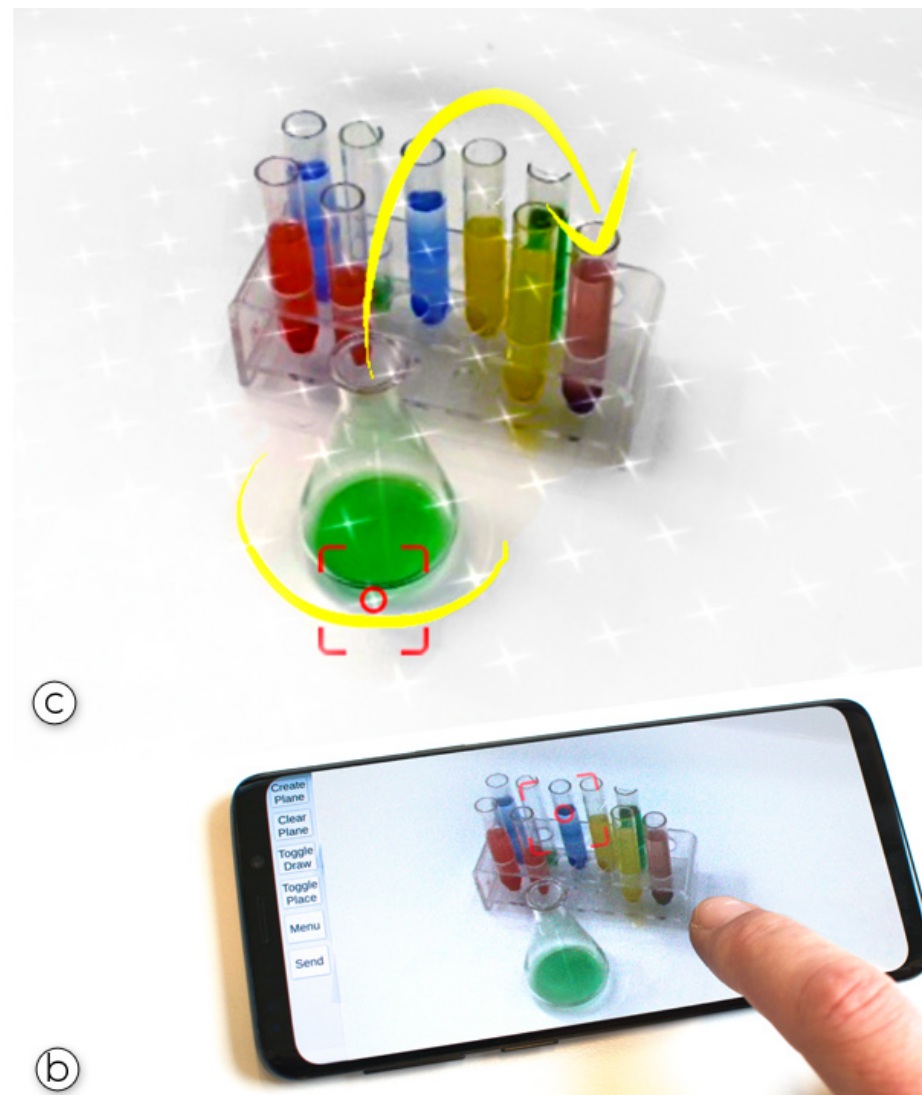
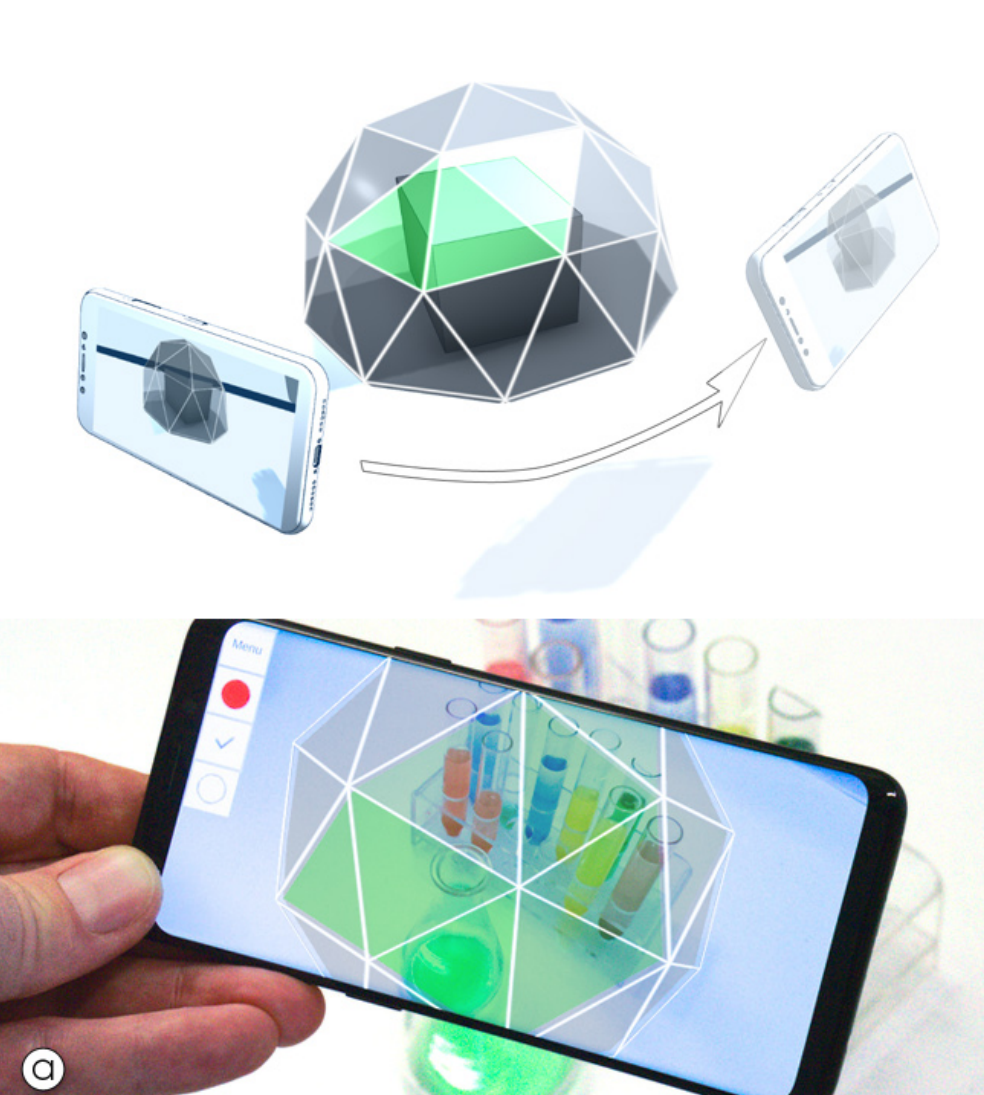
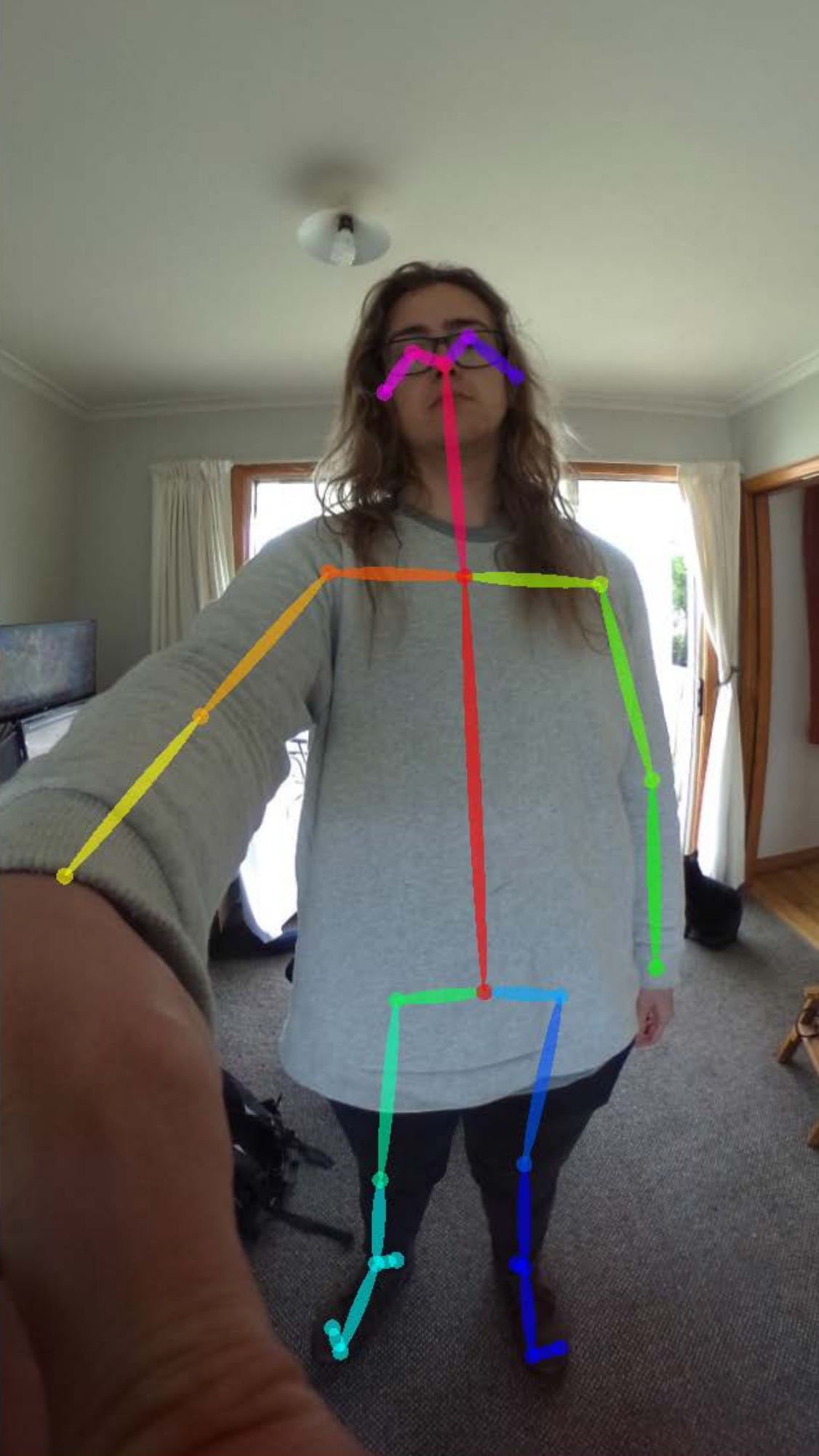
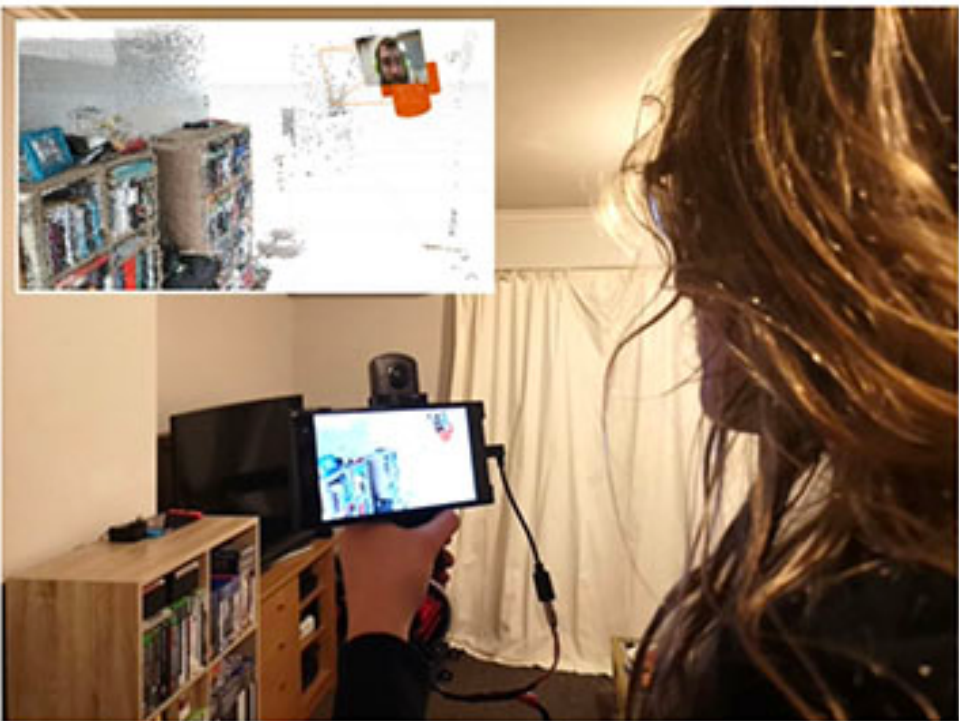


ARIVE

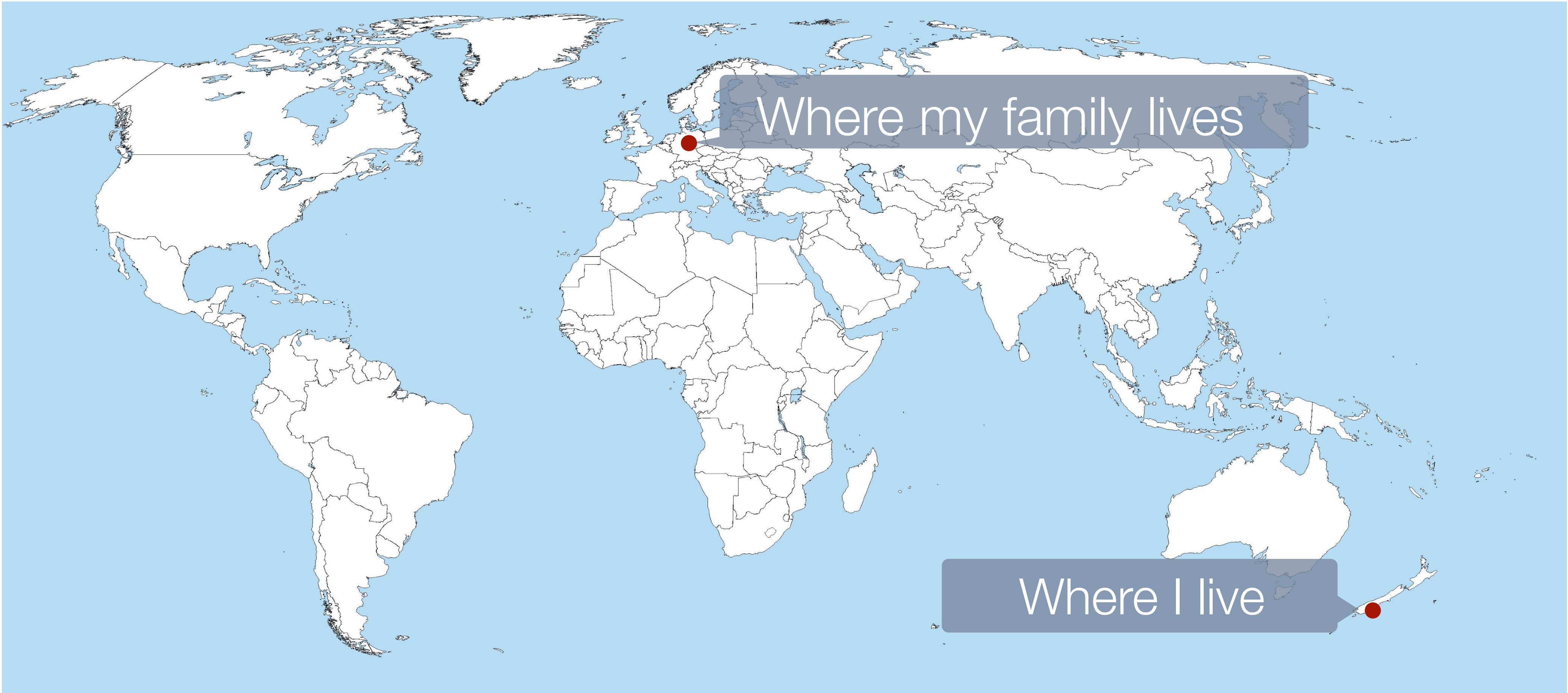


Mobileportation: Nomadic Telepresence for Mobile Devices

1

tobias langlotz, jacob young, matthew cook, jörg müller, holger regenbrecht, denis kalkofen, peter mahr

How it started...

