separation between real and virtual space



Augmented Reality Conferencing

- Augmented Reality
  - Combines real and virtual world
  - Interactive in real time
  - Registered in 3D

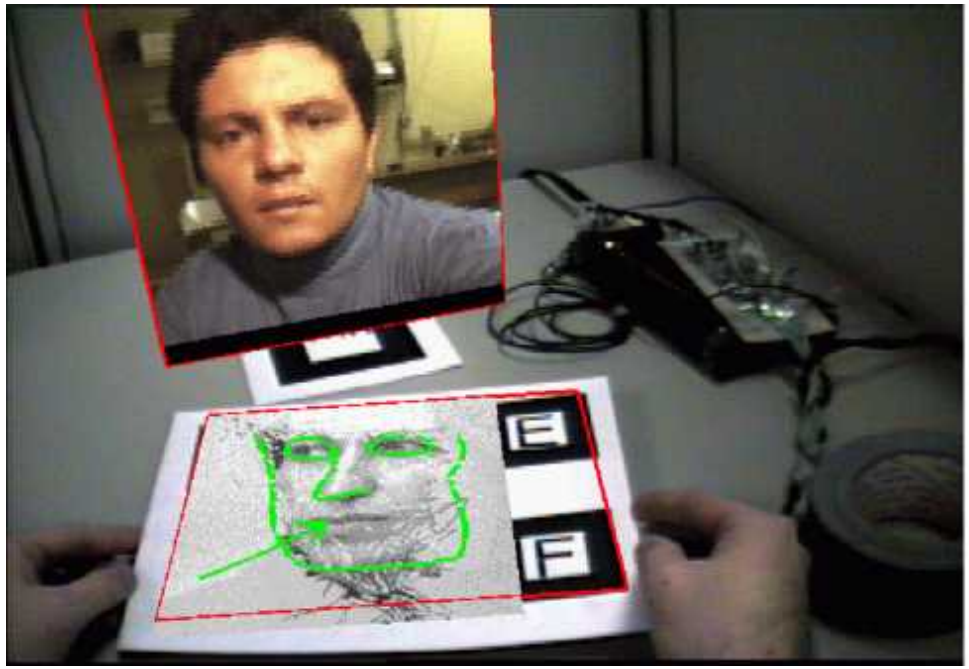
- AR Conferencing
  - Seamless blending of task/communication space
  - Natural spatial presentation/interaction
  - Support for realistic communication cues
  - Independent views of shared content

Augmented Reality Conferencing

- Tele-Presence
  - Bringing a remote person into your space
- Tele-Existence
  - Feeling like you are in a remote space

TELE-PRESENCE

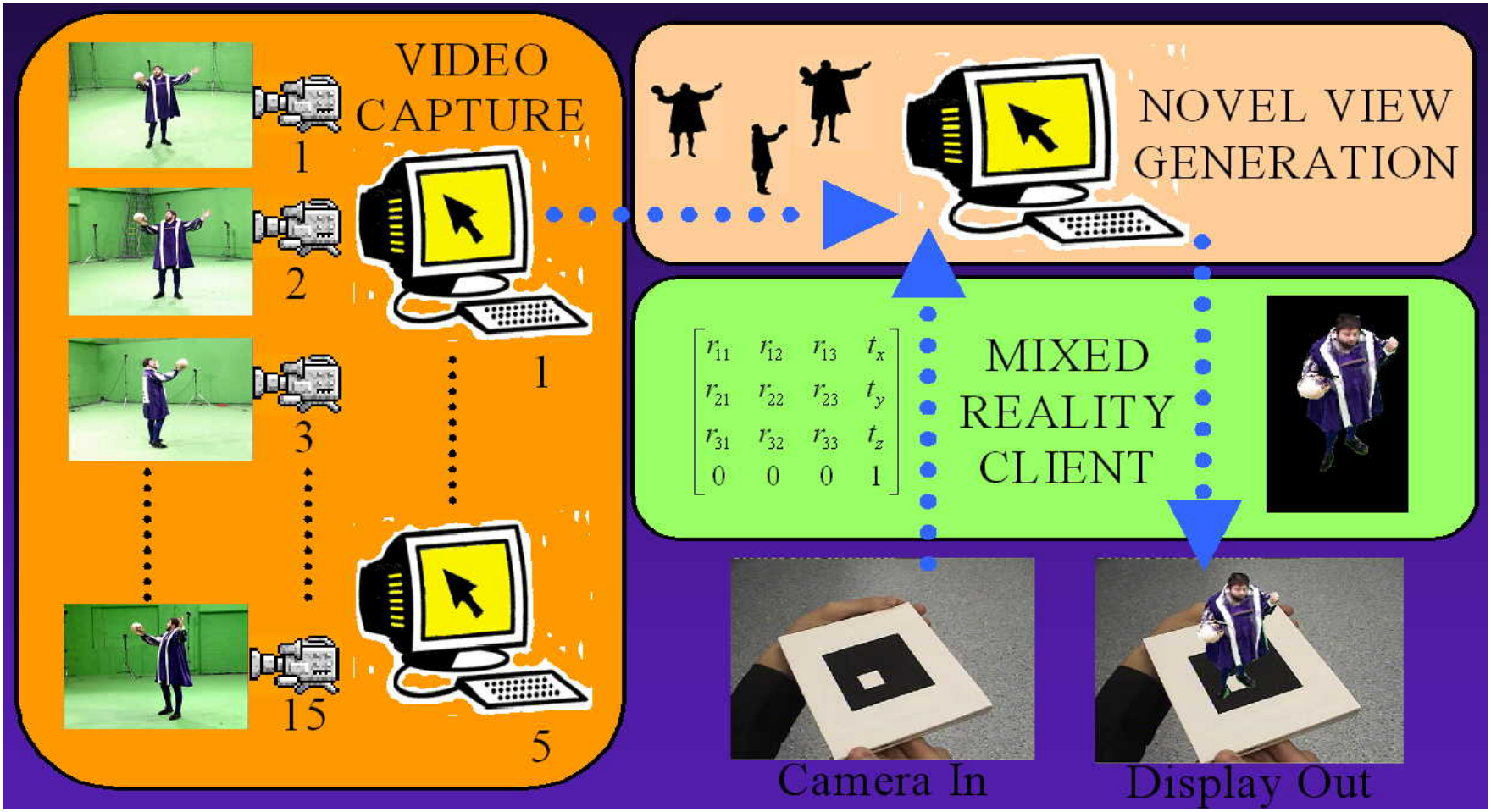
AR Video Conferencing (2001)



- Bringing conferencing into real world
- Using AR video textures of remote people
- Attaching AR video to real objects

Billinghurst, M., & Kato, H. (2002). Collaborative augmented reality. *Communications of the ACM*, *45*(7), 64-70.