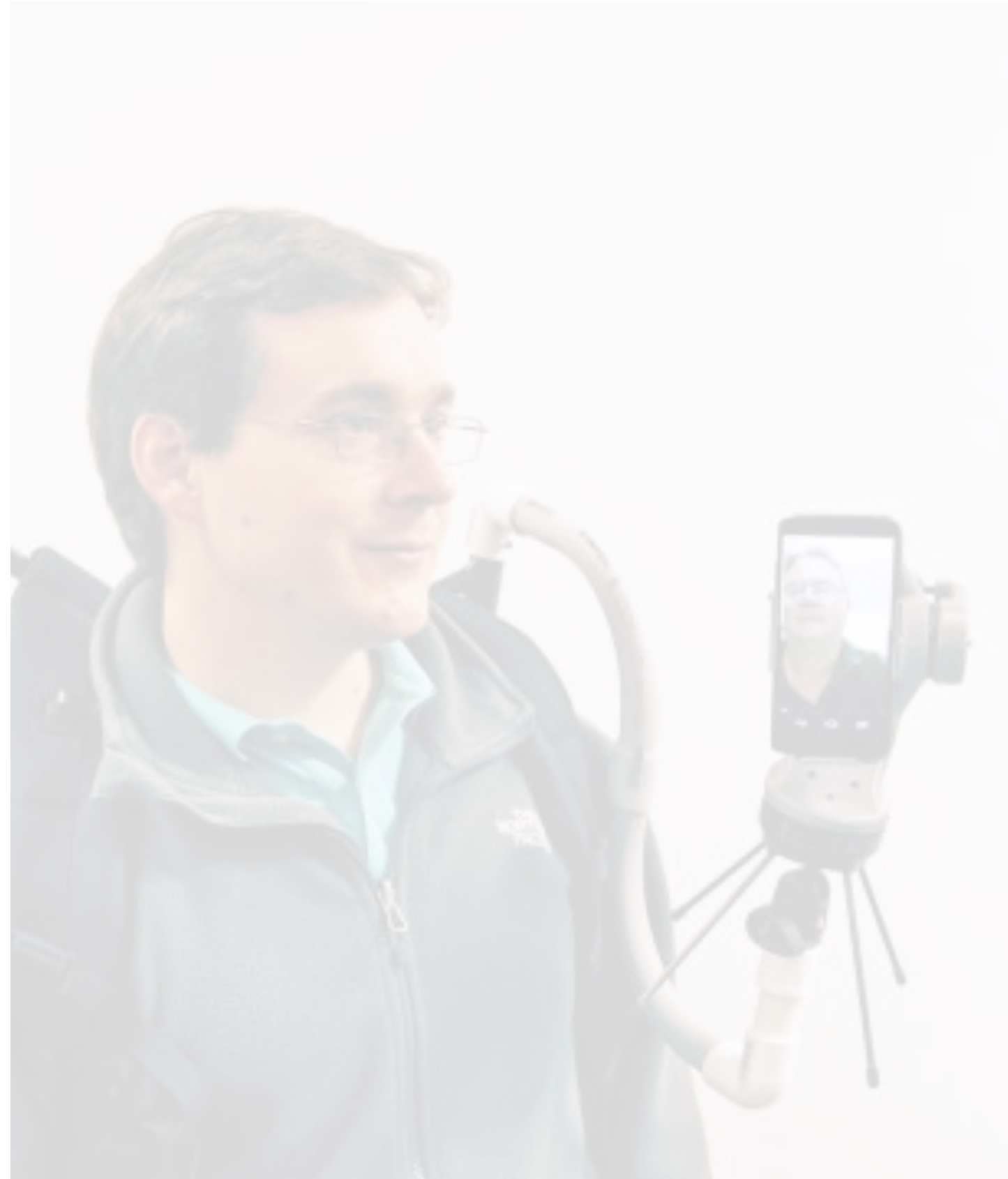




Skype & Facetime on mobiles



The iRobot Ava R 500 video collaboration robot



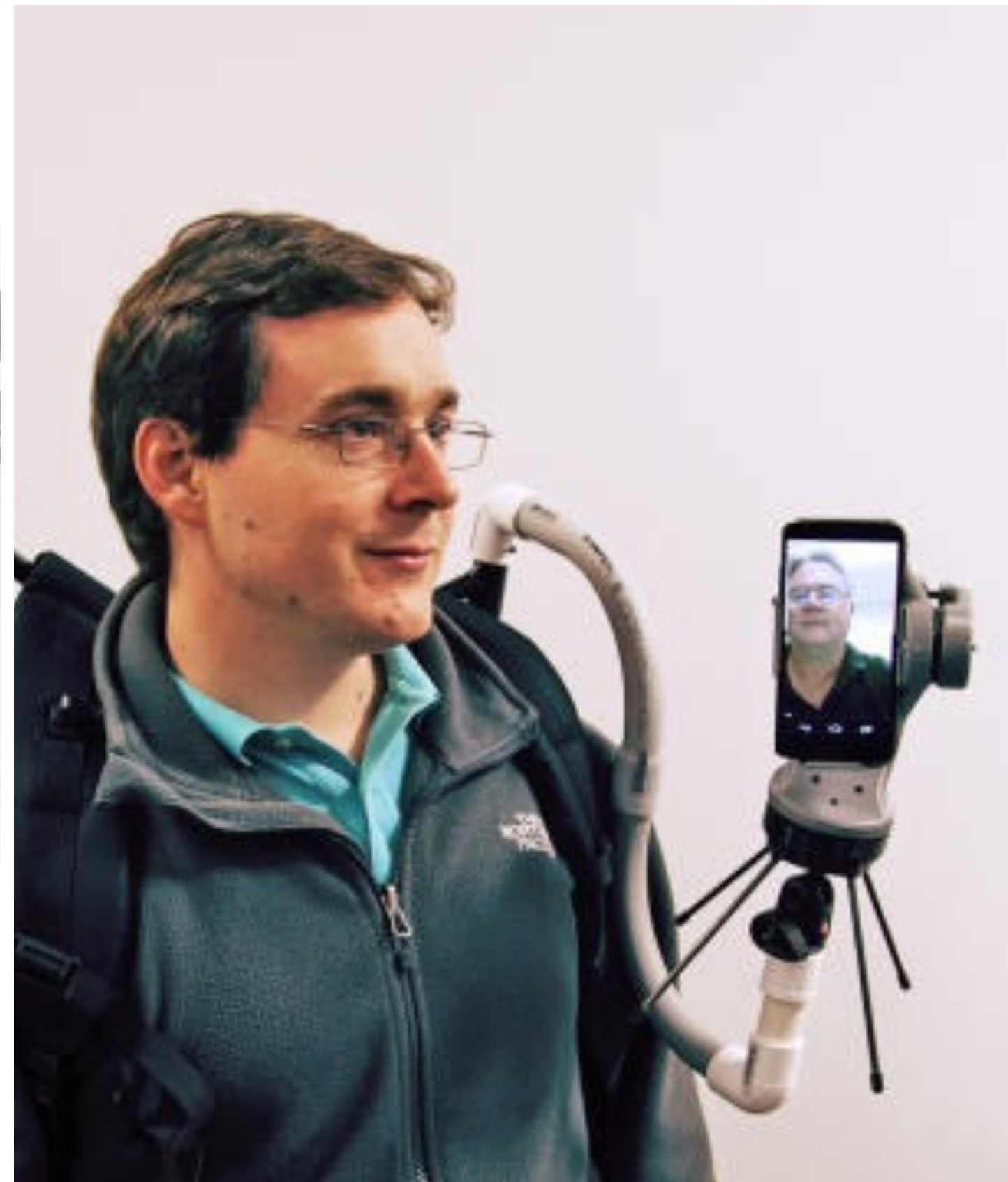
S. Kratz et al. "Polly," Proceedings of ACM MobileHCI '14, 2014, pp. 625–630.



H. Jo and S. Hwang, "Chili," in CHI '13 Extended Abstracts



The iRobot Ava R 500 video collaboration robot



S. Kratz et al. "Polly," Proceedings of ACM MobileHCI '14, 2014, pp. 625–630.



H. Jo and S. Hwang, "Chili," in CHI '13 Extended Abstracts



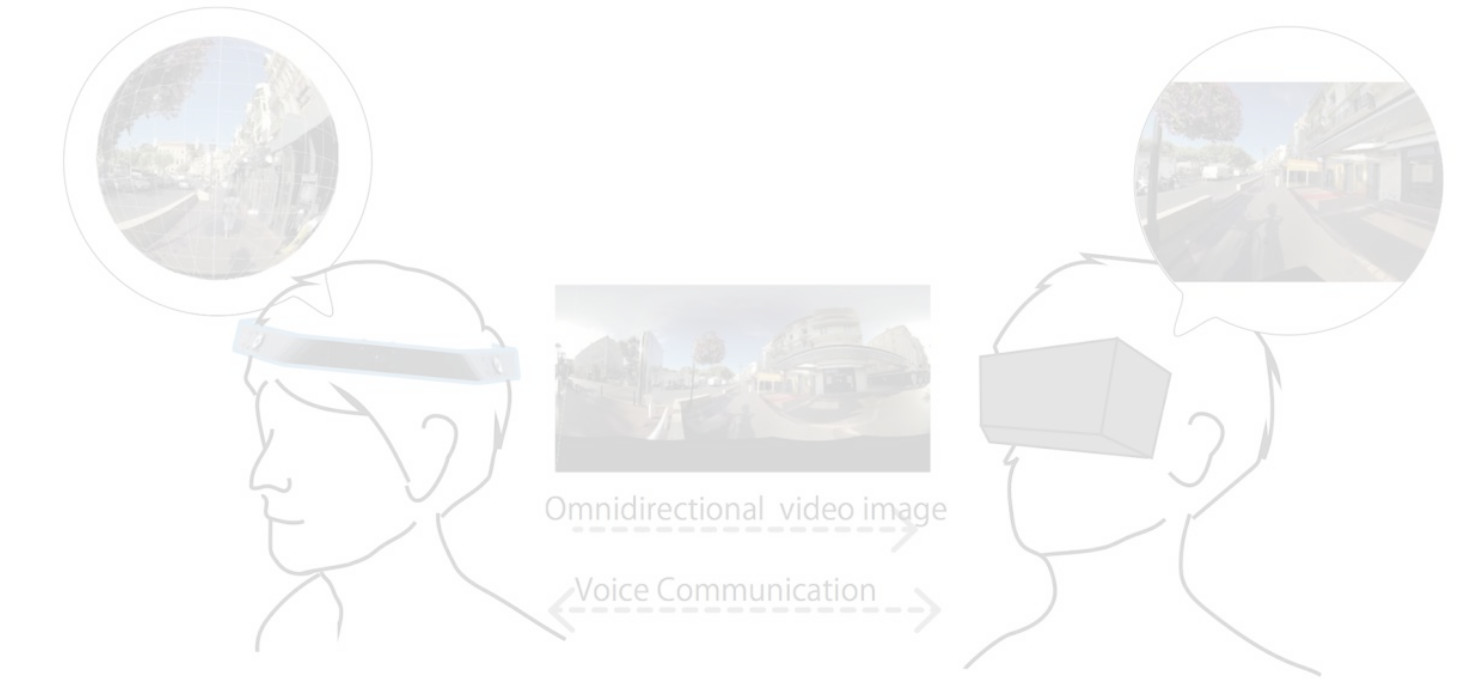
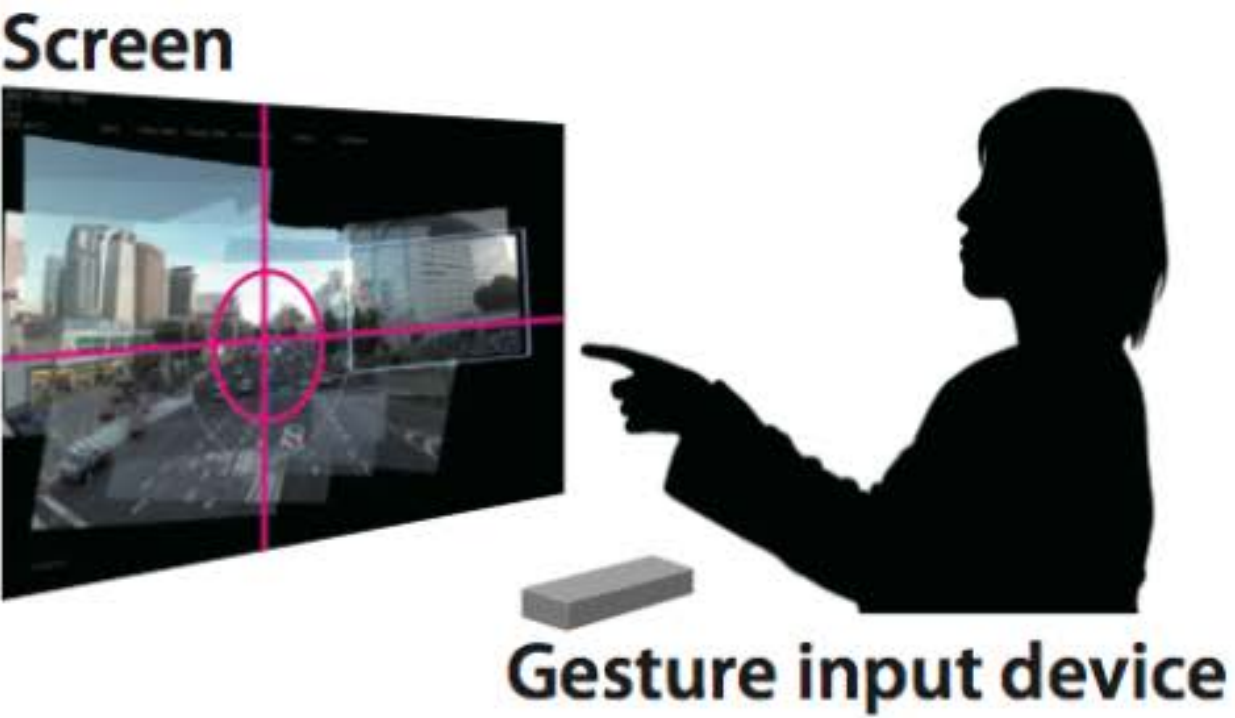
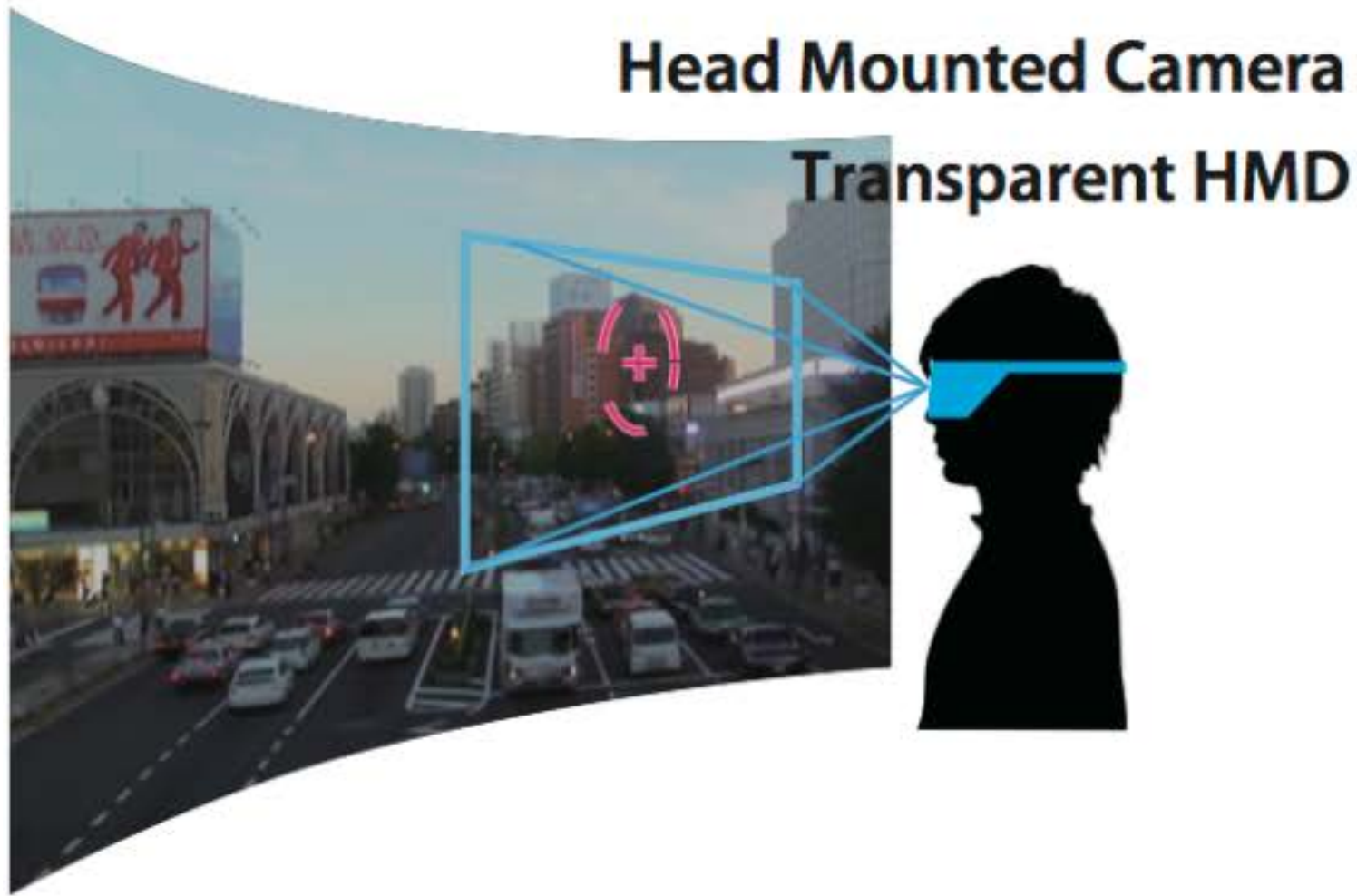
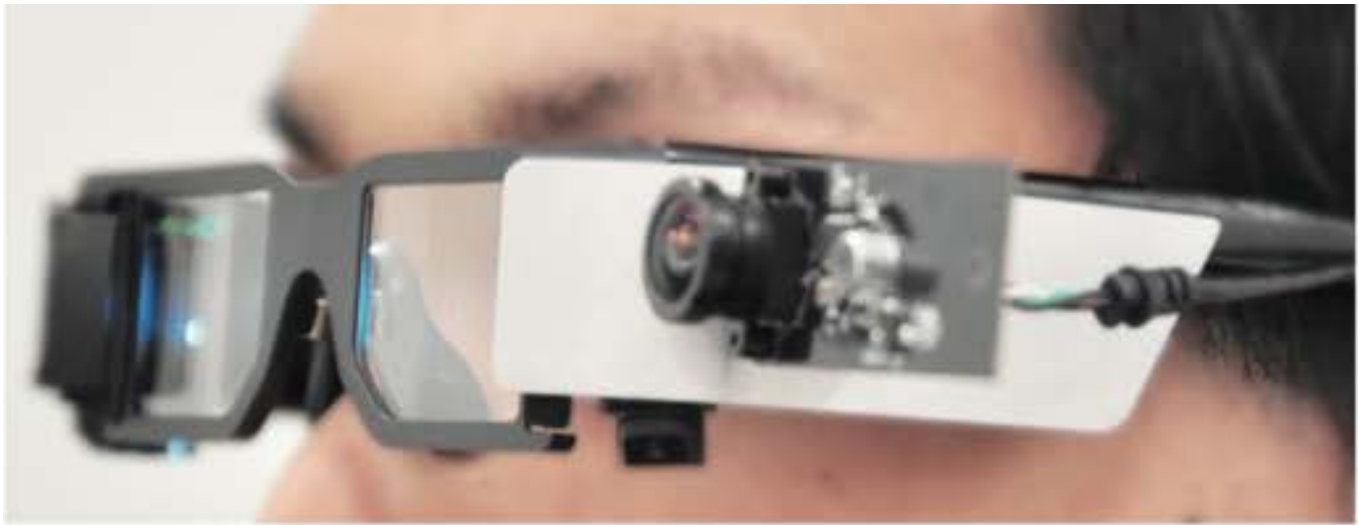
The iRobot Ava R 500 video collaboration robot



S. Kratz et al. “Polly,” Proceedings of ACM MobileHCI ’14, 2014, pp. 625–630.



H. Jo and S. Hwang, “Chili,” in CHI ’13 Extended Abstracts



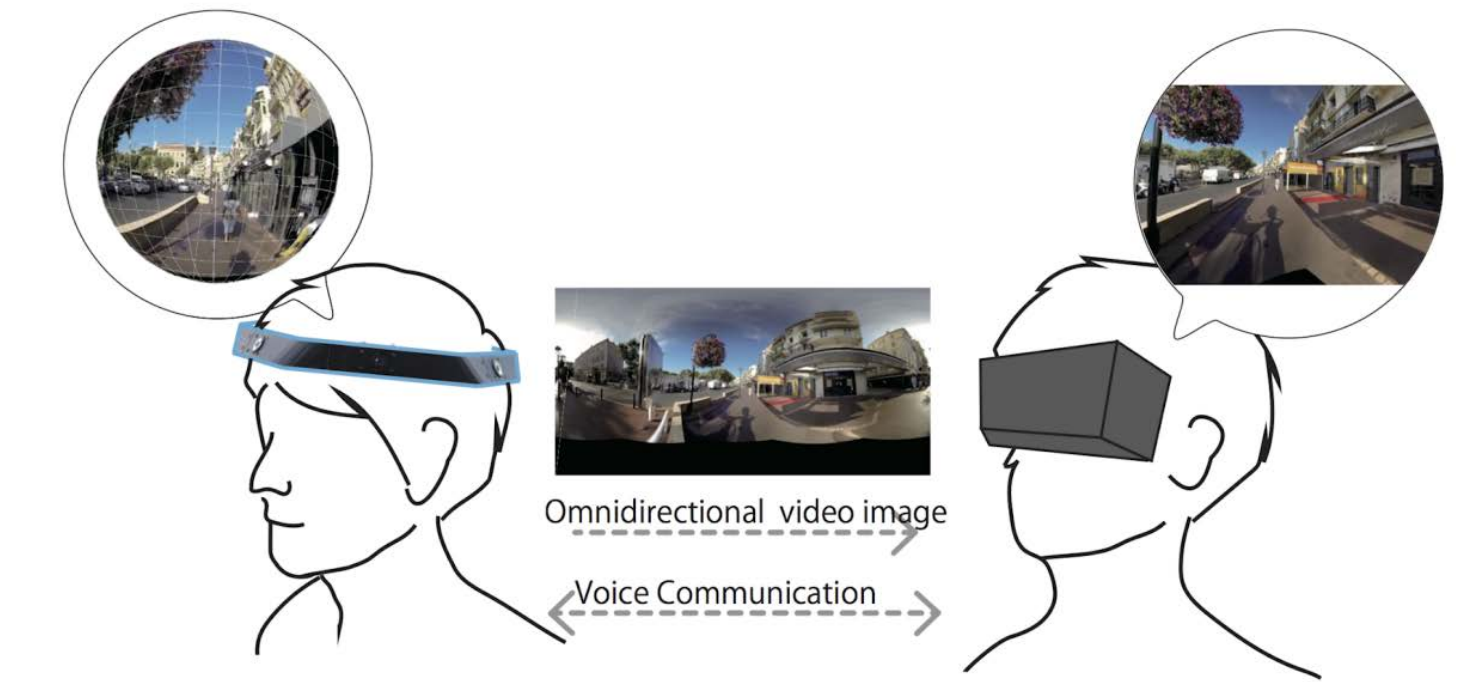
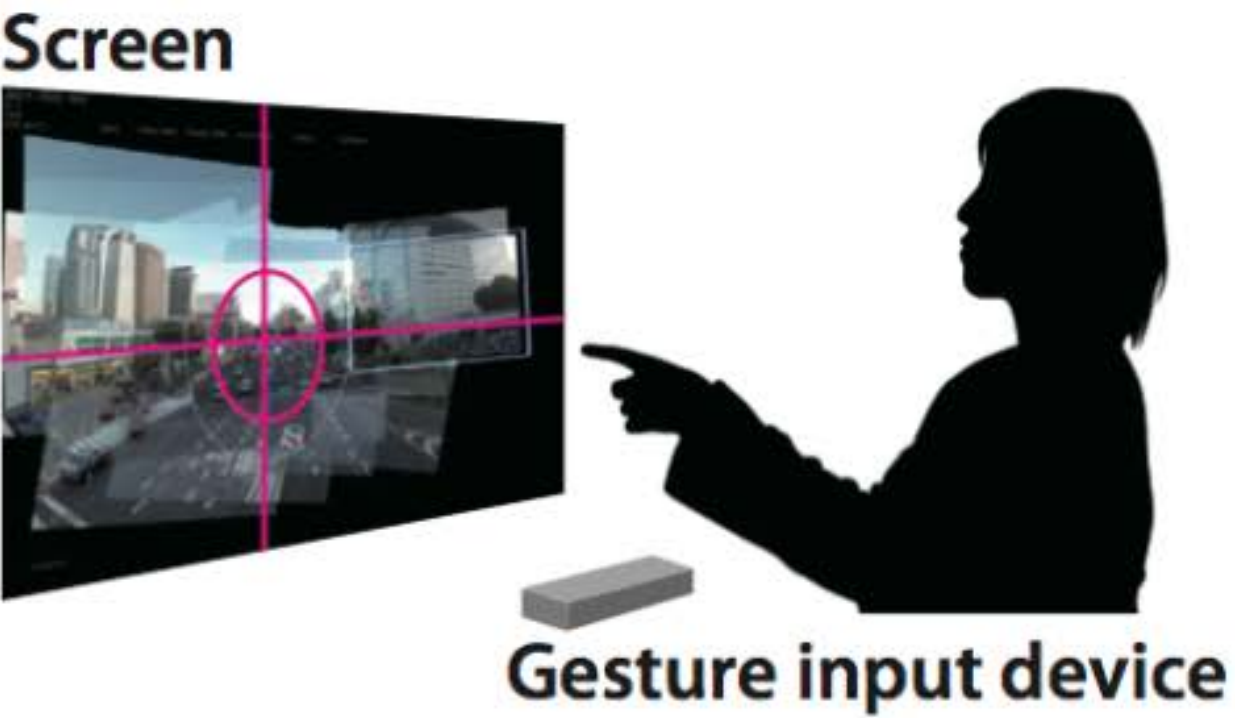
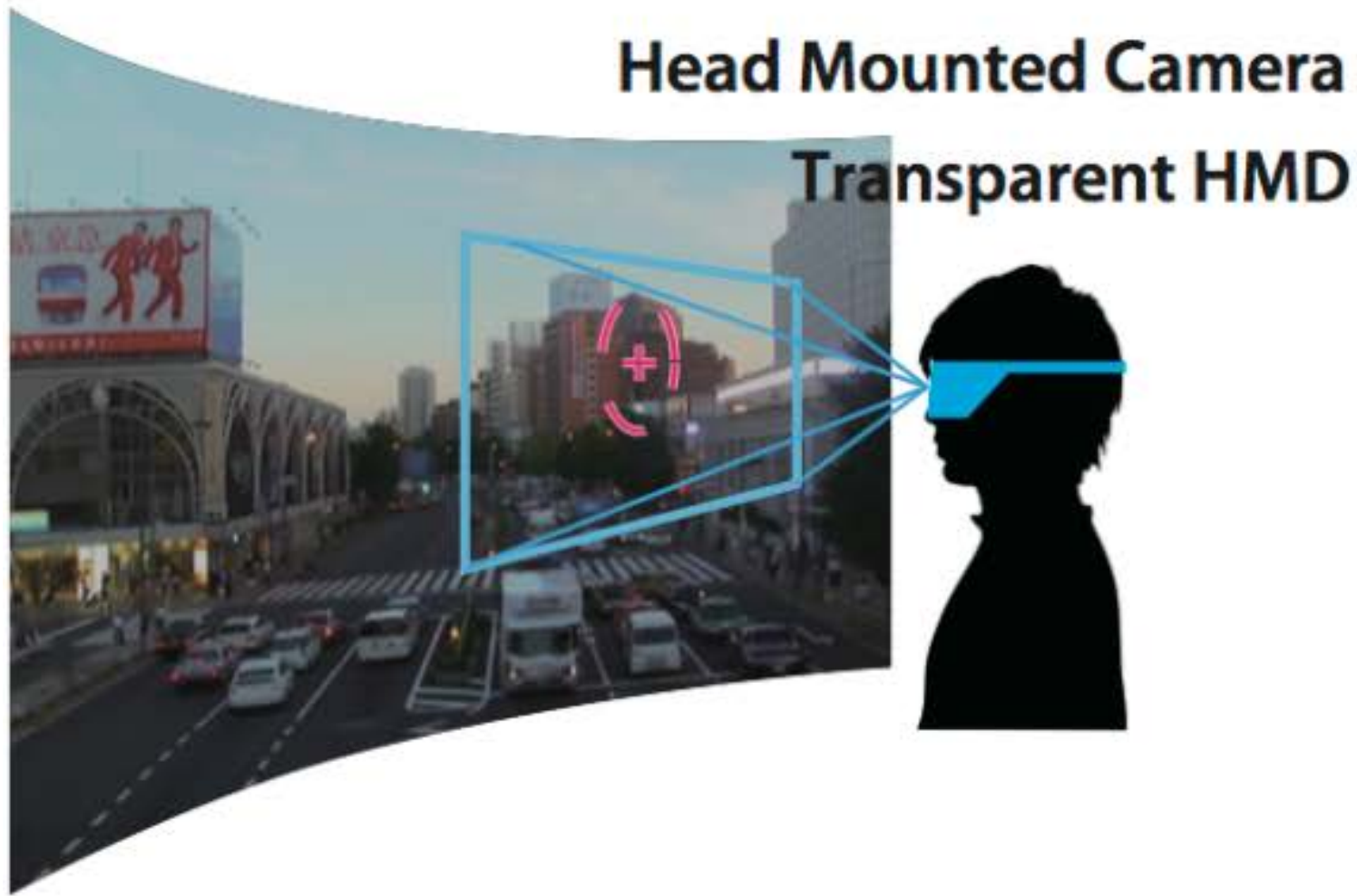
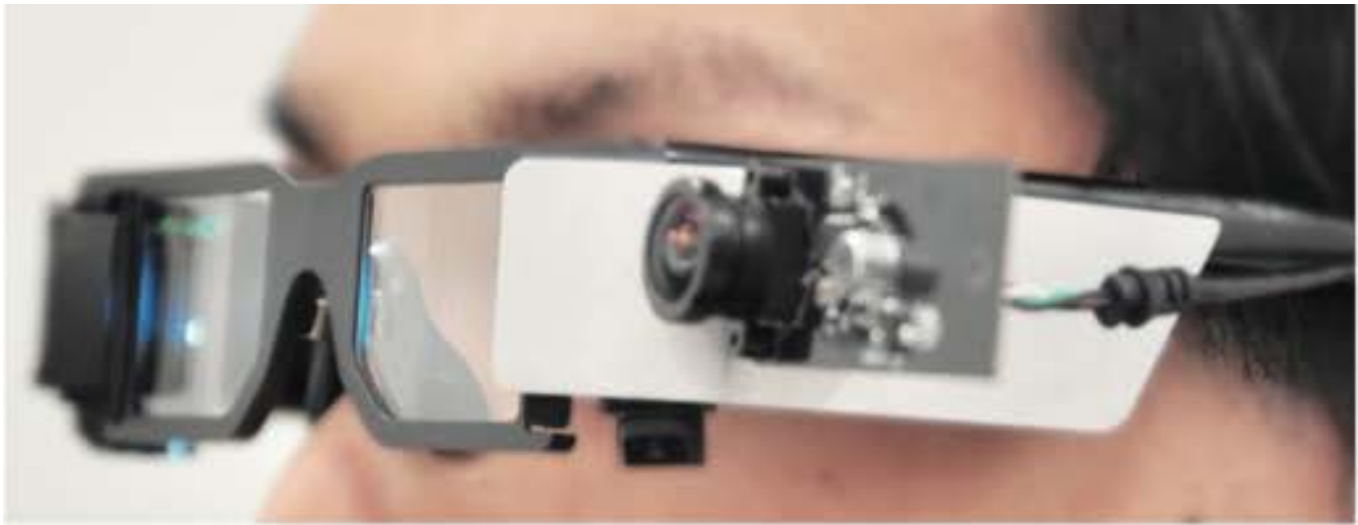
Local user/Body

Remote user/Ghost

Local user/Body Remote user/Ghost

S. Kasahara and J. Rekimoto, JackIn: Integrating First-Person View with Out-of-Body Vision Generation for Human-Human Augmentation, Augmented Human 2014

S. Nagai, S. Kasahara, J. Rekimoto, LiveSphere: Sharing the Surrounding Visual Environment for Immersive Experience in Remote Collaboration, TEI 2015



Local user/Body

Remote user/Ghost

Local user/Body Remote user/Ghost

S. Kasahara and J. Rekimoto, JackIn: Integrating First-Person View with Out-of-Body Vision Generation for Human-Human Augmentation, Augmented Human 2014

S. Nagai, S. Kasahara, J. Rekimoto, LiveSphere: Sharing the Surrounding Visual Environment for Immersive Experience in Remote Collaboration, TEI 2015



Google Jump



Samsung Project
Beyond



LG 360 camera



The iRobot Ava R 500 video collaboration robot



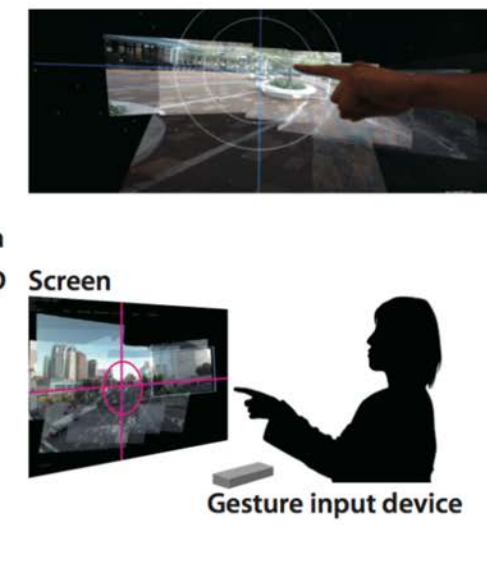
S. Kratz et al. "Polly," Proceedings of ACM MobileHCI '14, 2014, pp. 625–630.



H. Jo and S. Hwang, "Chili," in CHI '13 Extended Abstracts on Human Factors in Computing Systems



Body User



Ghost User



Body User

Ghost User



Google Jump



Samsung Project Beyond

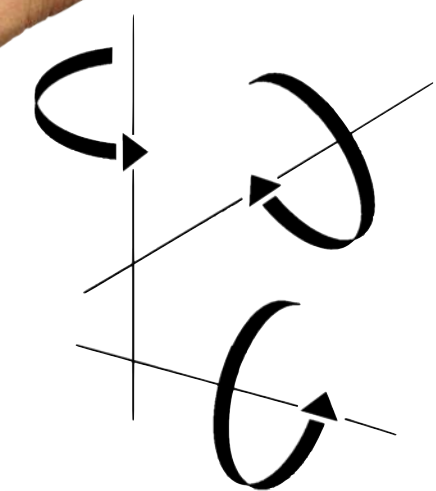
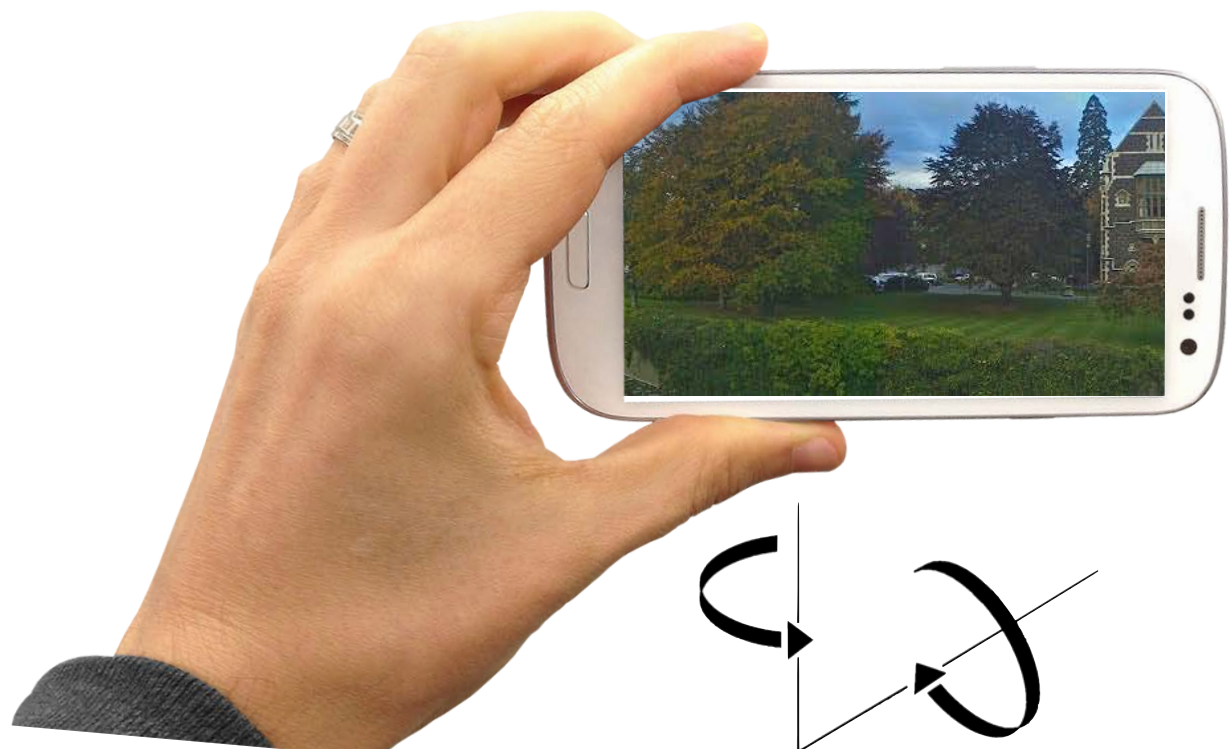


LG 360 camera

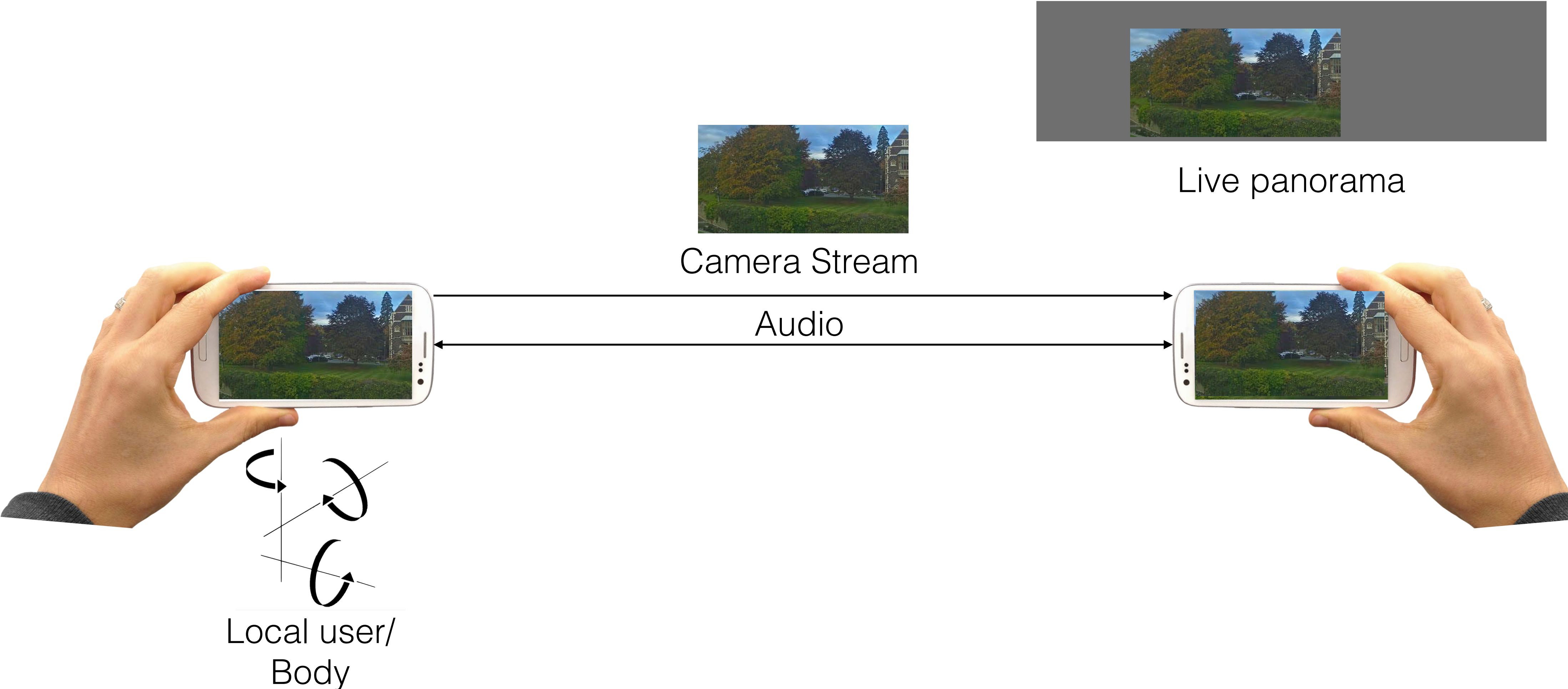
• Summary

- Not fully mobile (mobile to desktop, robot to desktop, wearable to desktop)
- Asymmetric (can't switch roles)
- Custom hardware required