Multi-View AR Conferencing



Billinghurst, M., Cheok, A., Prince, S., & Kato, H. (2002). Real world teleconferencing. *Computer Graphics and Applications, IEEE, 22(6), 11-13.*

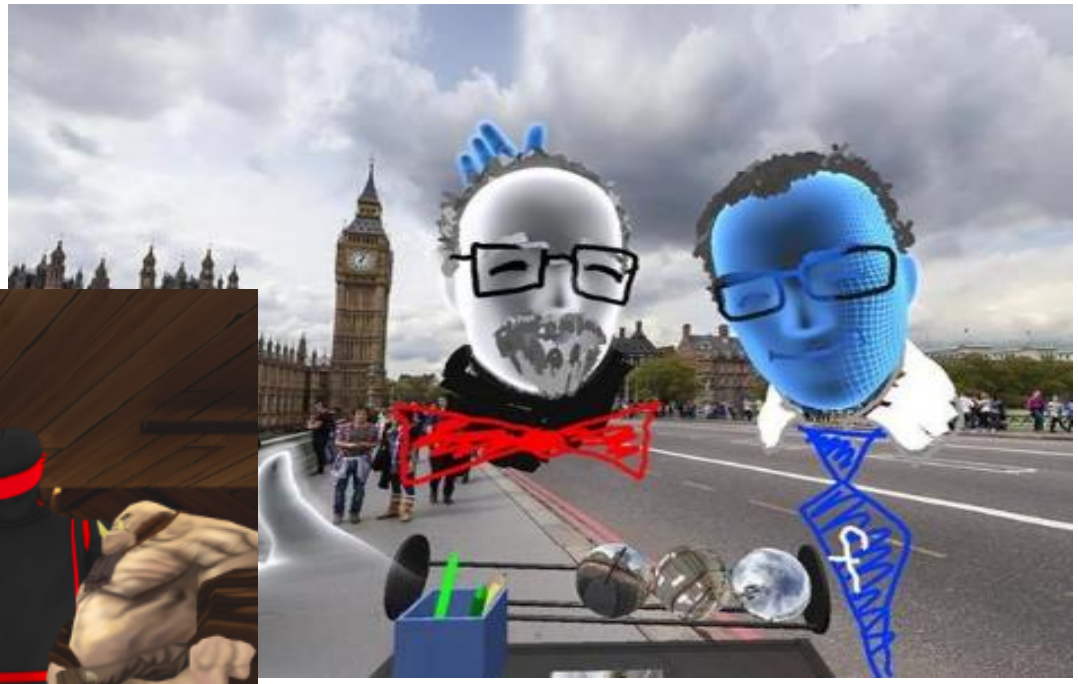
Holoportation (2016)

- Augmented Reality + 3D capture + high bandwidth
- http://research.microsoft.com/en-us/projects/holoportation/

Holoportation Video

https://www.youtube.com/watch?v=7d59O6cfaM0

Social VR



- Facebook Spaces, AltspaceVR
  - Bringing Avatars into VR space
  - Natural social interaction

Demo: Facebook Spaces VR

https://www.youtube.com/watch?v=PVf3m7e7OKU

Mini-Me – Miniature Avatar

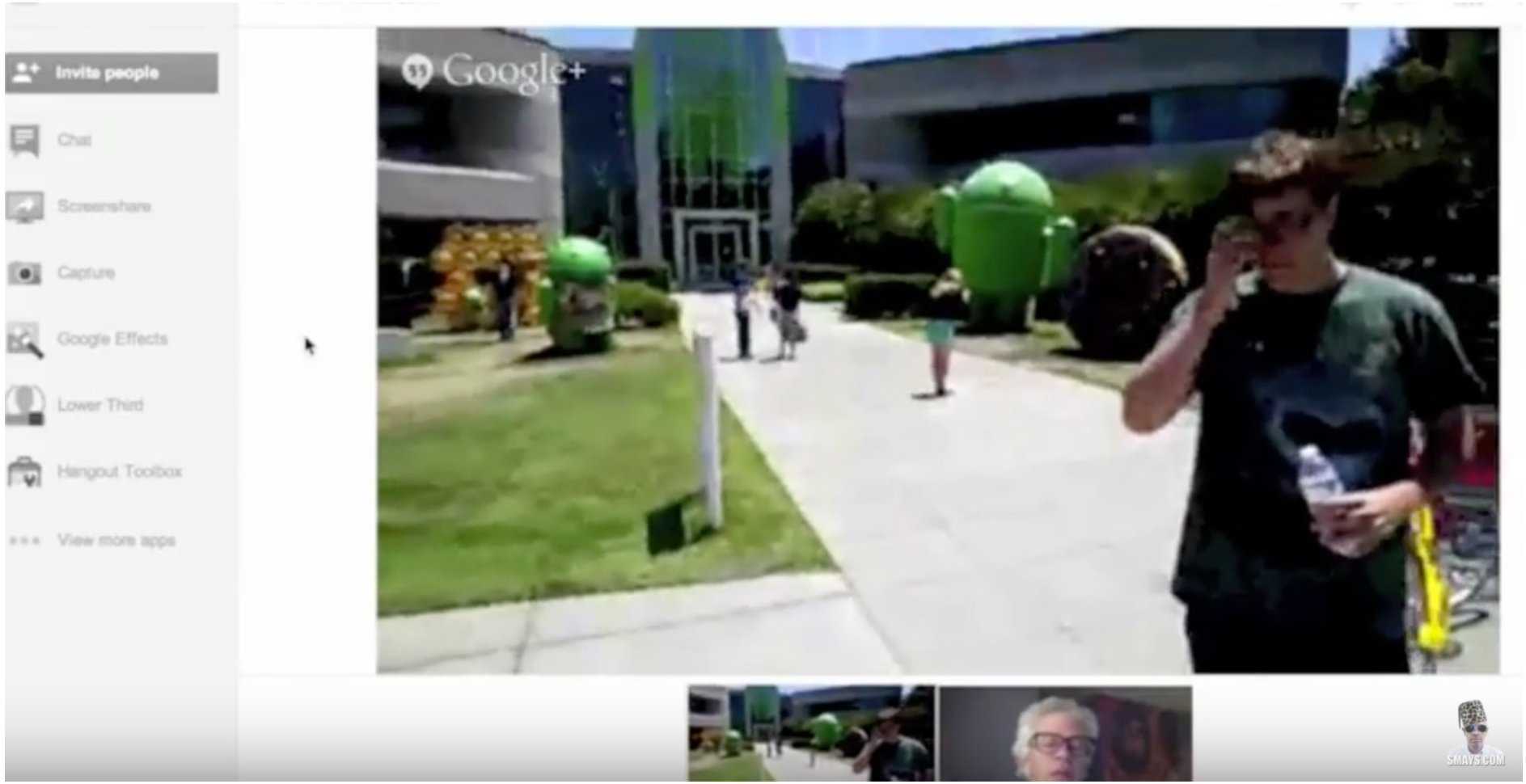
- Using a miniature Avatar to show communication cues

TELE-EXISTENCE

Example: Google Glass

- Camera + Processing + Display + Connectivity
- Ego-Vision Collaboration (But with Fixed View)

First Person Sharing Through Glass



https://www.youtube.com/watch?v=LyKaUT1bArw

Current Collaboration on Wearables

- First person remote conferencing/hangouts
- Limitations
  - Single POV, no spatial cues, no annotations, etc

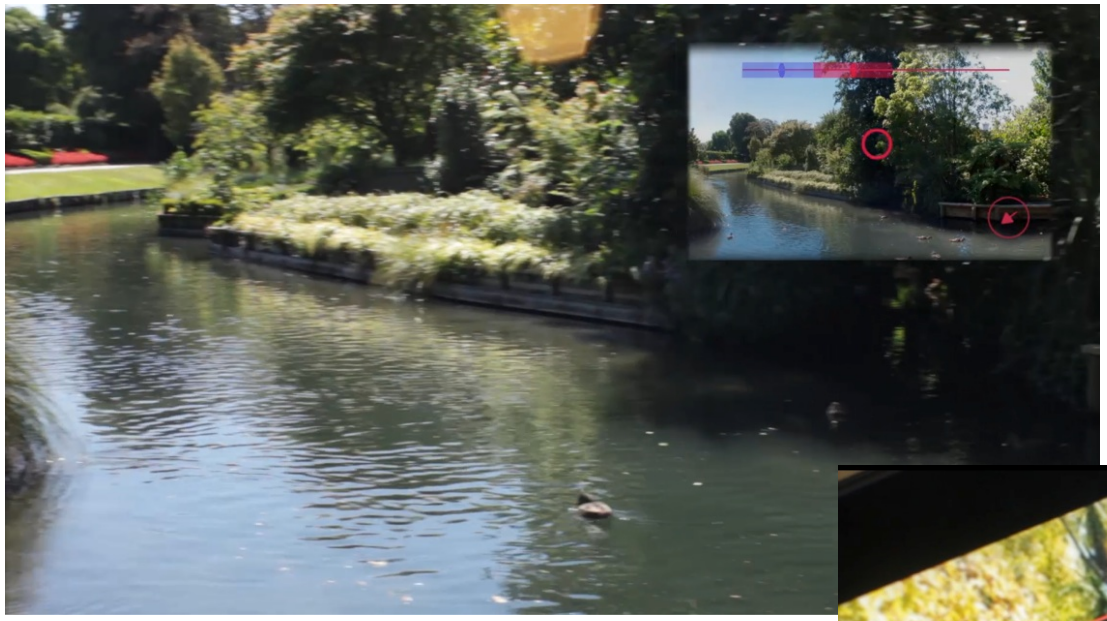
Social Panoramas (ISMAR 2014)