Panorama-based Mobile Telepresence



Local user/
Body

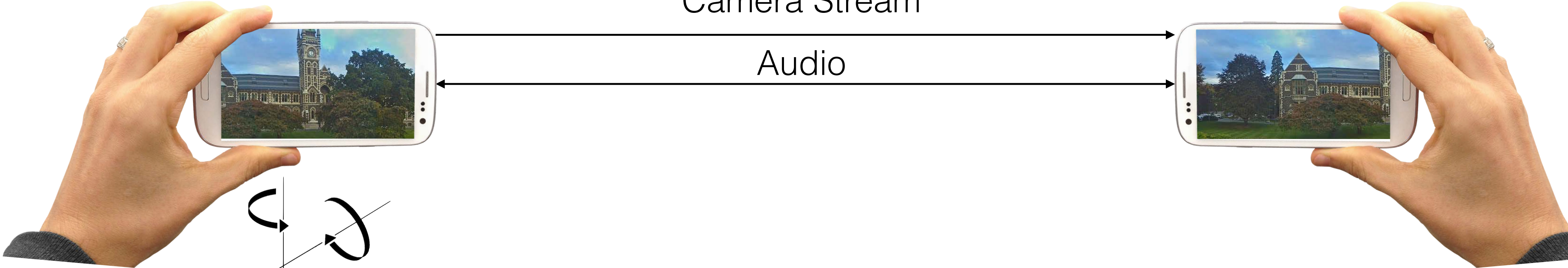




Live panorama



Camera Stream



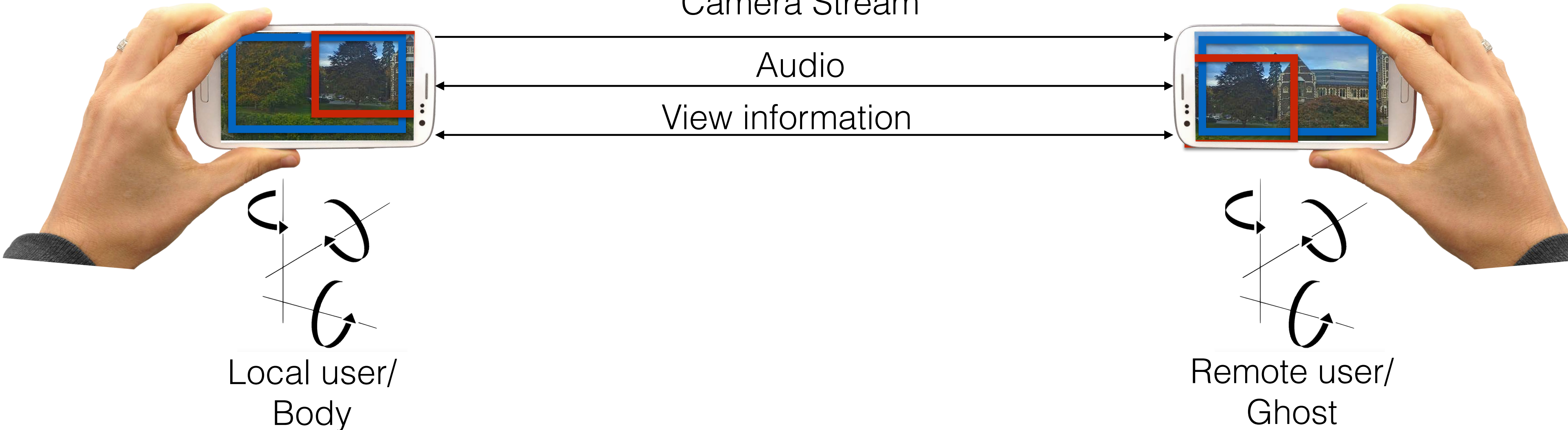
Local user/
Body

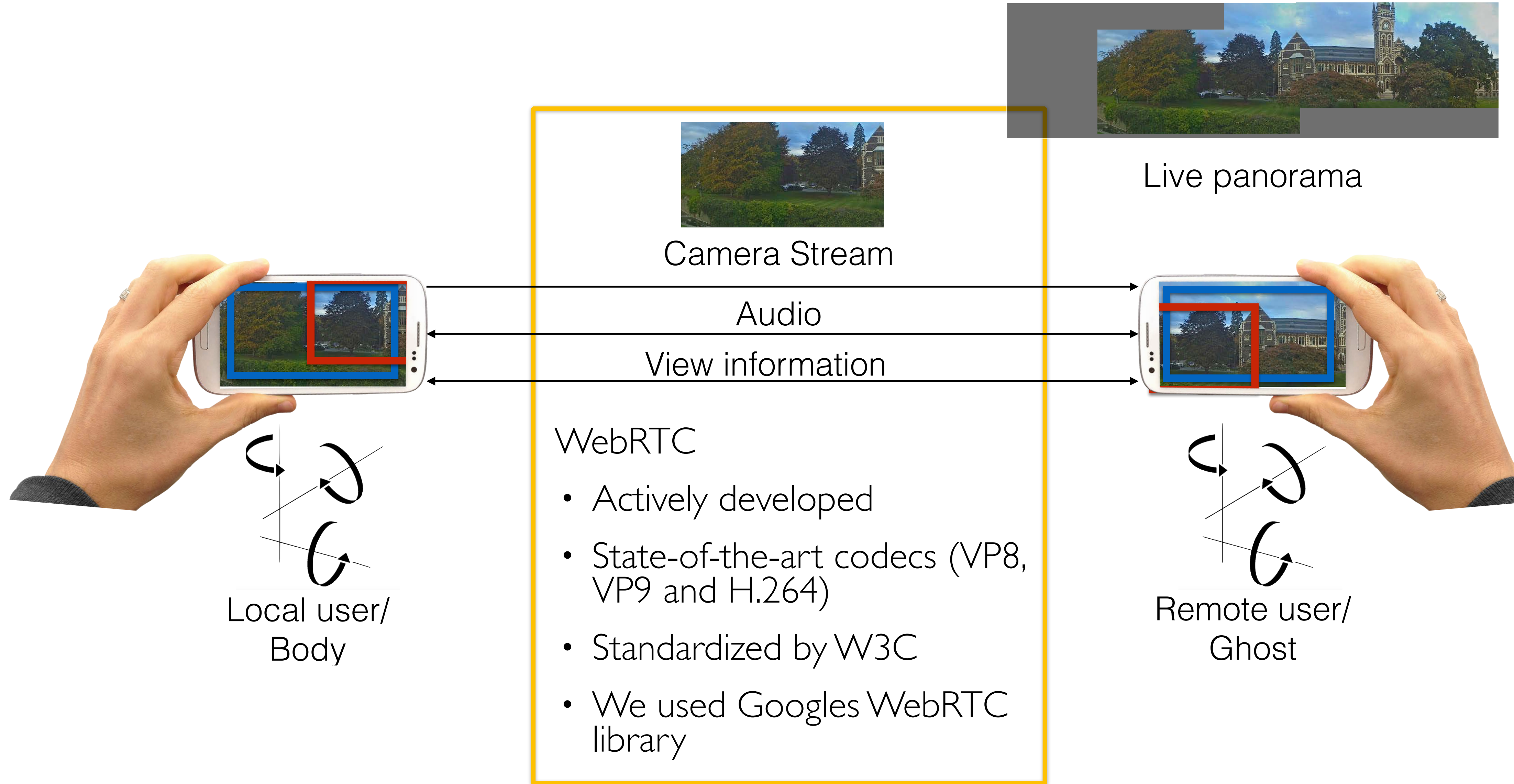


Camera Stream



Live panorama





ARIVE



Jörg Müller, Tobias Langlotz, Holger Regenbrecht (2017) "*PanoVC: Pervasive Telepresence using Mobile Phones*"
IEEE Pervasive Computing and Communications (IEEE PerCom)



Jörg Müller, Tobias Langlotz, Holger Regenbrecht (2017) “*PanoVC: Pervasive Telepresence using Mobile Phones*”
IEEE Pervasive Computing and Communications (IEEE PerCom)

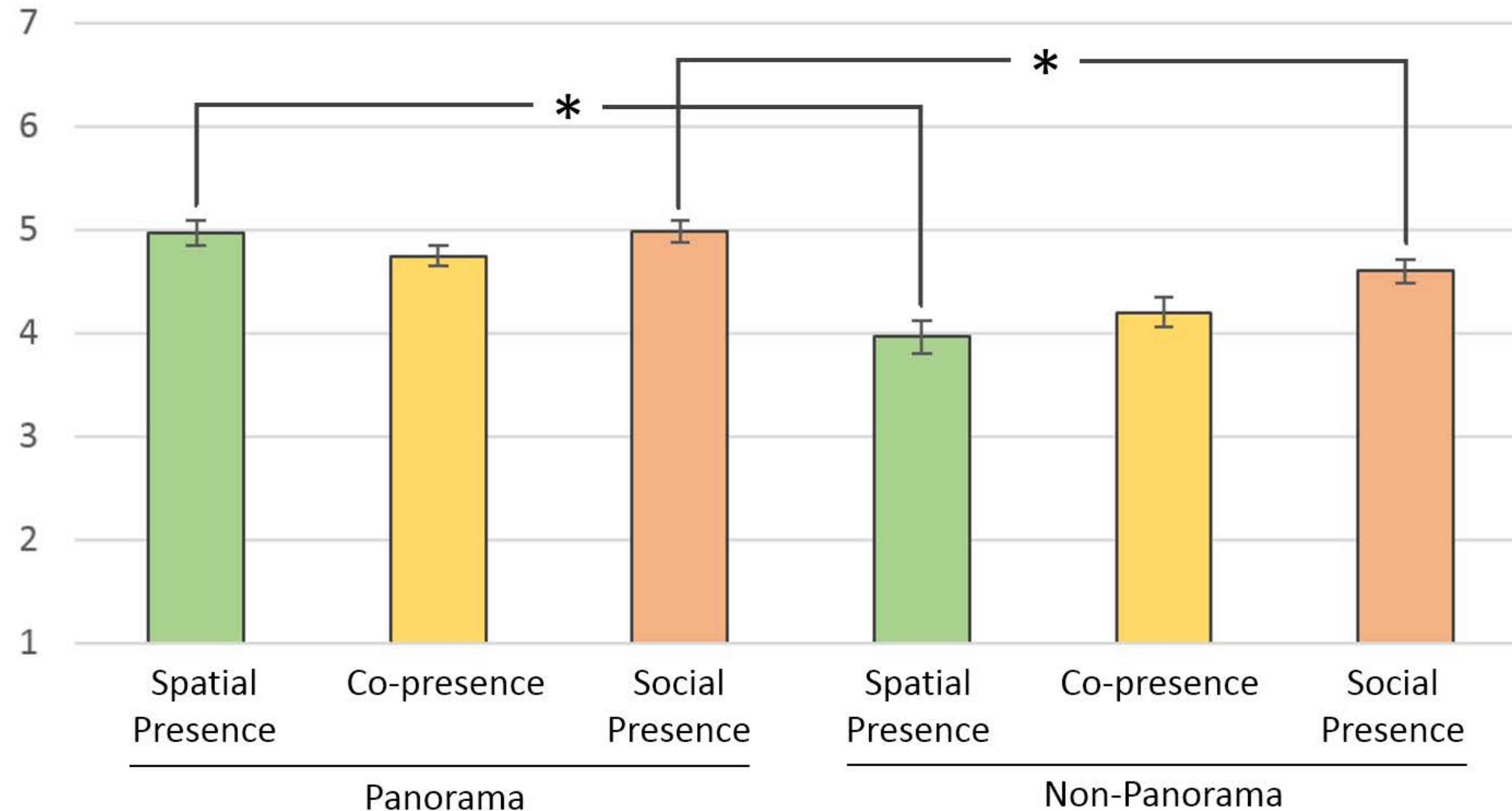


Jörg Müller, Tobias Langlotz, Holger Regenbrecht (2017) "*PanoVC: Pervasive Telepresence using Mobile Phones*"
IEEE Pervasive Computing and Communications (IEEE PerCom)

- Latency:
 - Communication latency (only transmitting the image)
 - 400-500ms (latency of 300-500ms reported by WebRTC developers)
 - End-to-end latency (Capture frame, transmission, track, map, and display panorama)
 - Min: 470ms and 550ms (Nexus 5 to Nexus 5)
- Overall:
 - Application is interactive in real-time (>30fps)
 - Panorama in a separate thread is nearly interactive in real-time (20-30fps)
 - Latency of ~500ms between the communication partners



- Presence:

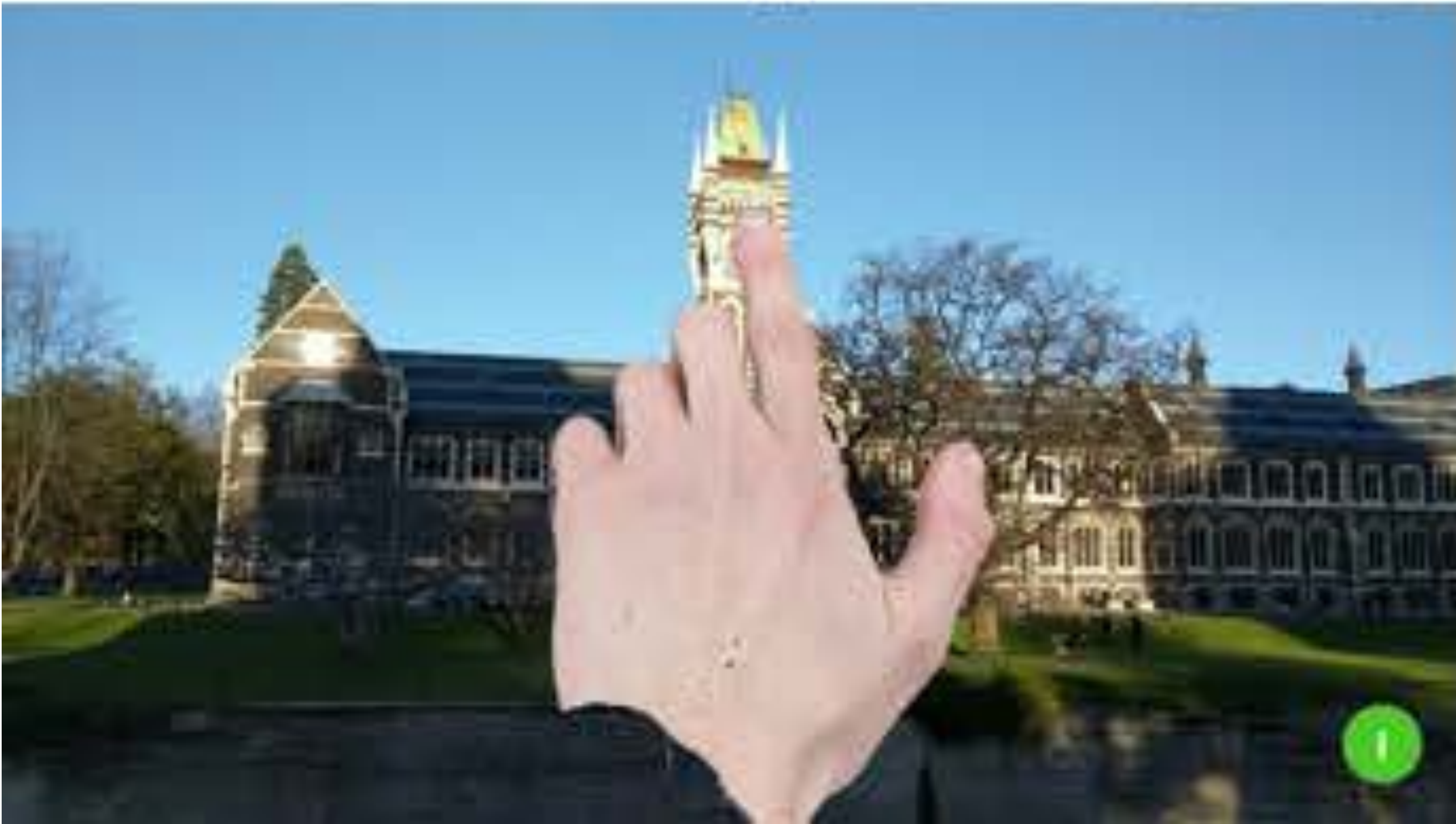


- Significant increase in reported spatial presence and social presence for the remote user / ghost
- Participants significantly preferred PanoVC over the VC mode

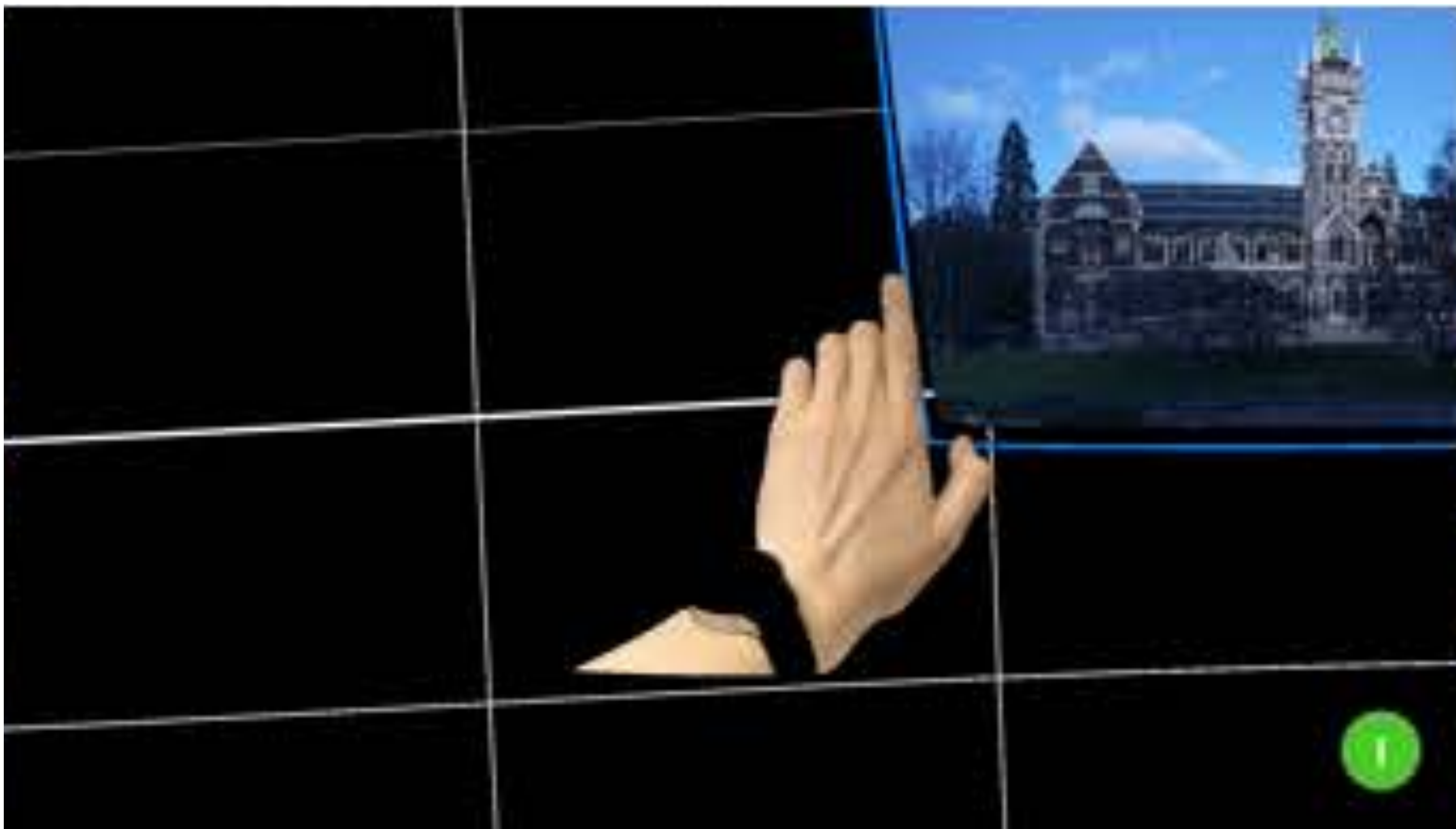
Exploration of Different Panoramic Modes for Mobile Telepresence