- Capture and share social spaces in real time
- Supports independent views into Panorama

Implementation

- Google Glass
  - Capture live image panorama (compass + camera)
- Remote device (tablet)
  - Immersive viewing, live annotation

User Interfaces



Glass View

Tablet View

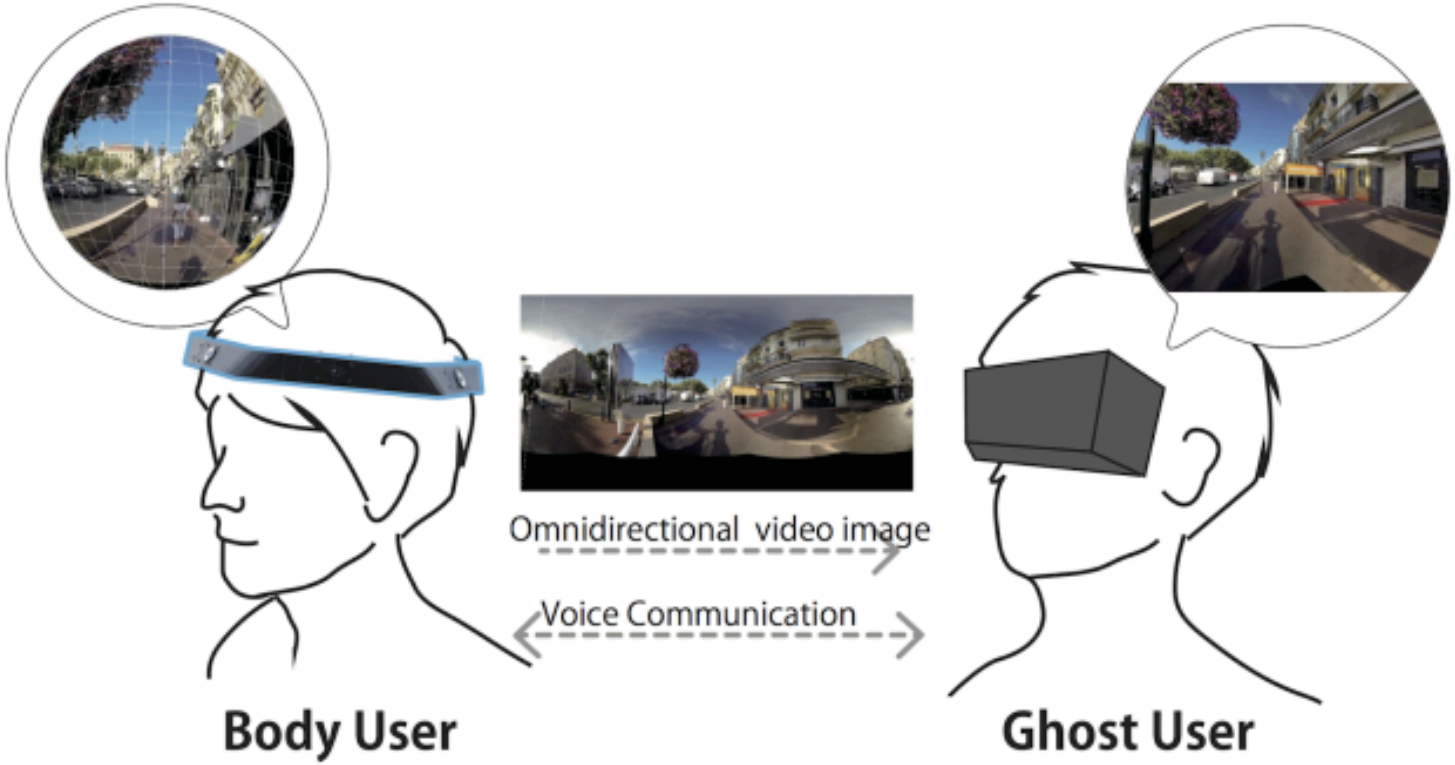
Social Panorama Demo

https://www.youtube.com/watch?v=vdC0-UV3hmY

Lessons Learned

- Good
  - Communication easy and natural
  - Users enjoy have view independence
  - Very natural capturing panorama on Glass
  - Sharing panorama enhances the shared experience
- Bad
  - Difficult to support equal input
  - Need to provide awareness cues

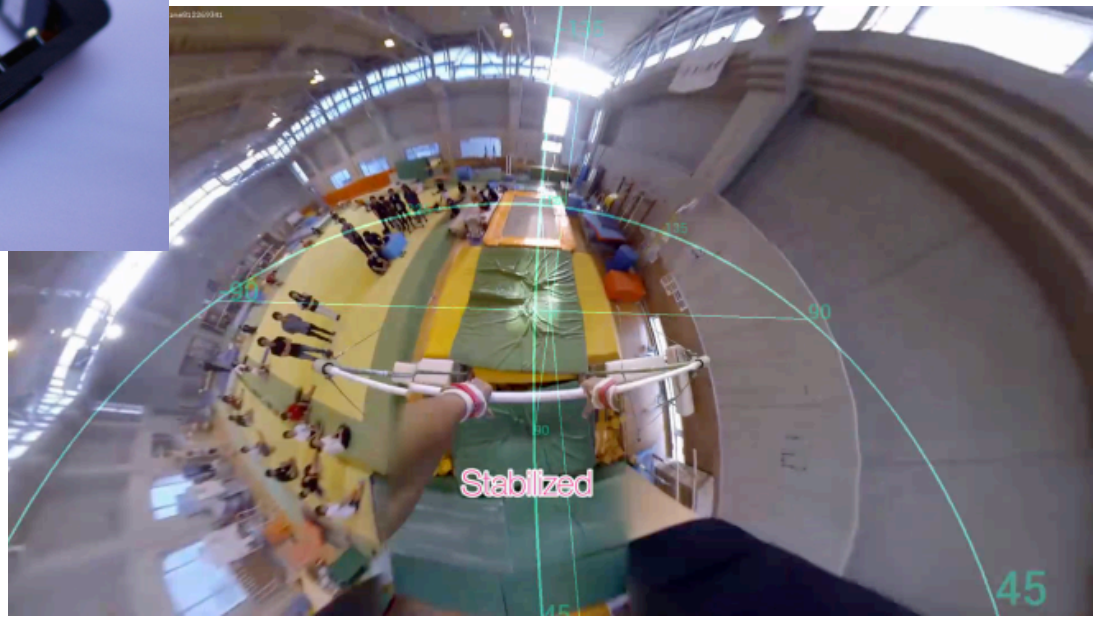
JackIn – Live Immersive Video Streaming



- Jun Rekimoto – University of Tokyo/Sony CSL

Kasahara, S., & Rekimoto, J. (2014, March). JackIn: integrating first-person view with out-of-body vision generation for human-human augmentation. In *Proceedings of the 5th Augmented Human International Conference* (p. 46). ACM.