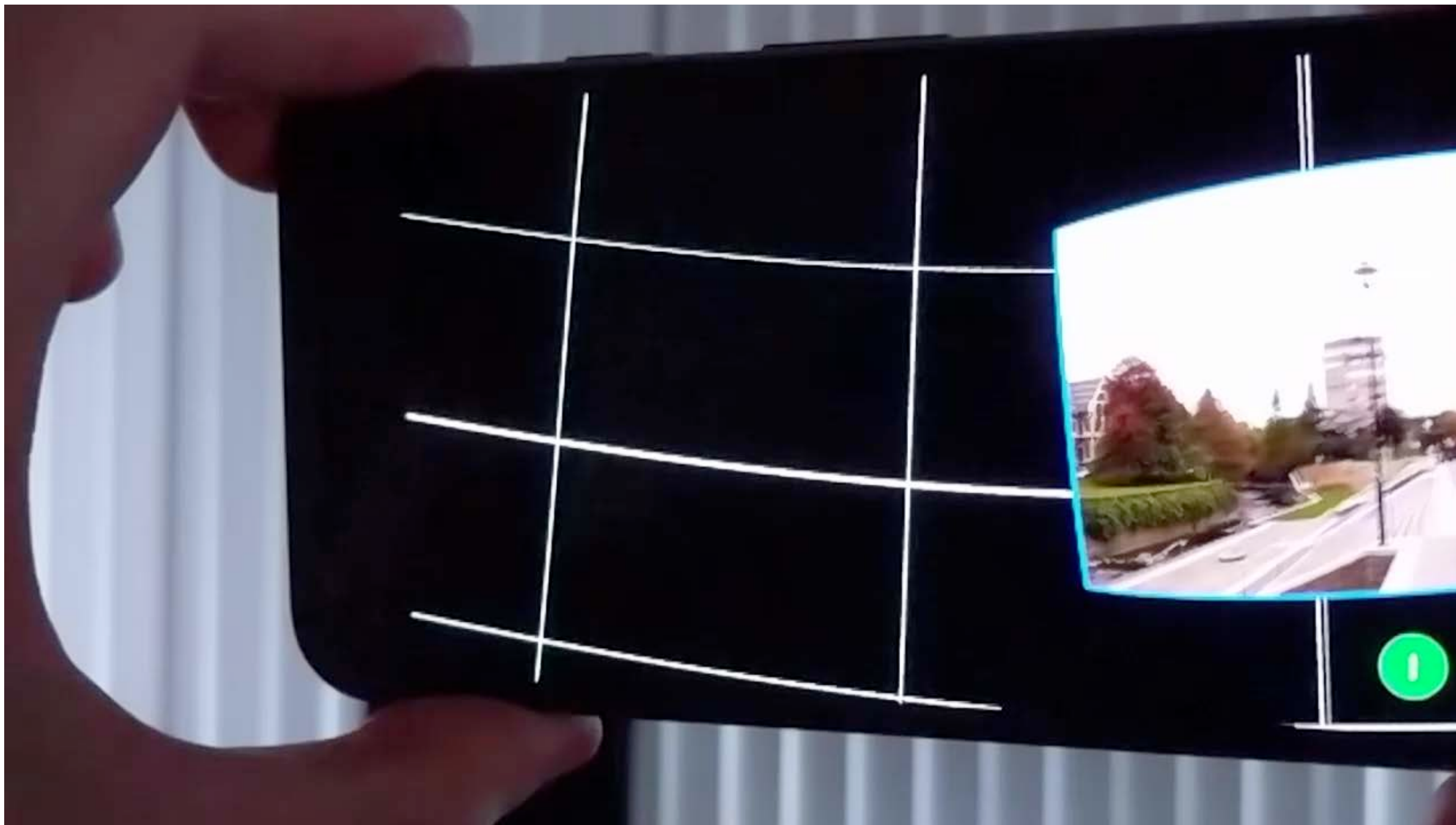




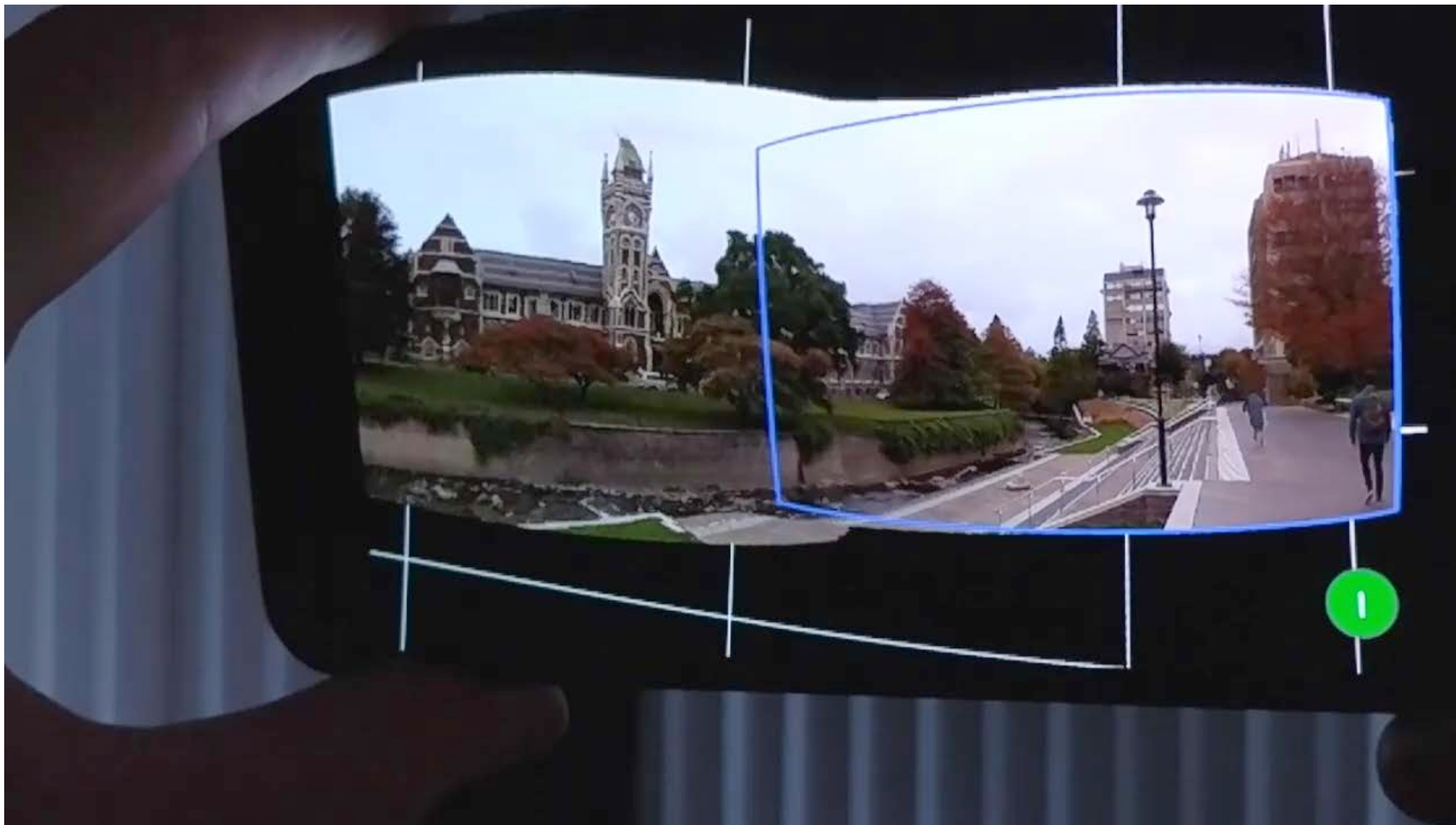
Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee



Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee



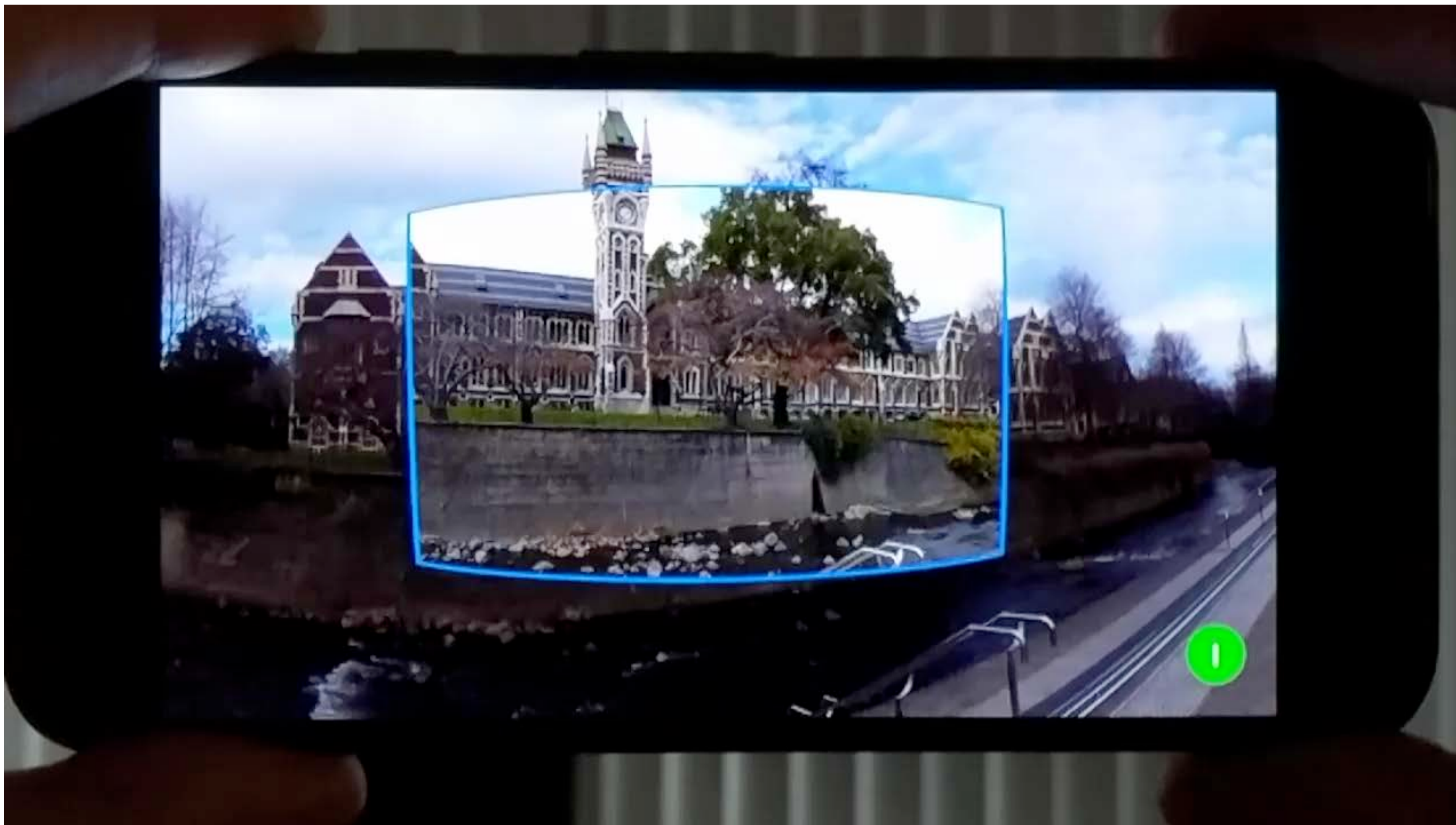
Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee



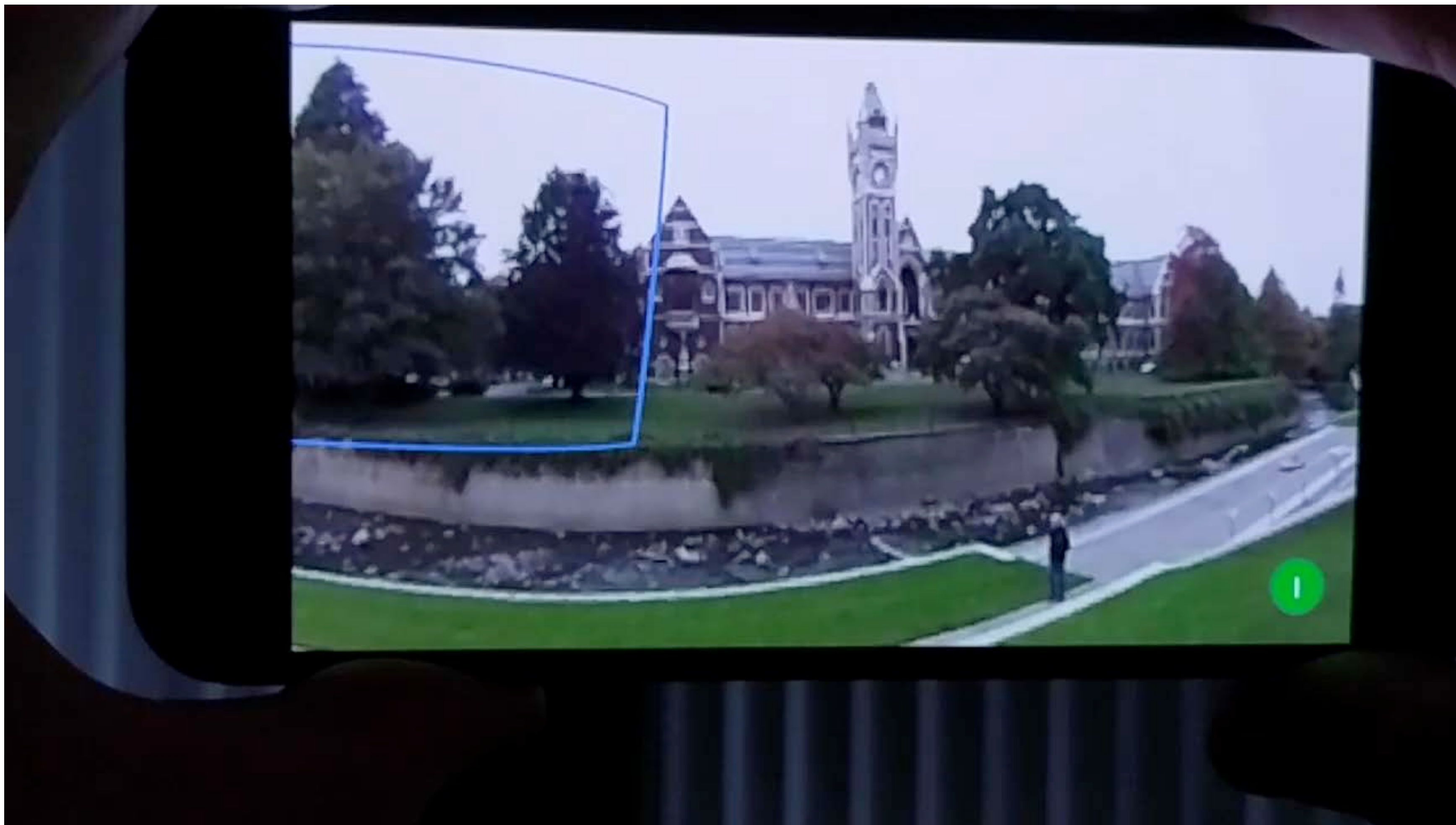
Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee

ARIVE





Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee

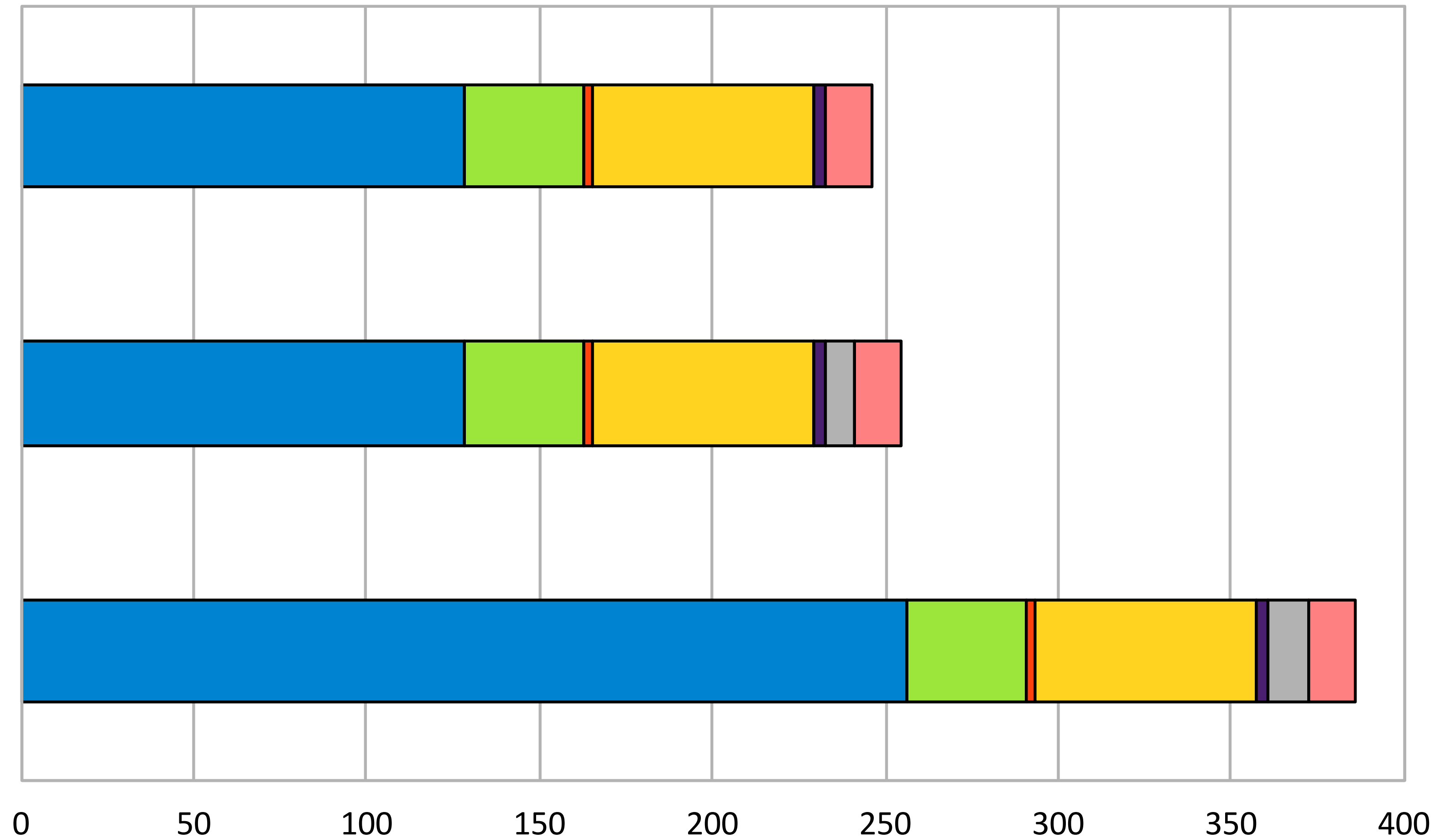


Jacob Young, Tobias Langlotz, Matthew Cook, Steven Mills, Holger Regenbrecht (2019) Immersive Telepresence and Remote Collaboration using Mobile and Wearable Devices IEEE Transactions on Visualisation and Computer Graphics. Best Paper Award Nominee

Live Video Calling,
Live Spatial Video Calling,
Panoramic Calling with
Live Inserts

Incremental Panoramic
Calling

Live Panoramic Video Calling



Time Taken per Operation (ms)

- Capture image
- Hand Segmentation*
- Process image for sending
- Network latency
- Process received image
- Project to Panorama*
- Display in HMD

Integrating 3D and Panoramic Mobile Telepresence





Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.



Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.

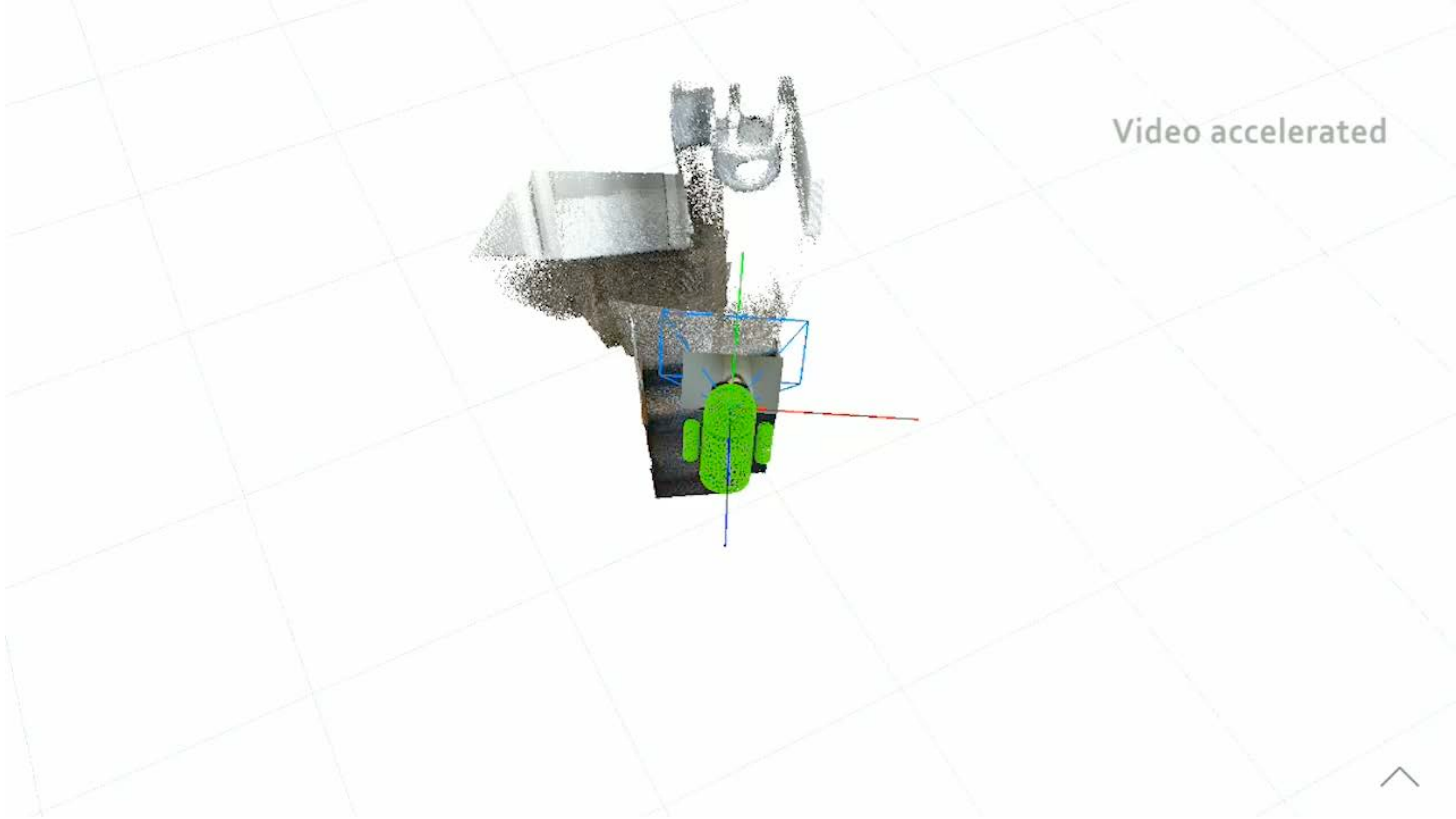




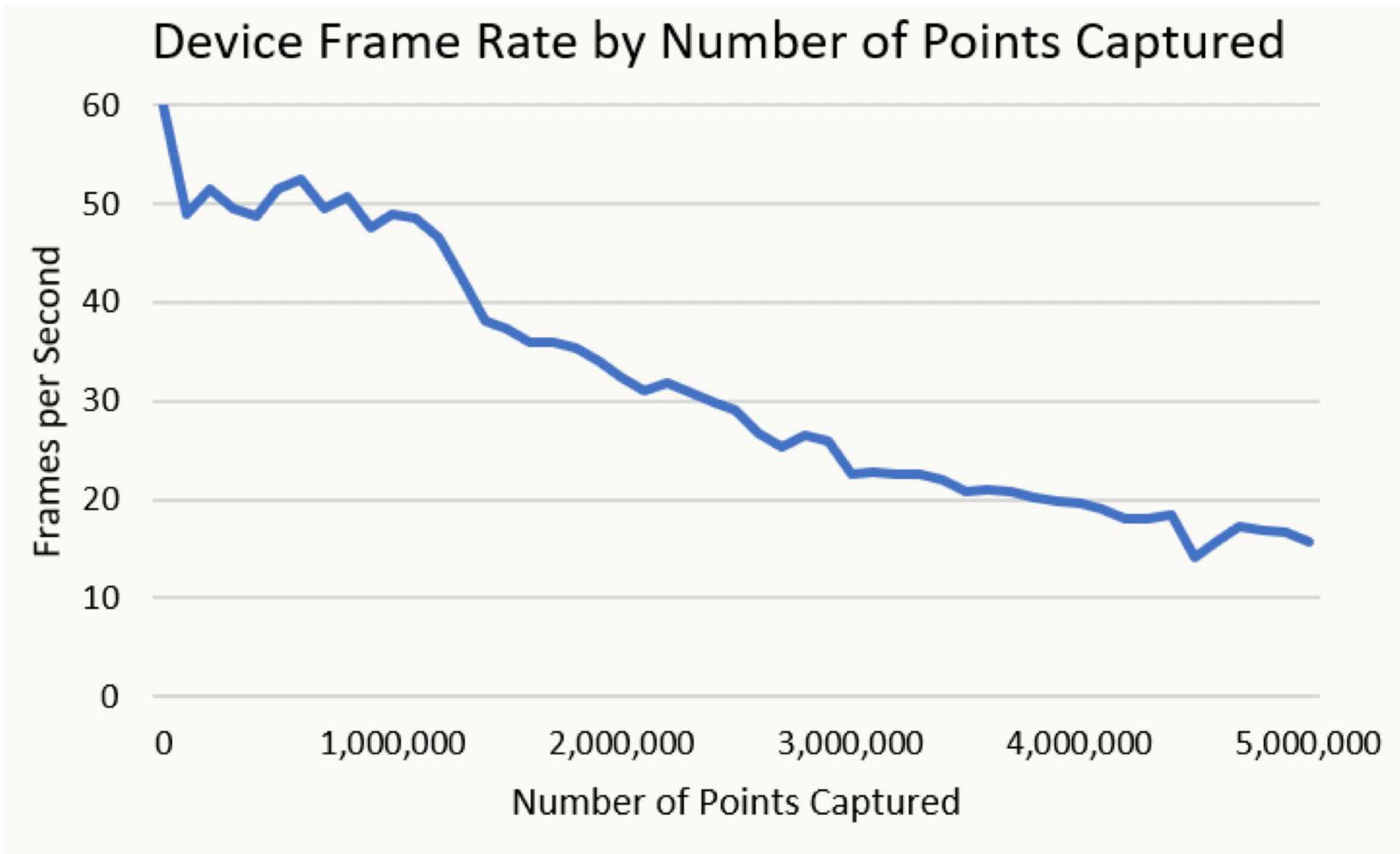
Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.



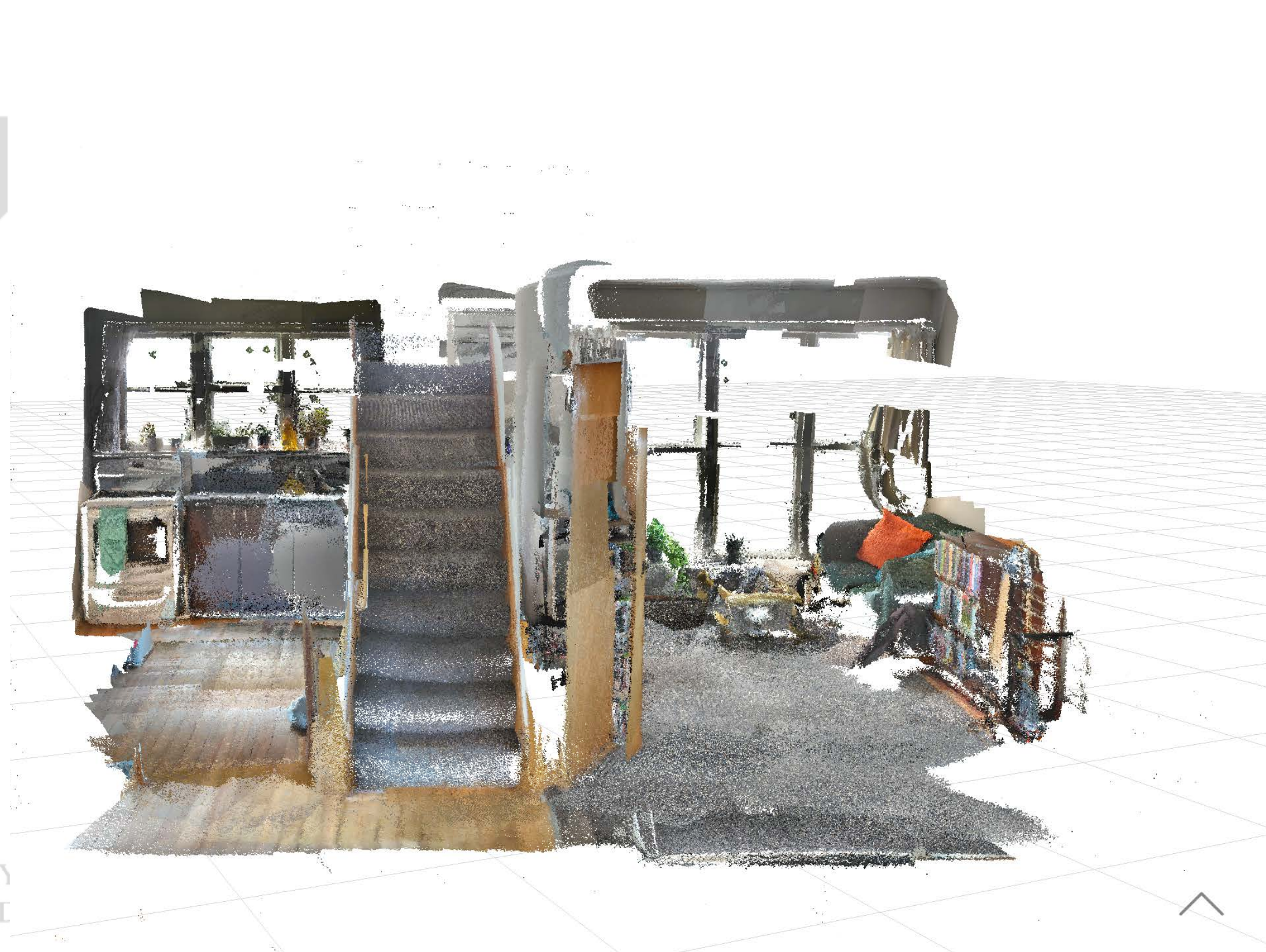
Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.



Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.

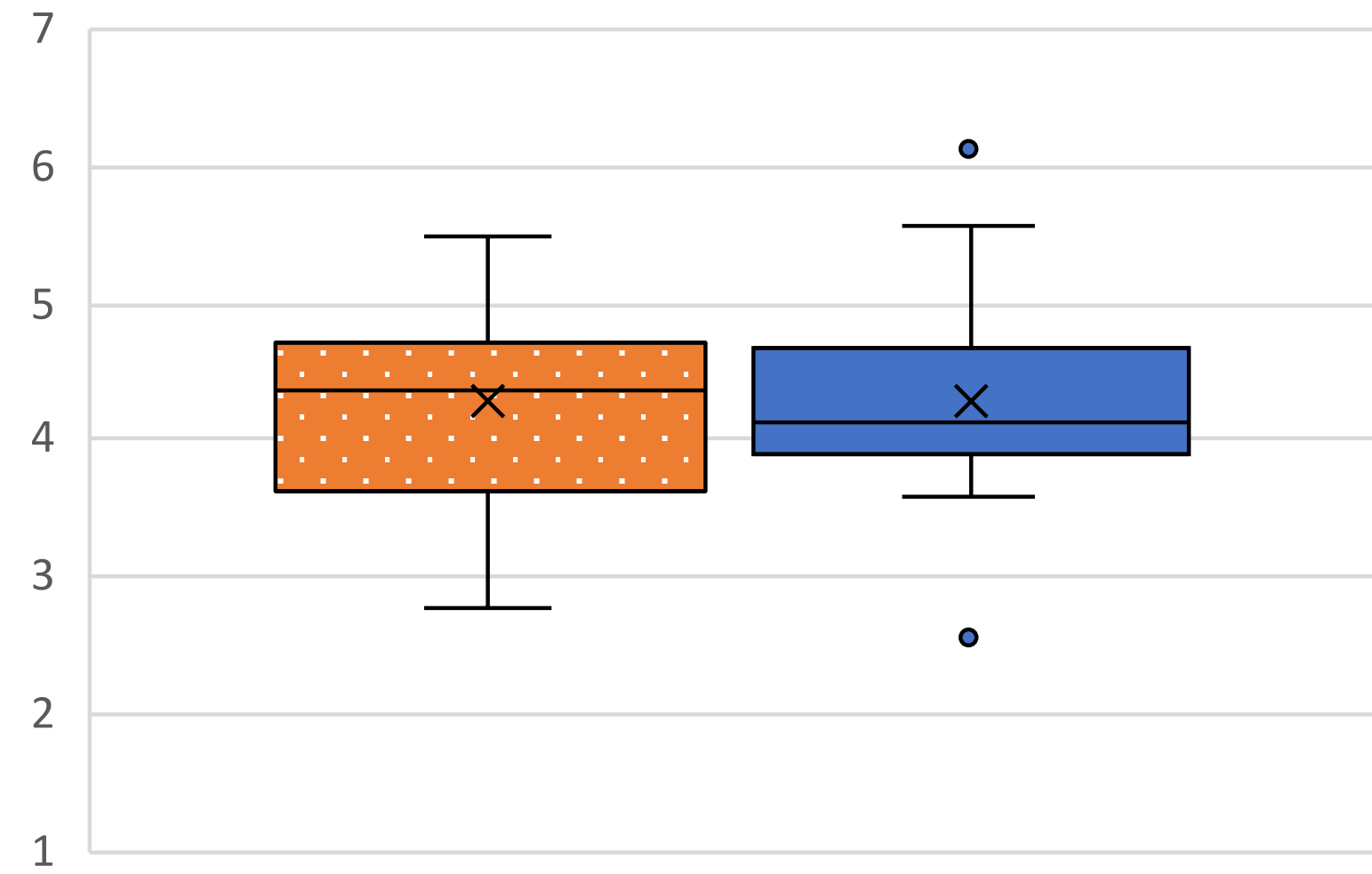


Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.

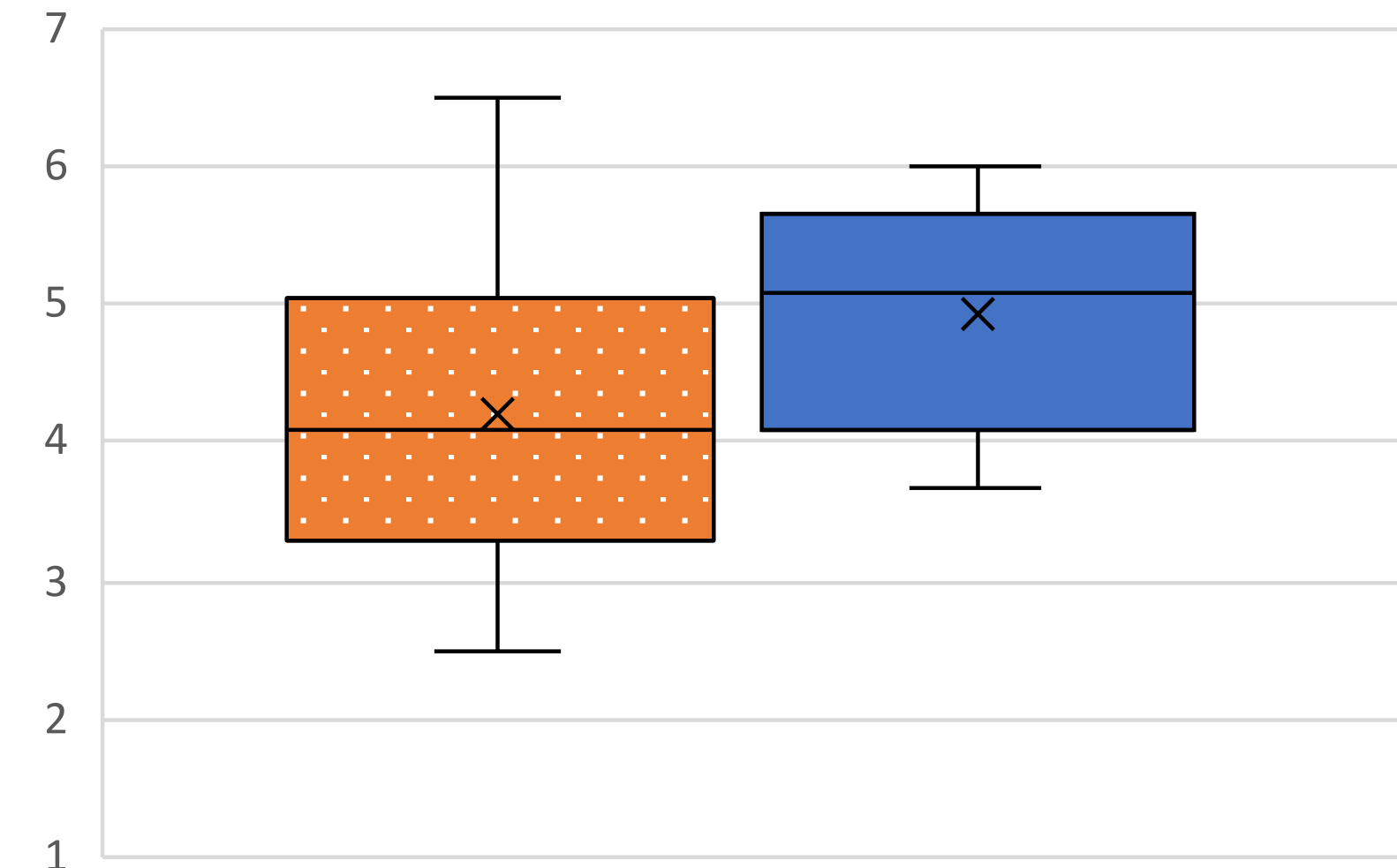


Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.