JackIn Hardware



- Wide angle cameras – 360 degree video capture
- Live video stitching

JackIn Demo

https://www.youtube.com/watch?v=Lkuz6LhIBf8

JospehTame – Tokyo Marathon

- Live streaming from Tokyo marathon
- http://josephta.me/en/tokyo-marathon/

Shared Sphere – 360 Video Sharing

Theta S
360 Camera

Hi-res Camera

Epson BT-200
See-through HMD

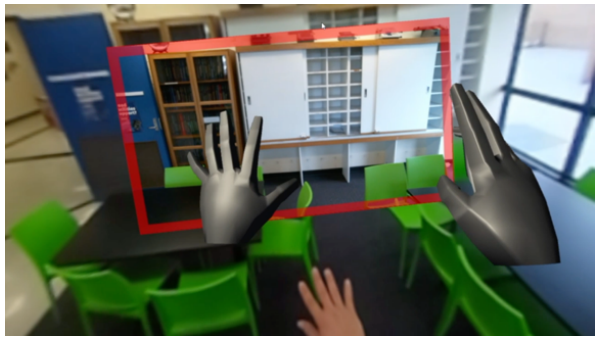
Shared
Live 360 Video

Oculus Rift
HMD

Leap Motion

Host User

Guest User



Mixed Space Collaboration (2017)

Real World

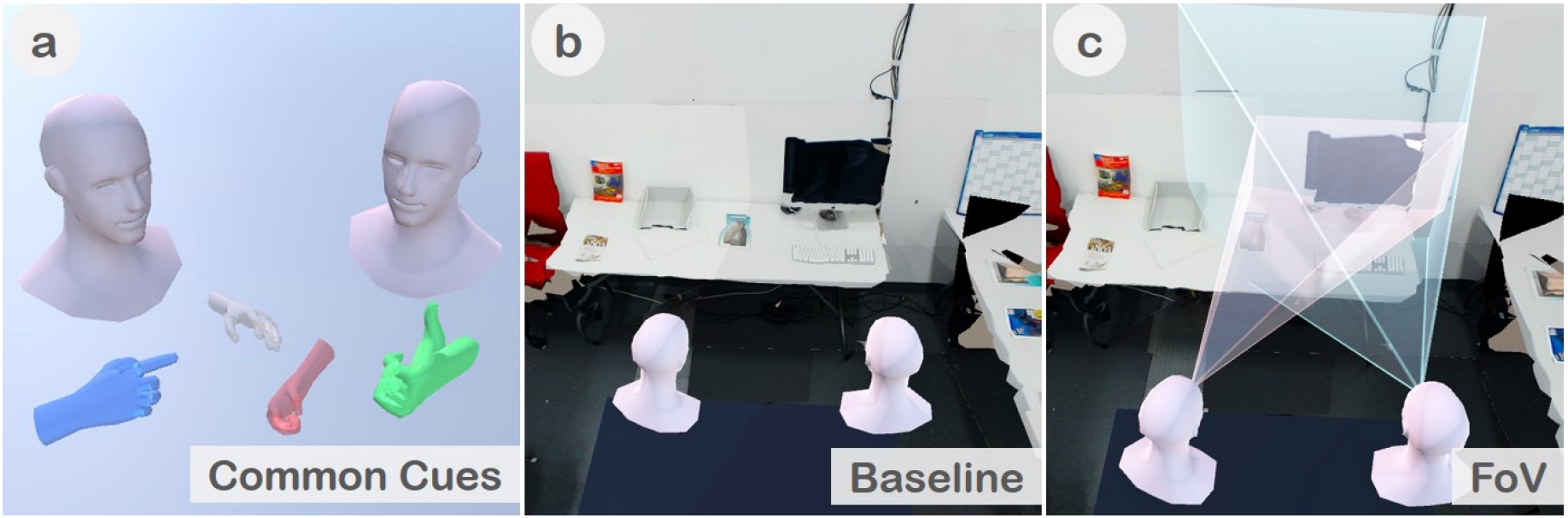
Virtual World

- Make 3D copy of real space
- AR user in real world, VR user in 3D copy of real space
  - Hololens for AR user, HTC Vive for VR user
- Share virtual body cues (head, hands, gaze information)

AR User/VR User Displays

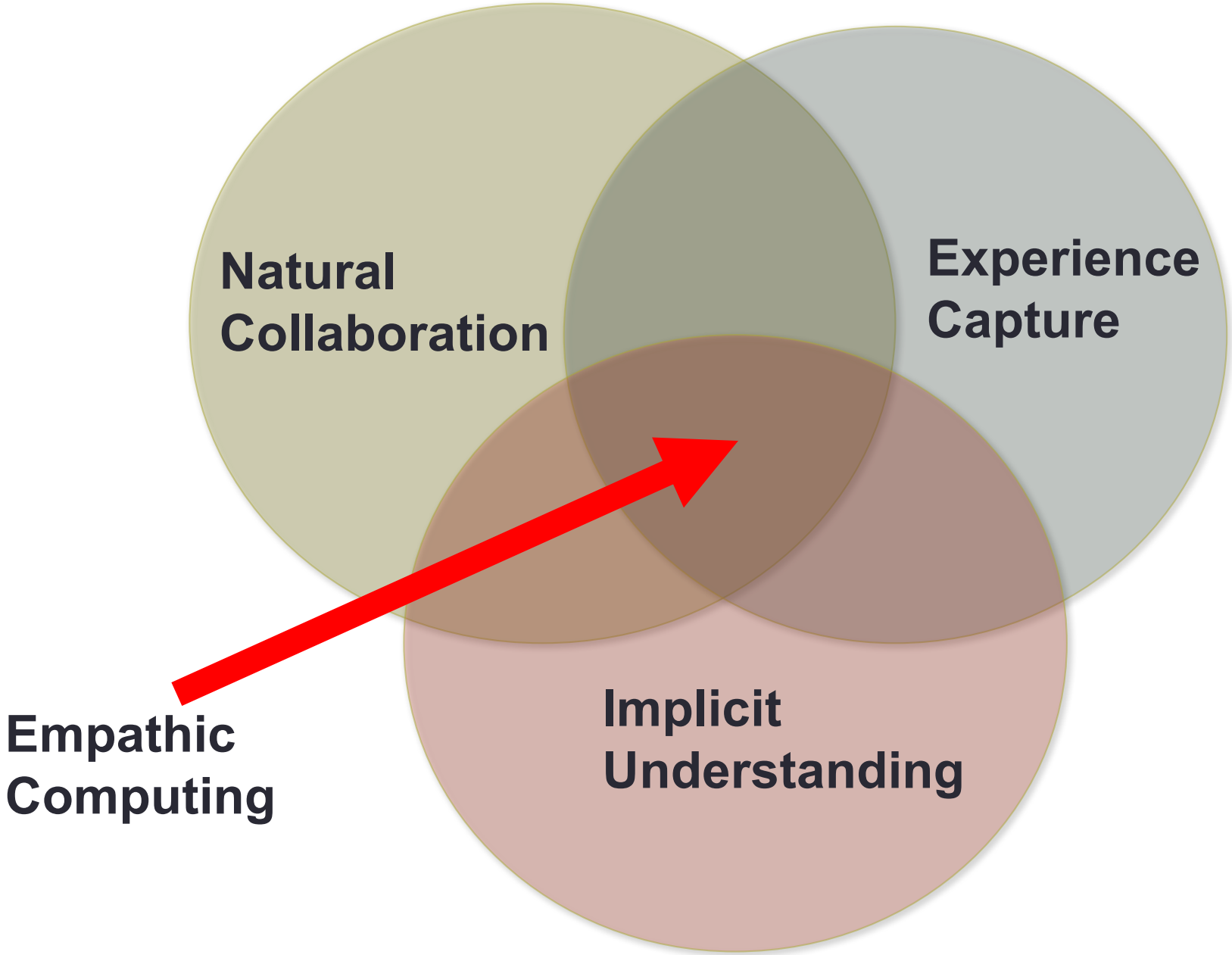
- HTC Vive (VR User), HoloLens (AR User)
- Room scale tracking
- Gesture input (Leap Motion)

Virtual Body Cues



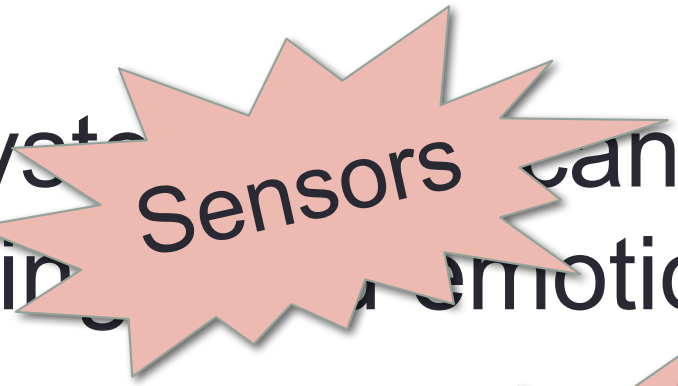
- Virtual head, hands
- View frustums

EMPATHIC COMPUTING

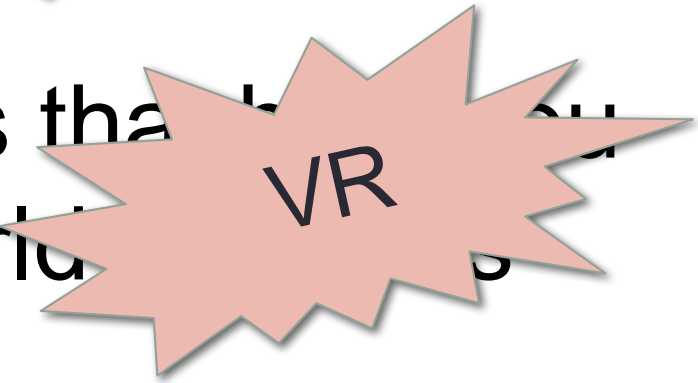

Natural
Collaboration
Experience
Capture
Implicit
Understanding
Empathic
Computing

Empathic Computing

1. Understanding: Syst[illegible]can understand your feelin[illegible]emotions

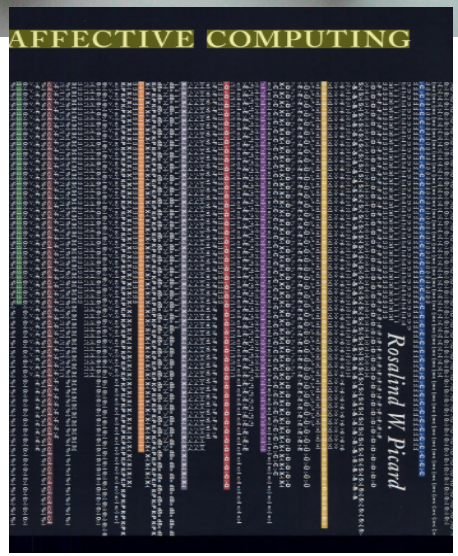


2. Experiencing: Systems tha[illegible] better experience the world[illegible]s



3. Sharing: Systems t[illegible]t help you better share the expe[illegible]thers

1. Understanding: Affective Computing



- Ros Picard – MIT Media Lab
- Systems that recognize emotion

Appliances That Make You Happy

- Jun Rekimoto – University of Tokyo/Sony CSL
- Smile detection + smart appliances

Happiness Counter Demo

https://vimeo.com/29169237

2. Experiencing: Virtual Reality

"Virtual Reality is the ultimate Empathy Machine"

Chris Milk

- Within
  - http://with.in/

Virtual Reality as Empathy Medium

"Virtual reality offers a whole different medium to tell stories that really connect people and create an empathic connection."

Nonny de la Peña

http://www.emblematicgroup.com/

Using VR for Empathy

- USC Project Syria (2014)
- Experience of Terrorism

- Project Homeless (2015)
- Experience of Homelessness

Hunger

- Experience of homeless waiting in food line

https://www.youtube.com/watch?v=wvXPP_0Ofzc

3. Sharing

Can we develop systems that allow us to share what we are seeing, hearing and feeling with others?

The Machine to Be Another (2014)

- Art project exploring issues of human identity
- One user has impression they're in the body of another
  - VR HMDs, stereo cameras, video mixing
- http://www.themachinetobeanother.org/

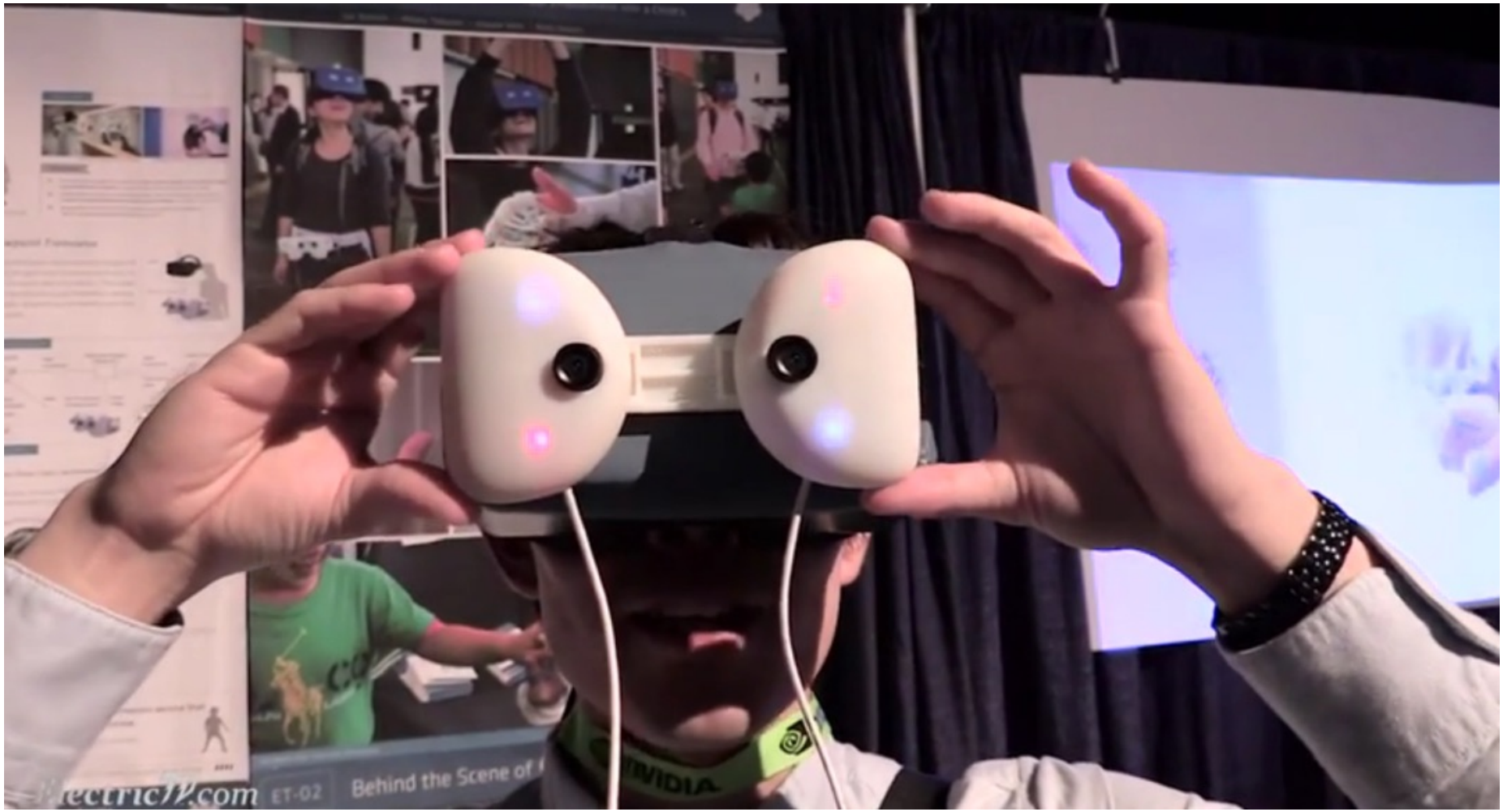
Machine to Be Another

- https://www.youtube.com/watch?v=_Wk489deqAQ

CHILDHOOD

- Kenji Suzuki, University of Tsukuba
- What does it feel like to be a child?
- VR display + moved cameras + hand restrictors