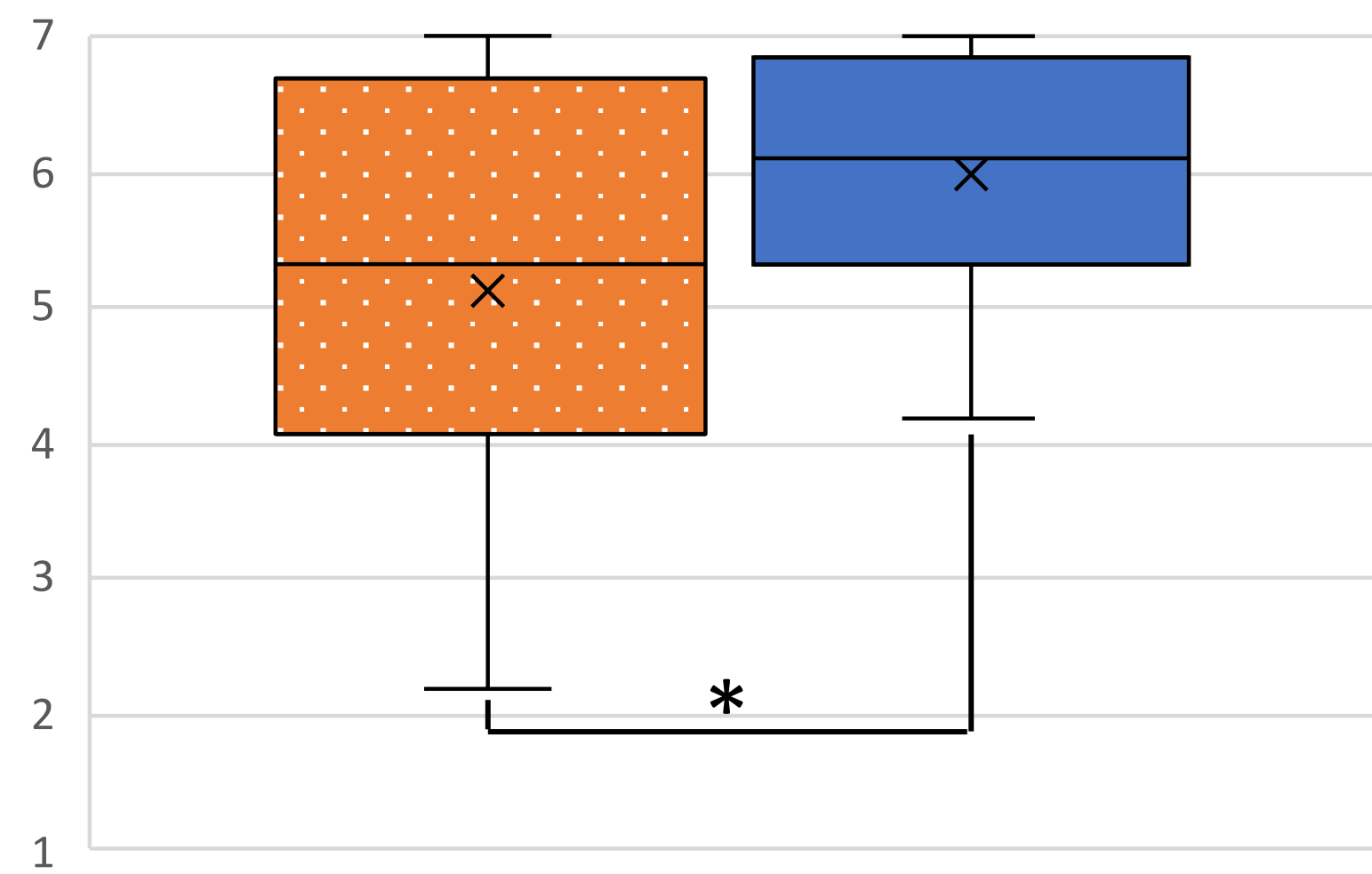
Spatial Presence



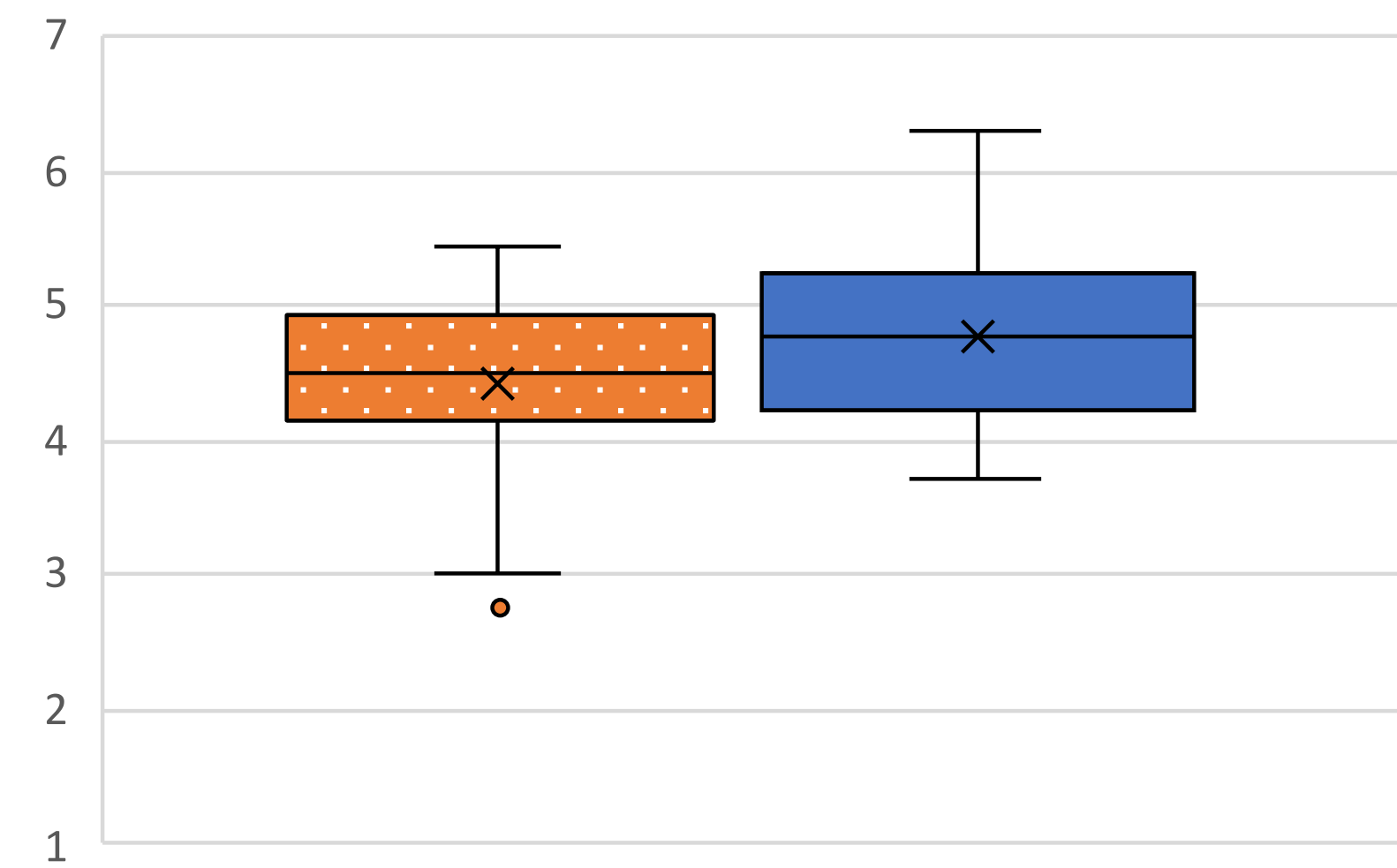
Co-Presence



Social Presence

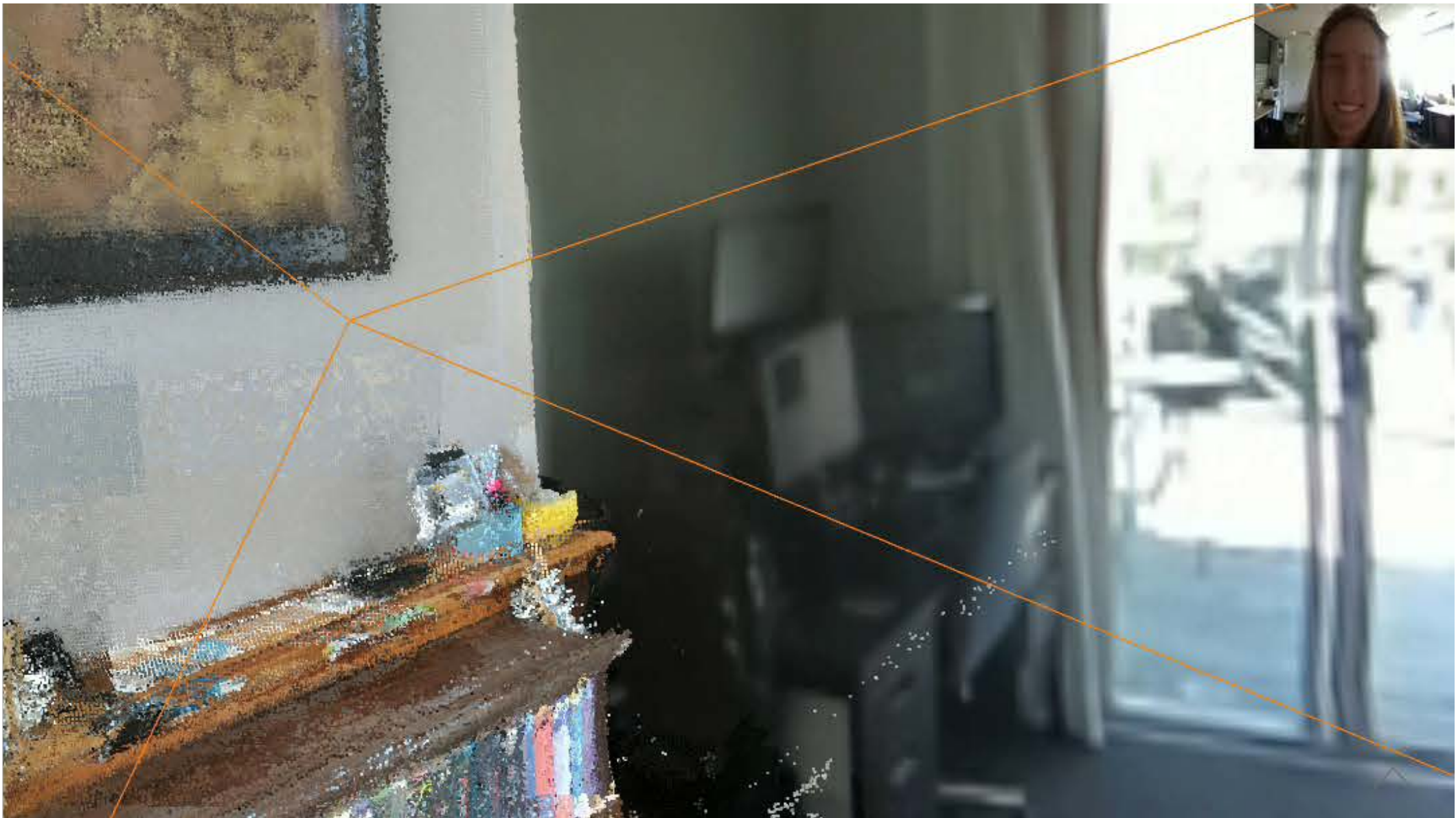


Overall

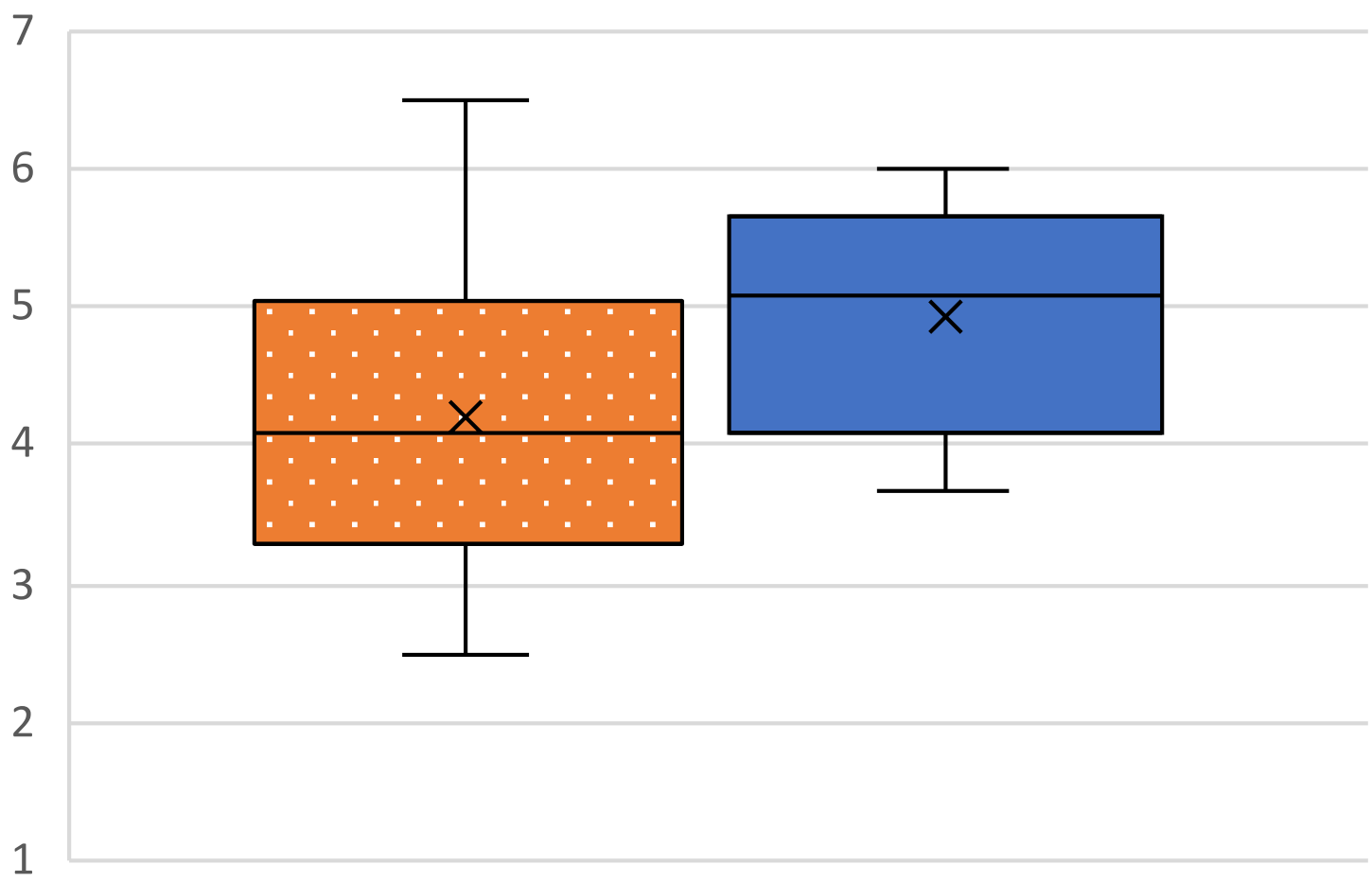


360° Videoconferencing Mobileportation

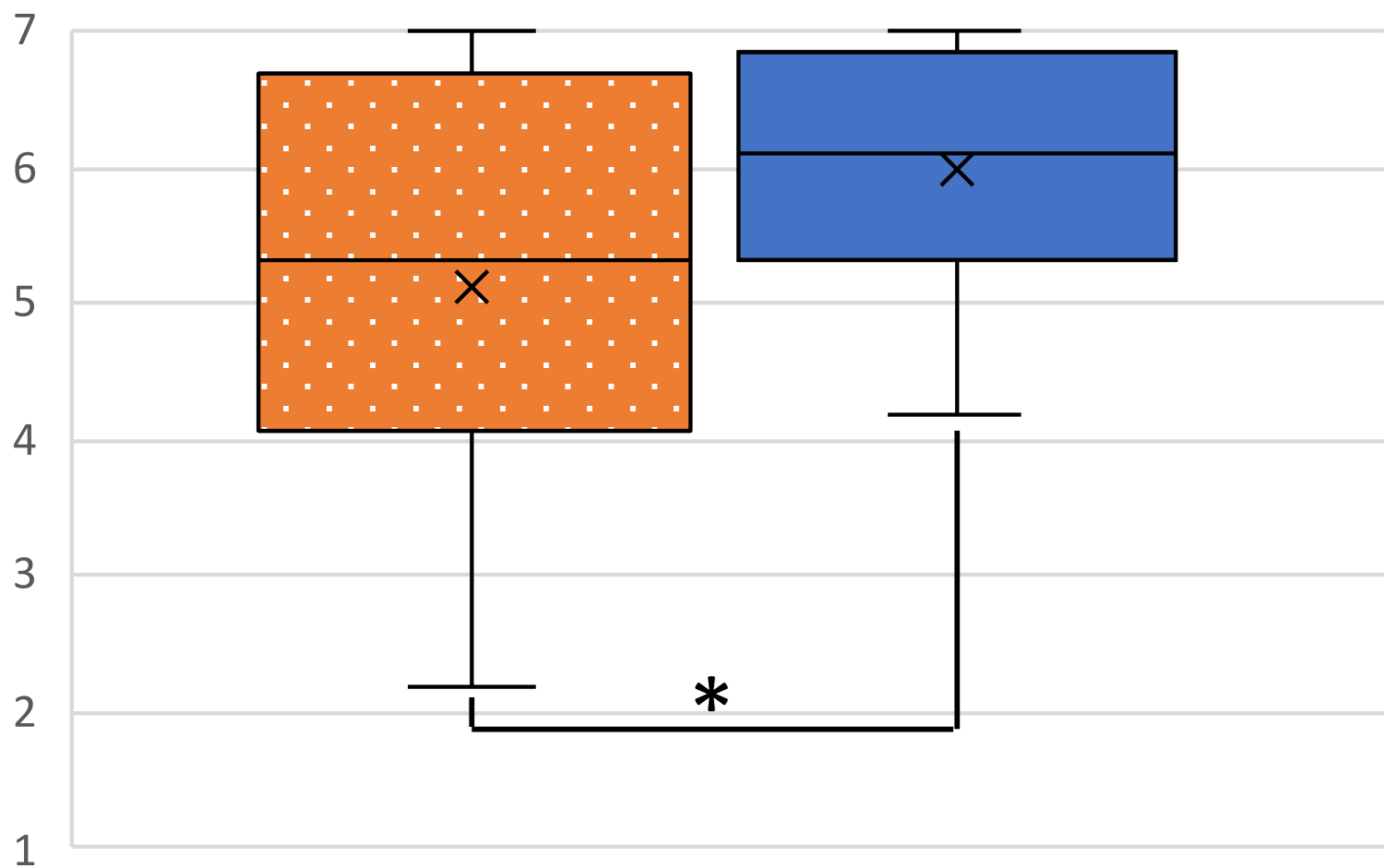
Jacob Young, Tobias Langlotz, Steven Mills, Holger Regenbrecht (2020) Mobileportation: Nomadic Telepresence for Mobile Devices Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies / ACM International Joint Conference on Pervasive and Ubiquitous Computing, 2020.



Co-Presence



Social Presence

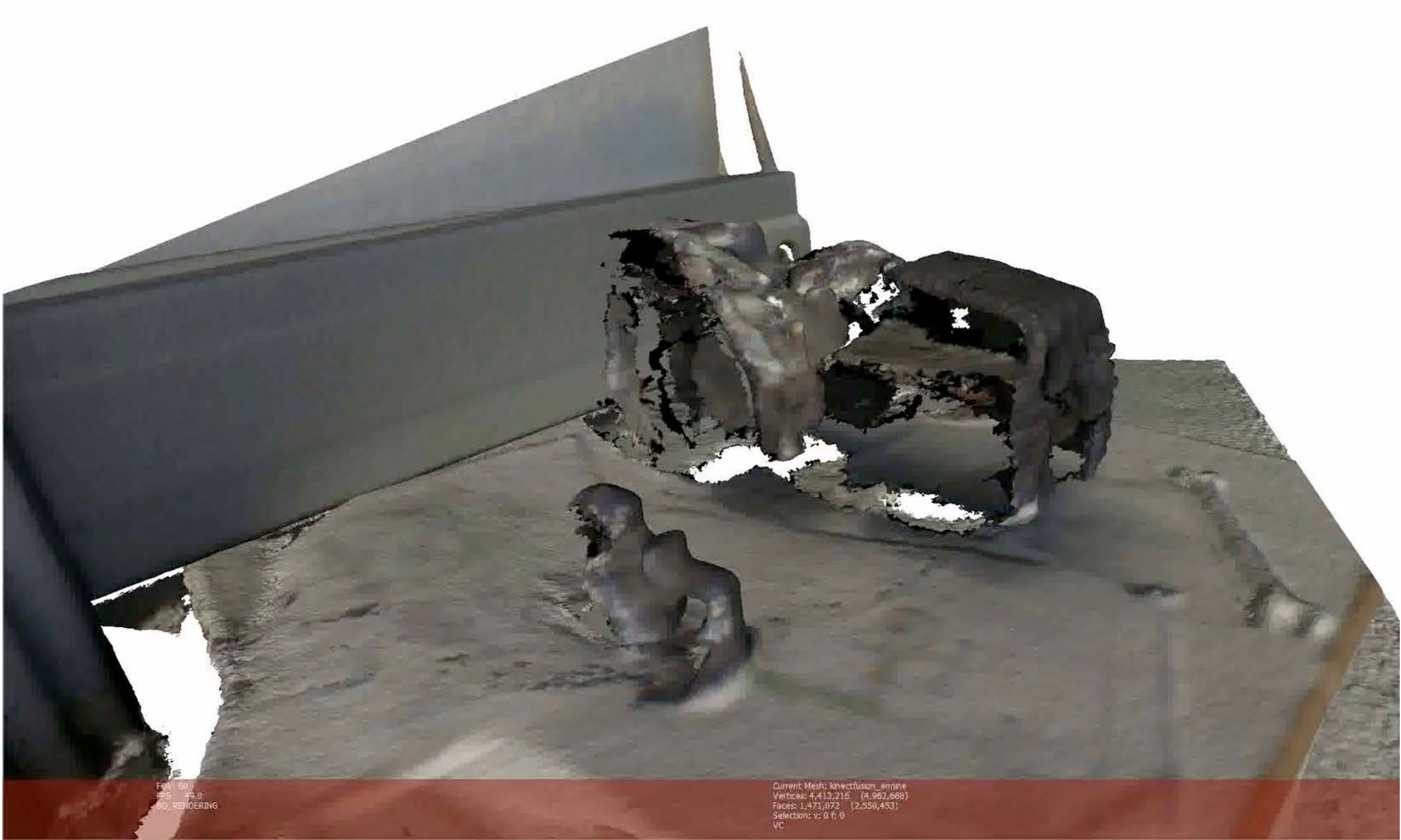


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Mixed Reality Light Fields for Mobile Telepresence