CHILDHOOD Demo



https://vimeo.com/128641932

Technical Requirements

- Basic Requirements
  - Make the technology transparent
    - Wearable, unobtrusive
- Technology for transmitting
  - Sights, Sounds, Feelings of another
    - Audio, video, physiological sensors

Gaze and Video Conferencing

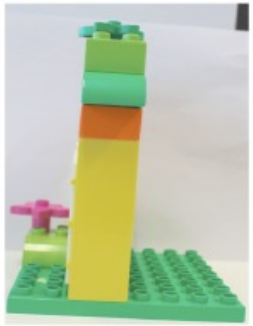
- Gaze tracking
  - Implicit communication cue
  - Shows intent
- Task space collaboration
  - HMD + camera + gaze tracker
- Expected Results
  - Gaze cues reduce need for communication
  - Allow remote collaborator to respond faster

Gupta, K., Lee, G. A., & Billinghurst, M. (2016). Do You See What I See? The Effect of Gaze Tracking on Task Space Remote Collaboration. *IEEE Transactions on Visualization and Computer Graphics*, *22*(11), 2413-2422.

Experiment Set Up

- Lego assembly
- Two assembly areas
- Remote expert

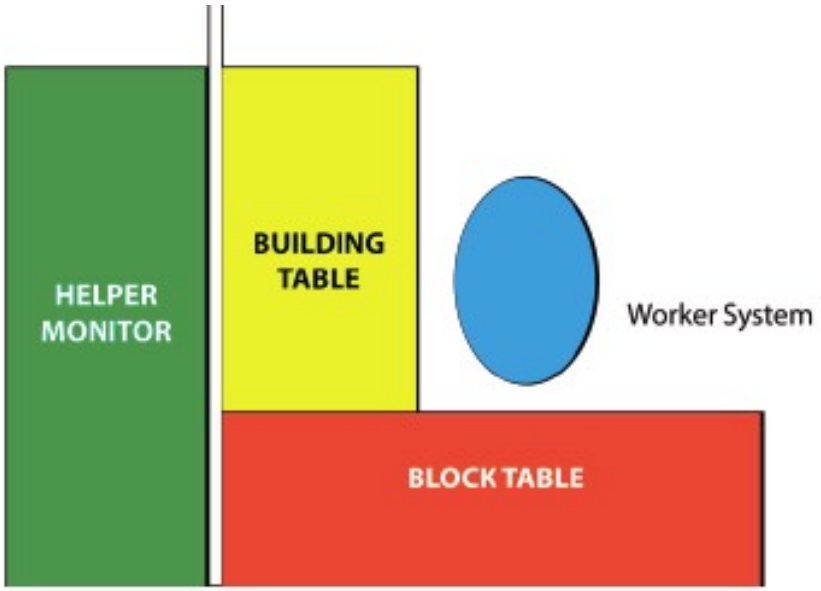
FRONT



RIGHT

LEFT

Helper System

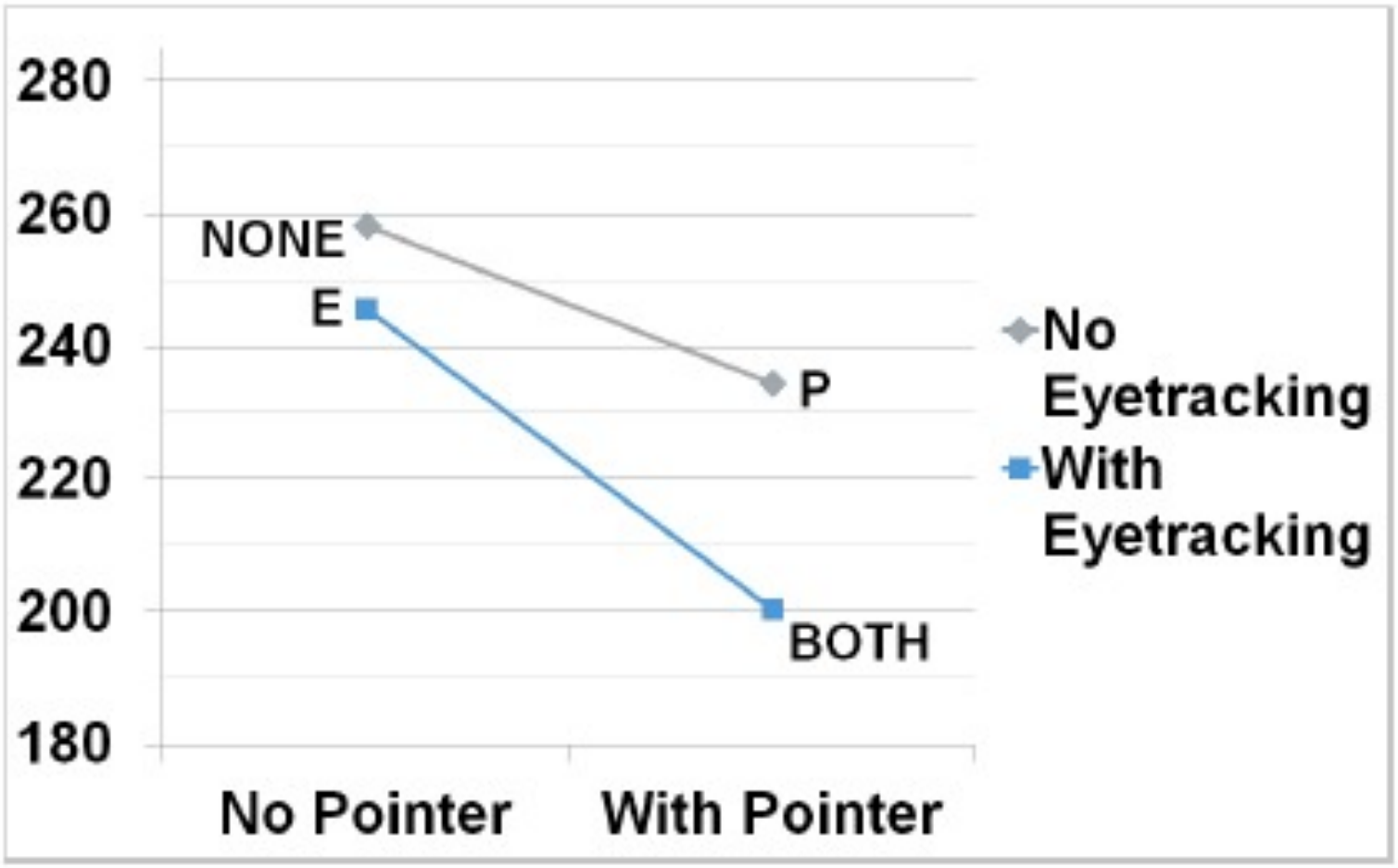


Experiment Design

	EYETRACKING: NO	EYETRACKING: YES
POINTER: NO	No Cue (NONE)	Eye Tracker Cue (E)
POINTER: YES	Pointer Cue (P)	Both Cues (BOTH)

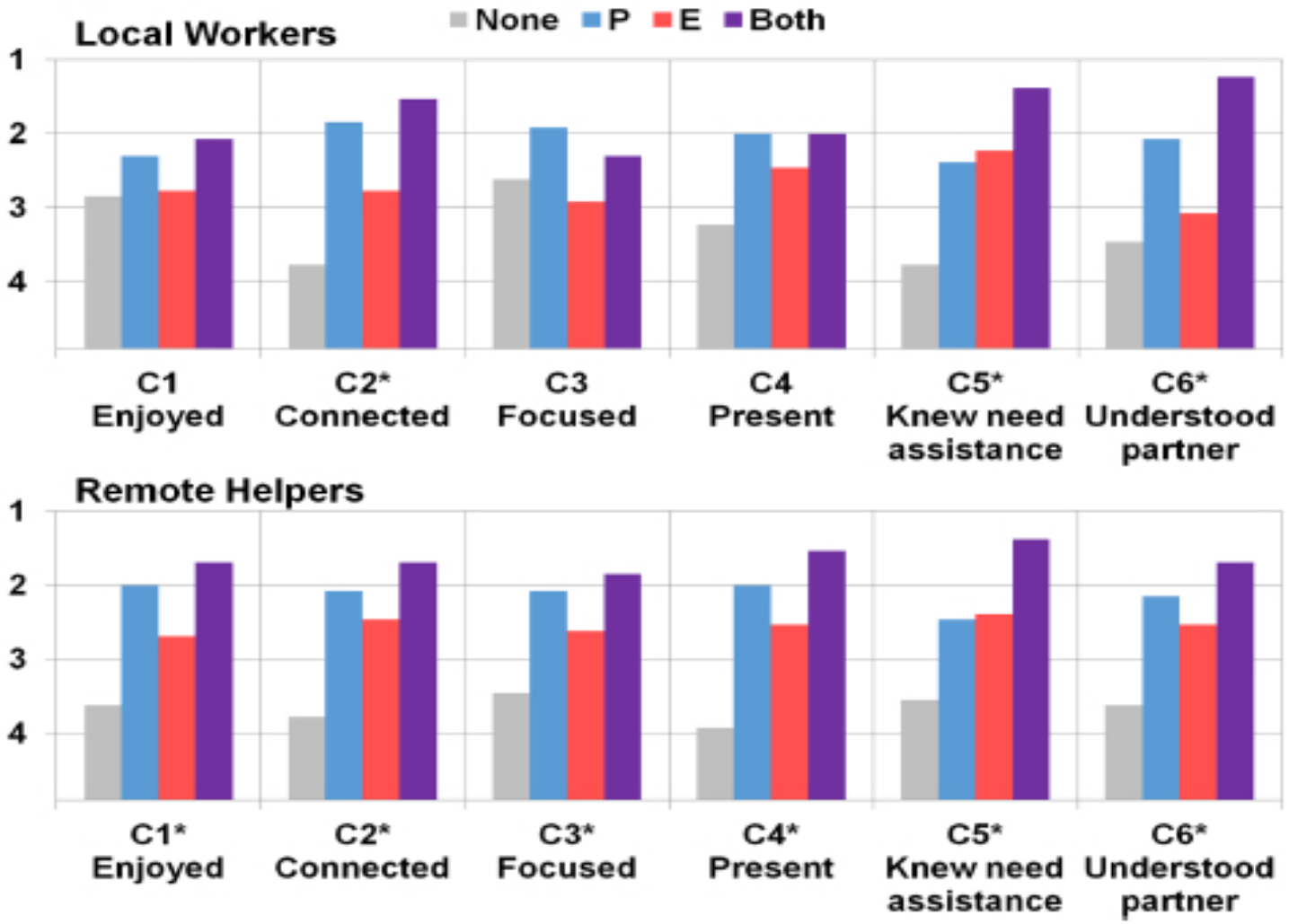
- 4 conditions varying eye-tracking/pointer support
- 13 pairs subjects
- Measures
  - Performance time
  - Likert scale results, Ranking results, User preference

Task Performance



- Performance Time (seconds)

Ranking



- Average Ranking Values

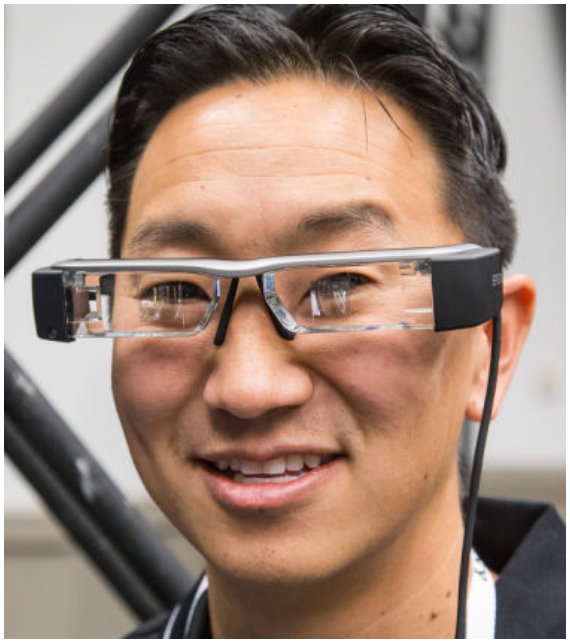
Key Results

- Both the pointer and eye tracking visual cues helped participants to perform significantly faster
- The pointer cue significantly improved perceived quality of collaboration and co-presence
- Eye-tracking improved the collaboration quality, and sense of being focused for the local users, and enjoyment for the remote users
- The Both condition was ranked as the best in user experience, while the None condition was worst.

Empathy Glasses (CHI 2016)

Pupil Labs

+



Epson BT-200

+

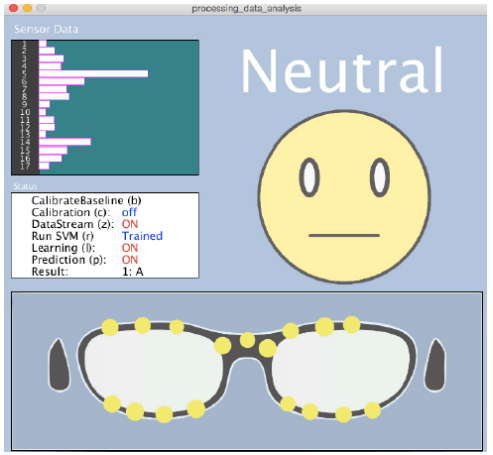
AffectiveWear

- Combine together eye-tracking, display, face expression
- Impicit 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.

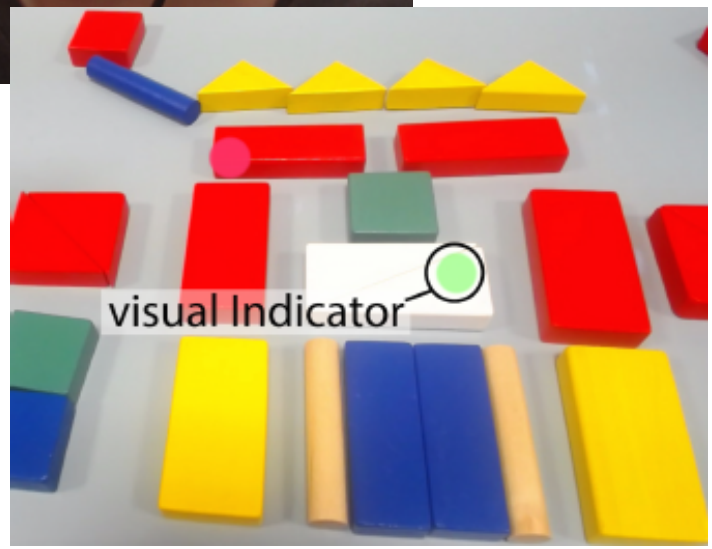
AffectiveWear – Emotion Glasses

- Photo sensors to recognize expression
- User calibration
- Machine learning
- Recognizing 8 face expressions

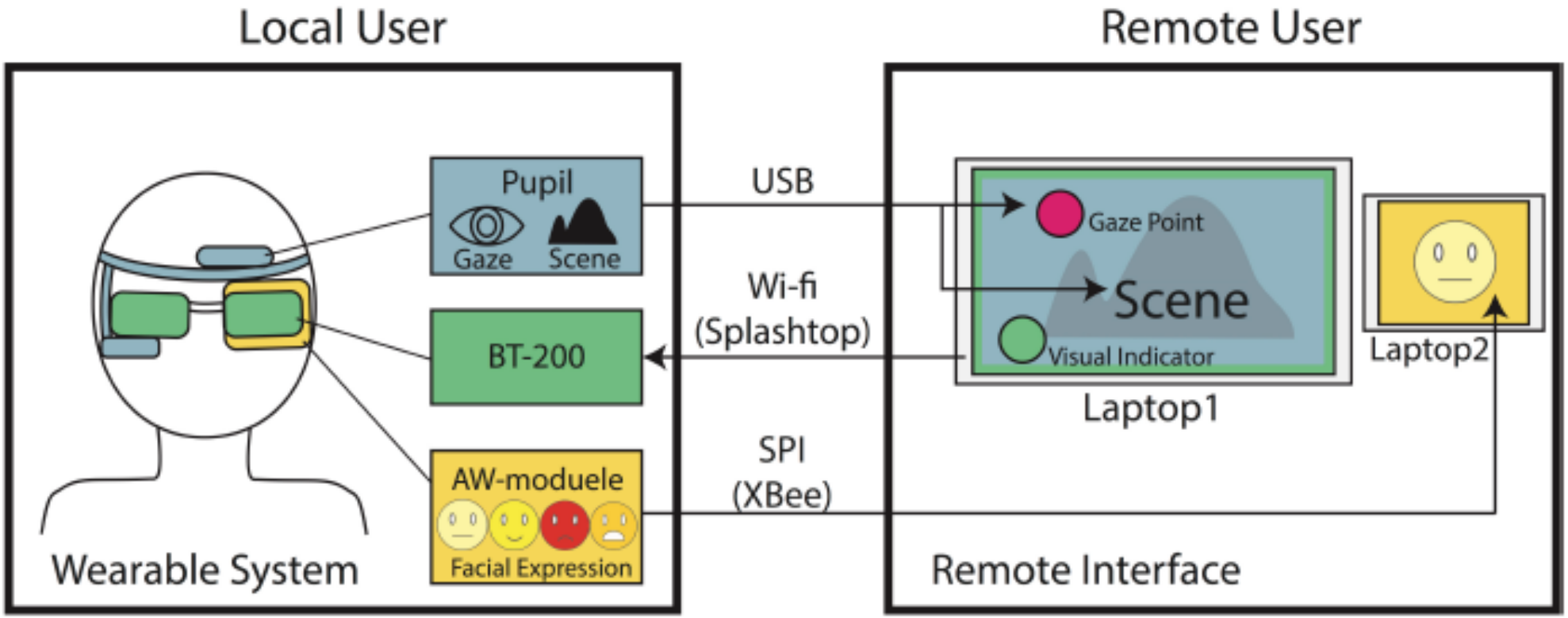


Integrated System

- Local User
  - Video camera
  - Eye-tracking
  - Face expression
- Remote Helper
  - Remote pointing



System Diagram

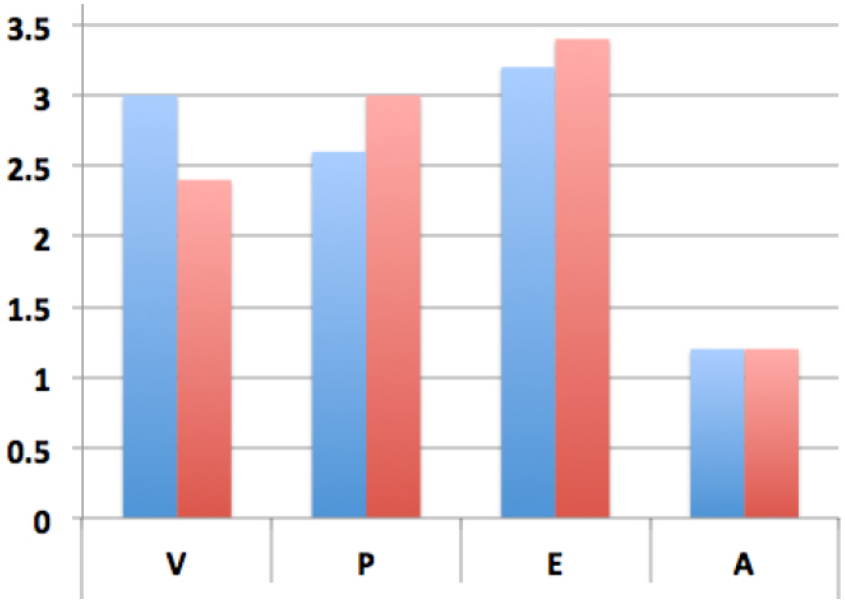


- Two monitors on Remote User side
  - Scene + Emotion Display

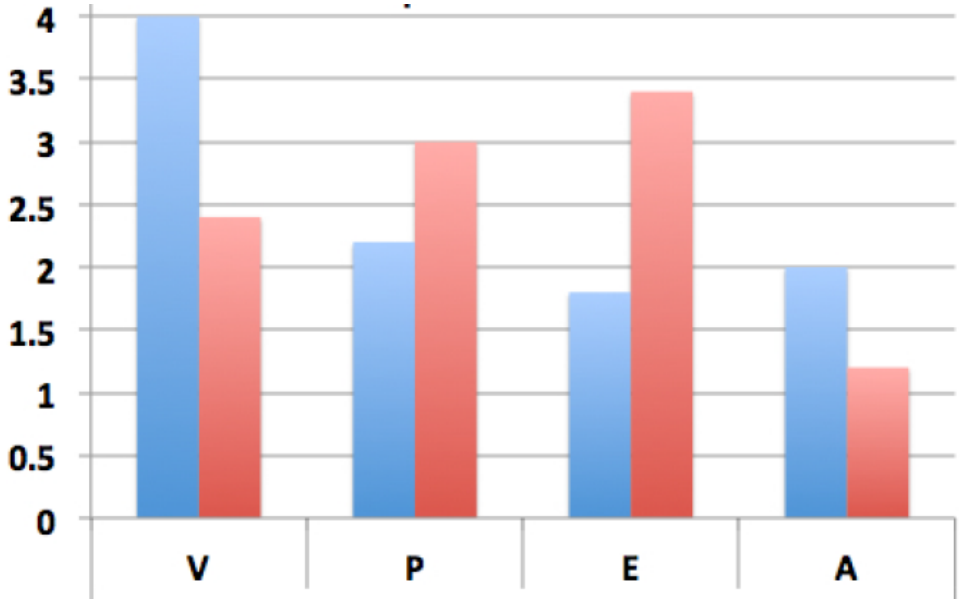
Empathy Glasses Demo

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

Ranking Results



Q2: Communication



Q3: Understanding partner

HMD – Local User

Computer – Remote User

"I ranked the (A) condition best, because I could easily point to communicate, and when I needed it I could check the facial expression to make sure I was being understood."

Lessons Learned

- Pointing really helps in remote collaboration
  - Makes remote user feel more connected
- Gaze looks promising
  - Shows context of what person talking about
  - Establish shared understanding/awareness
- Face expression
  - Used as an implicit cue to show comprehension
- Limitations
  - Limited implicit cues
  - Task was a poor emotional trigger
  - AffectiveWear needs improvement

CONCLUSIONS

AR Applications

- Current applications mostly gaming and marketing
- Application types ideal for AR
  - Involve 3D spatial data
  - Require physical interaction
  - Involve connection between real and digital worlds
  - Emphasis on Intelligence Amplification
- Promising Areas for future applications
  - Visualization
  - Conferencing
  - Empathic Computing

www.empathiccomputing.org

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