ARIVE

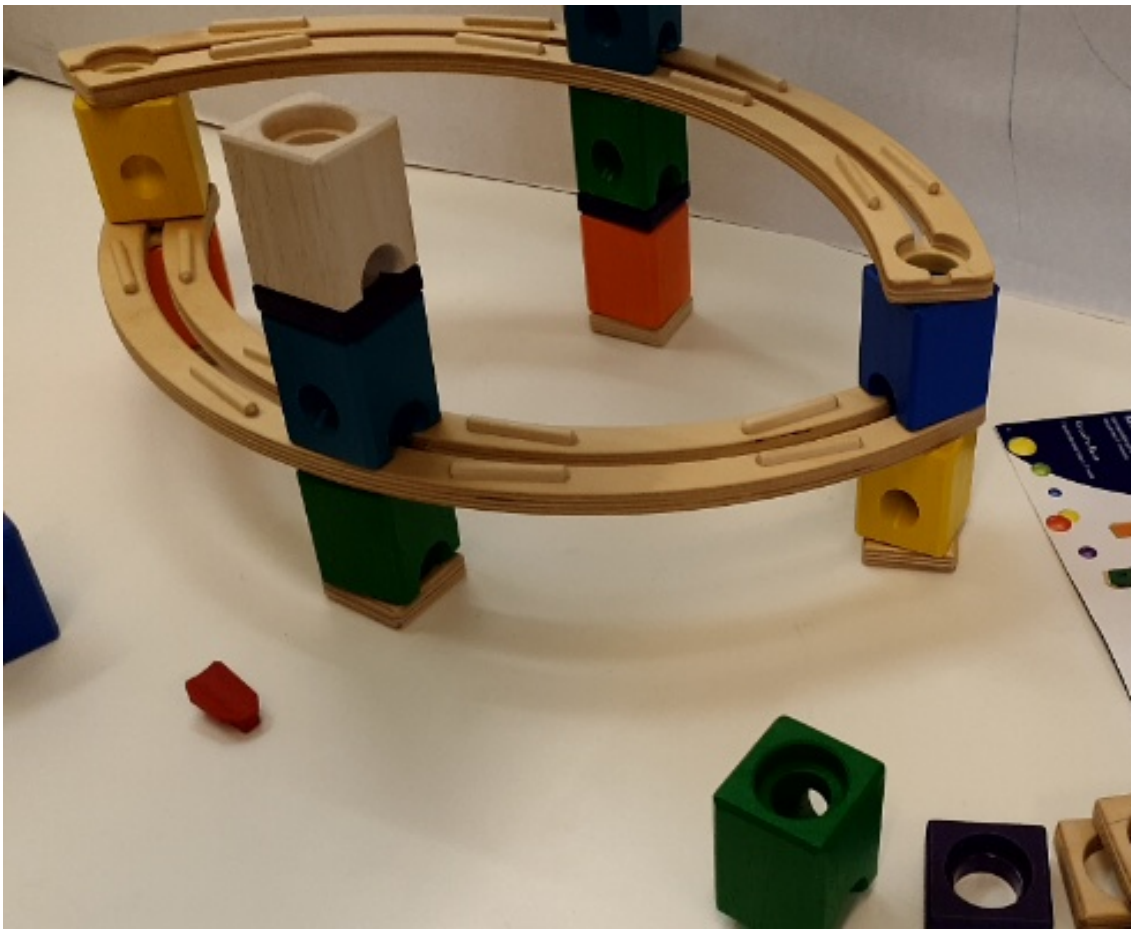
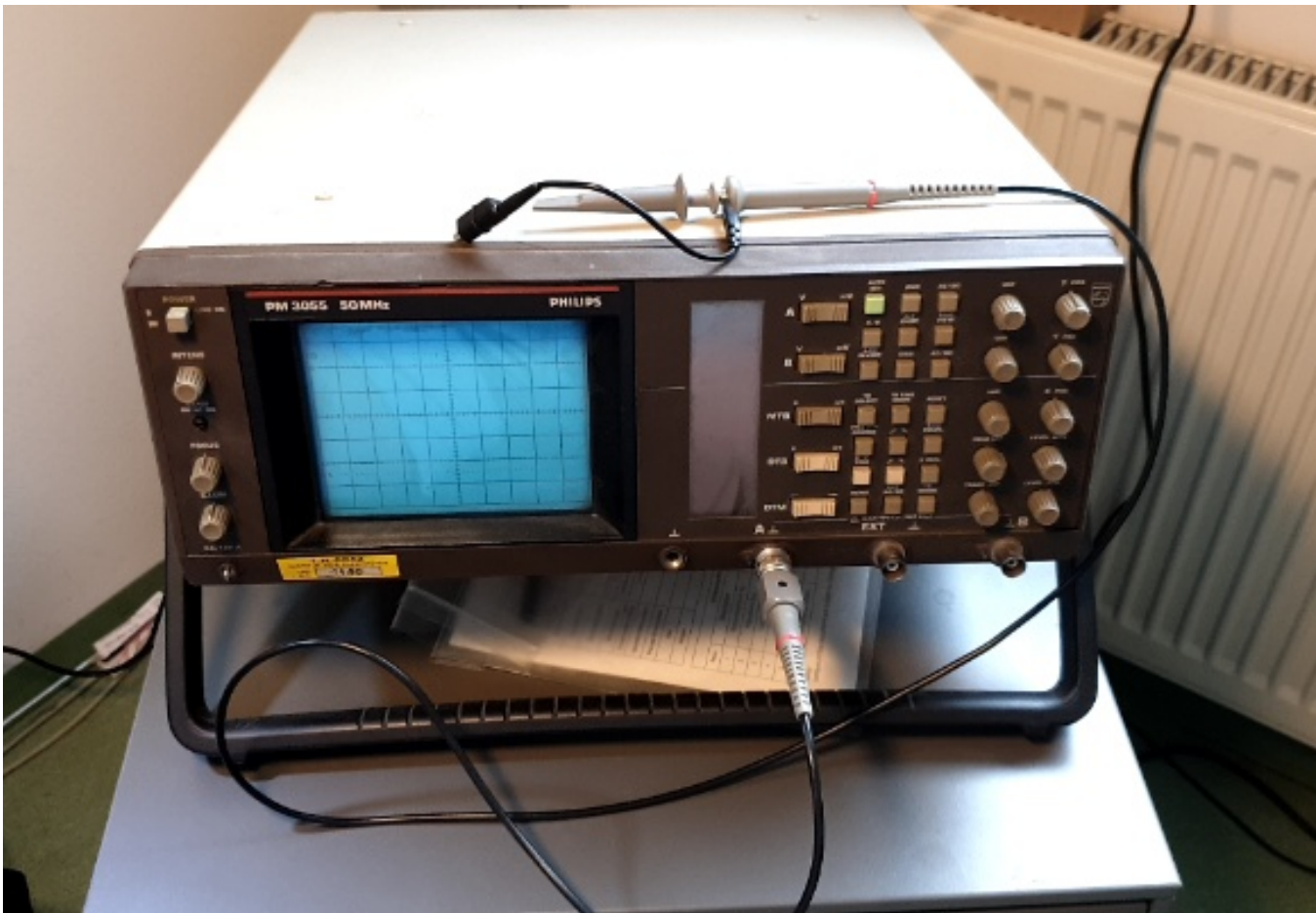
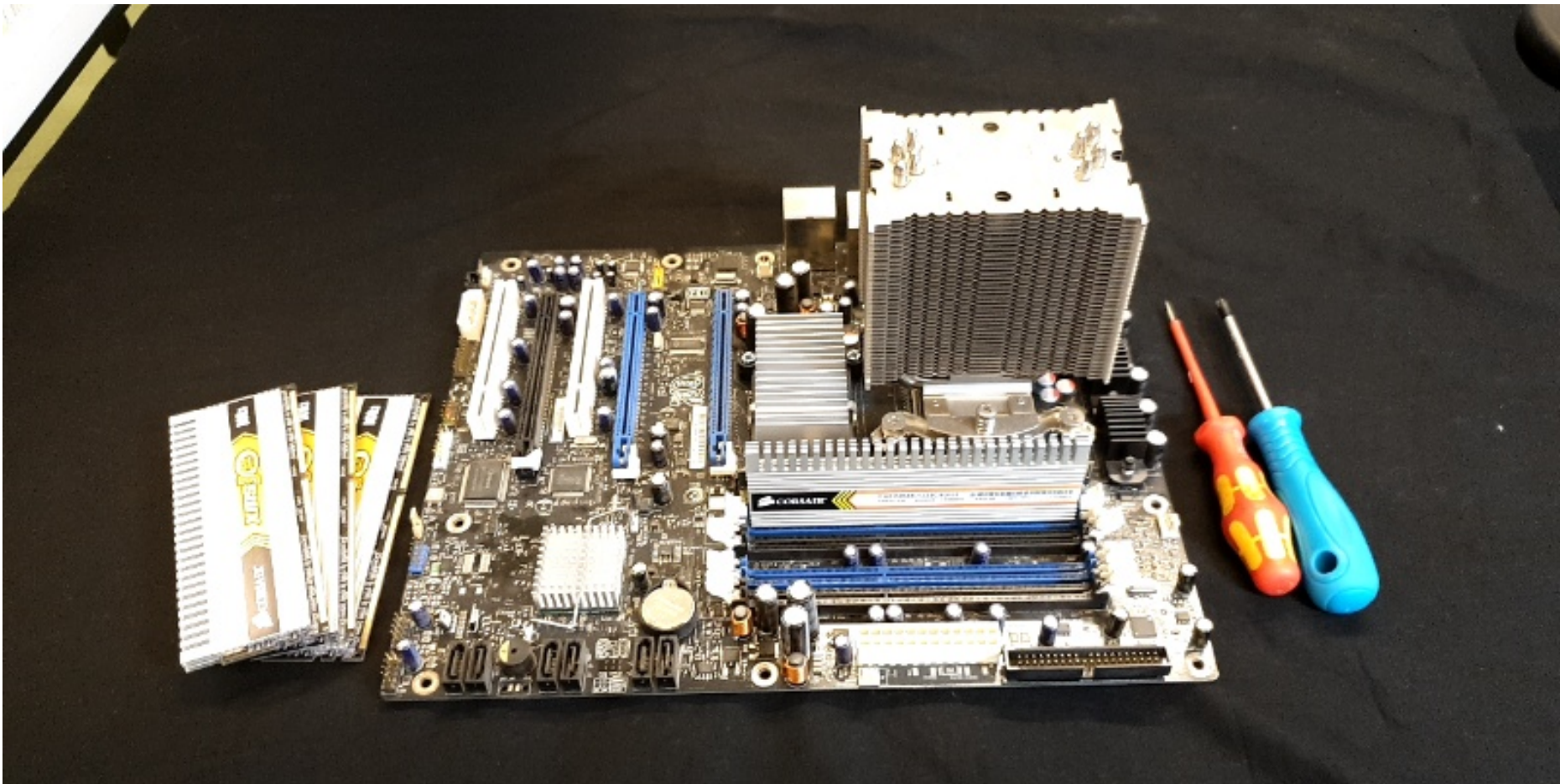
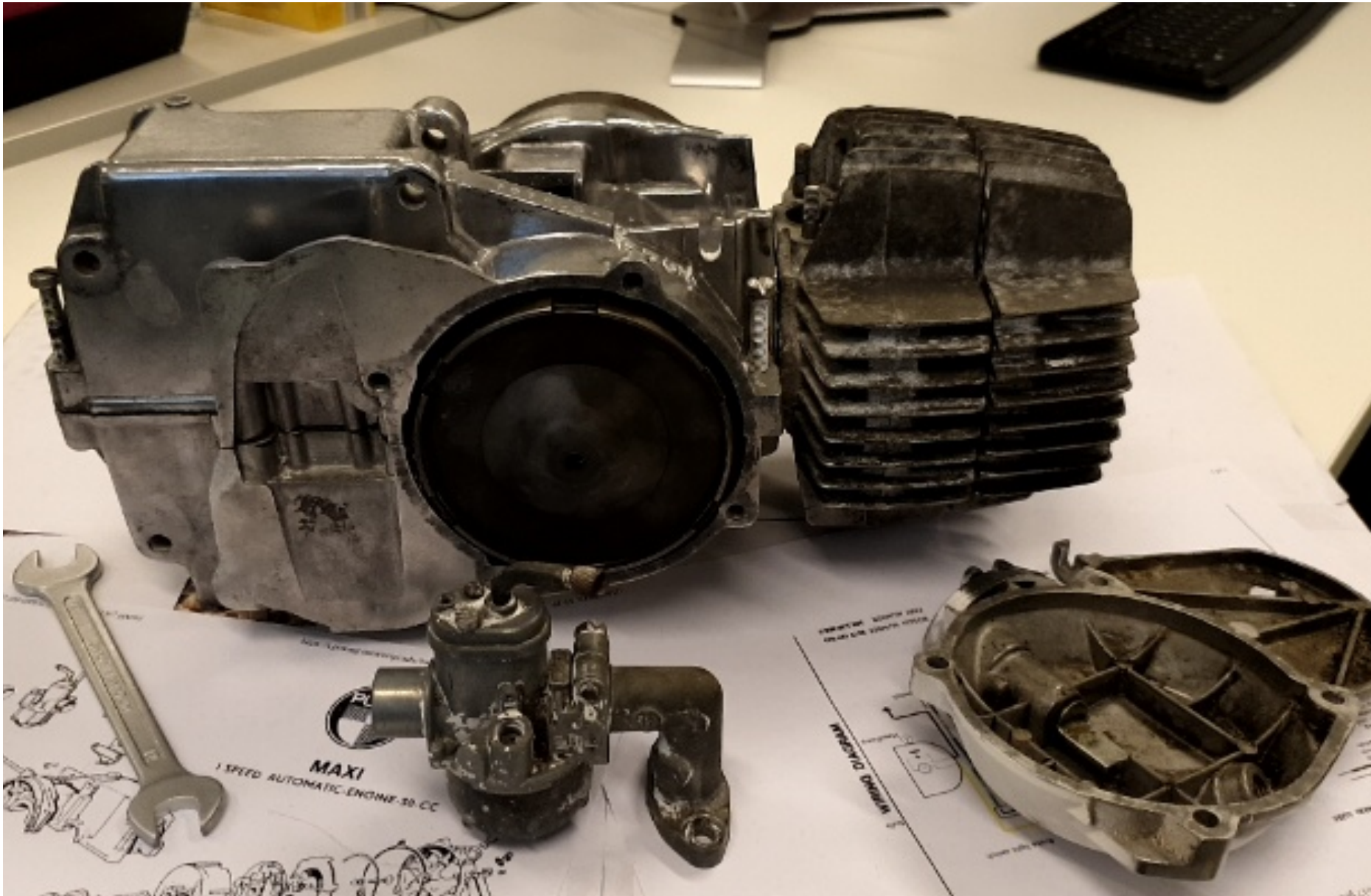




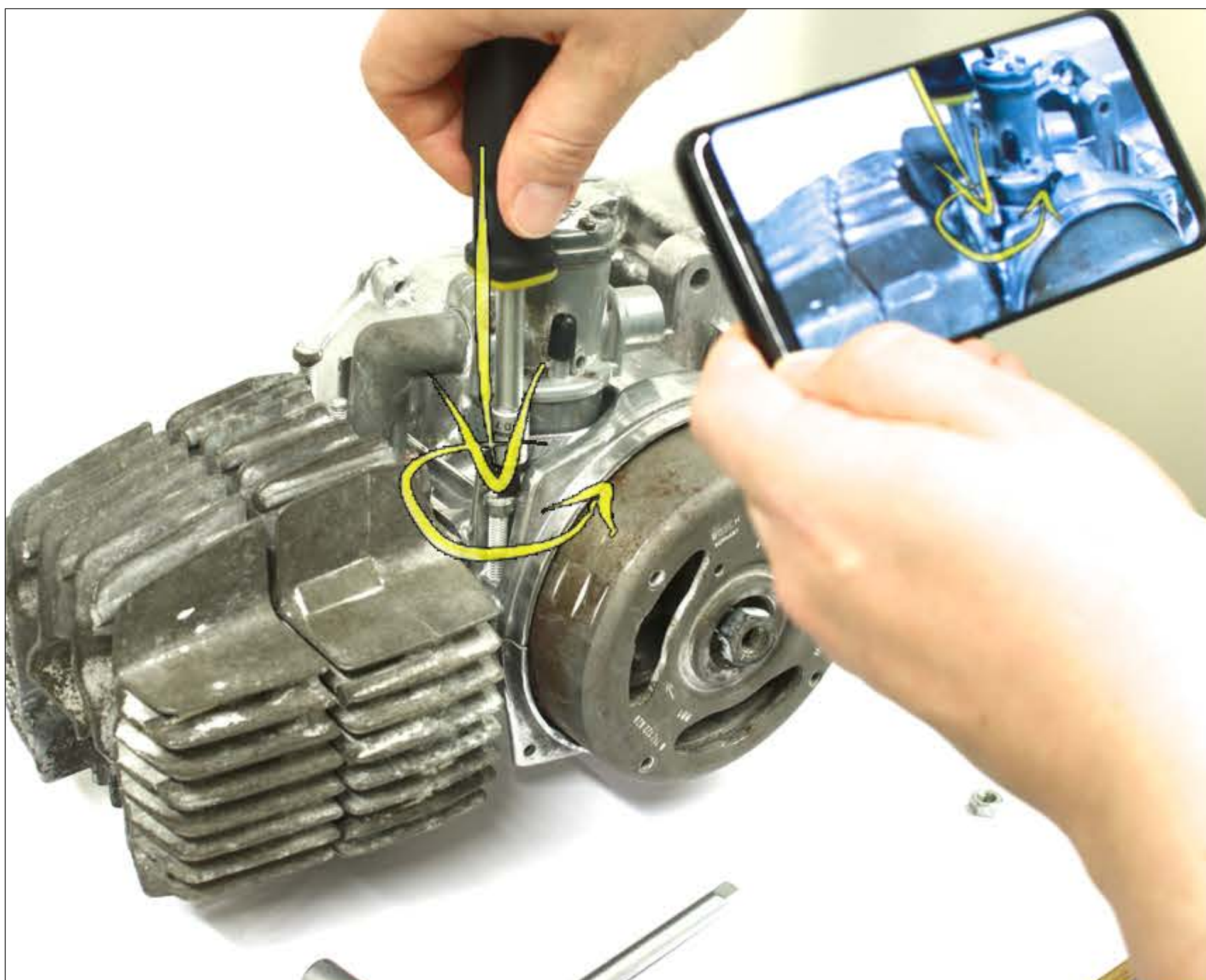
Kinect Fusion



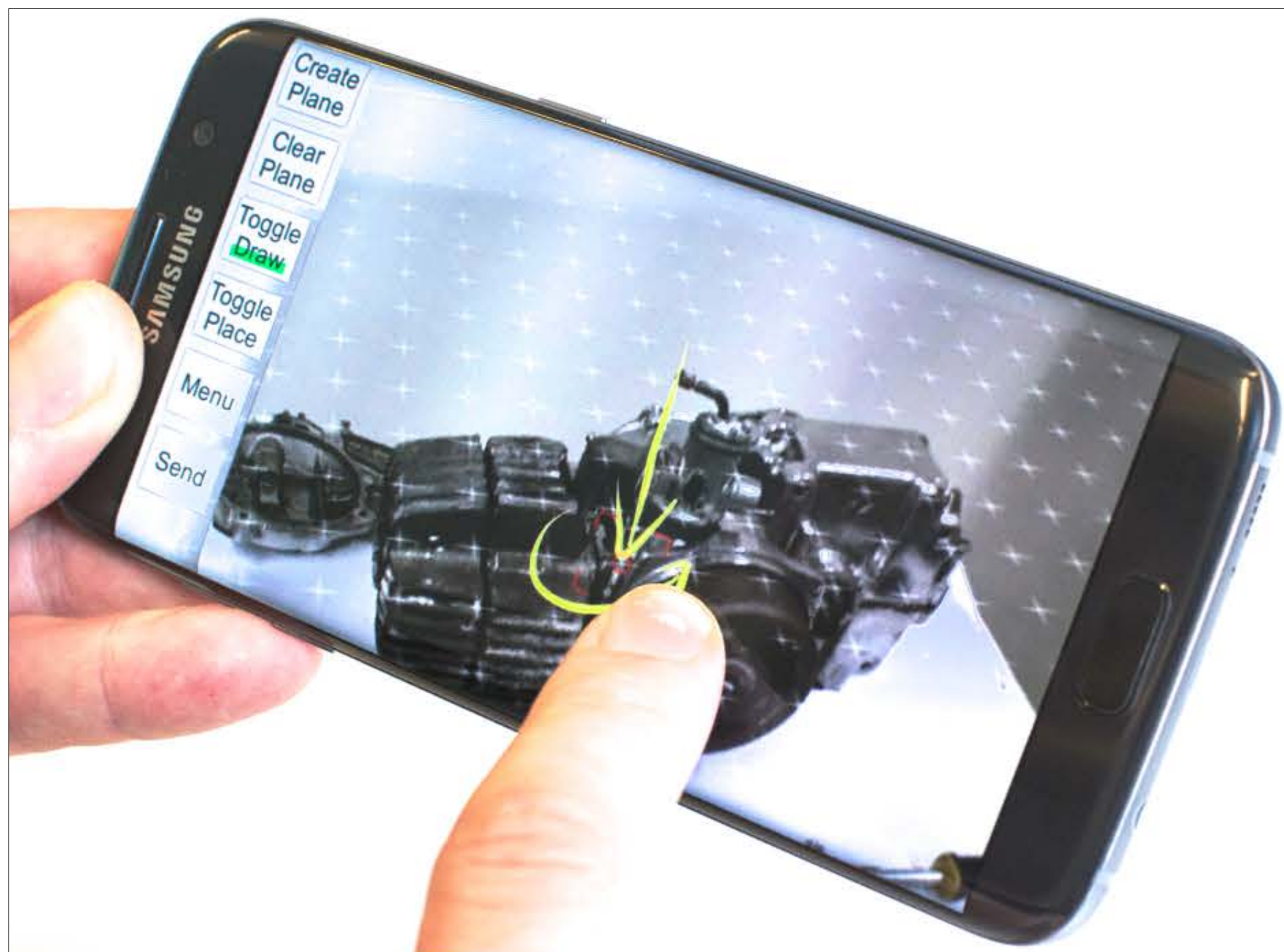
Structure from Motion (187 images, 59min)



Local worker

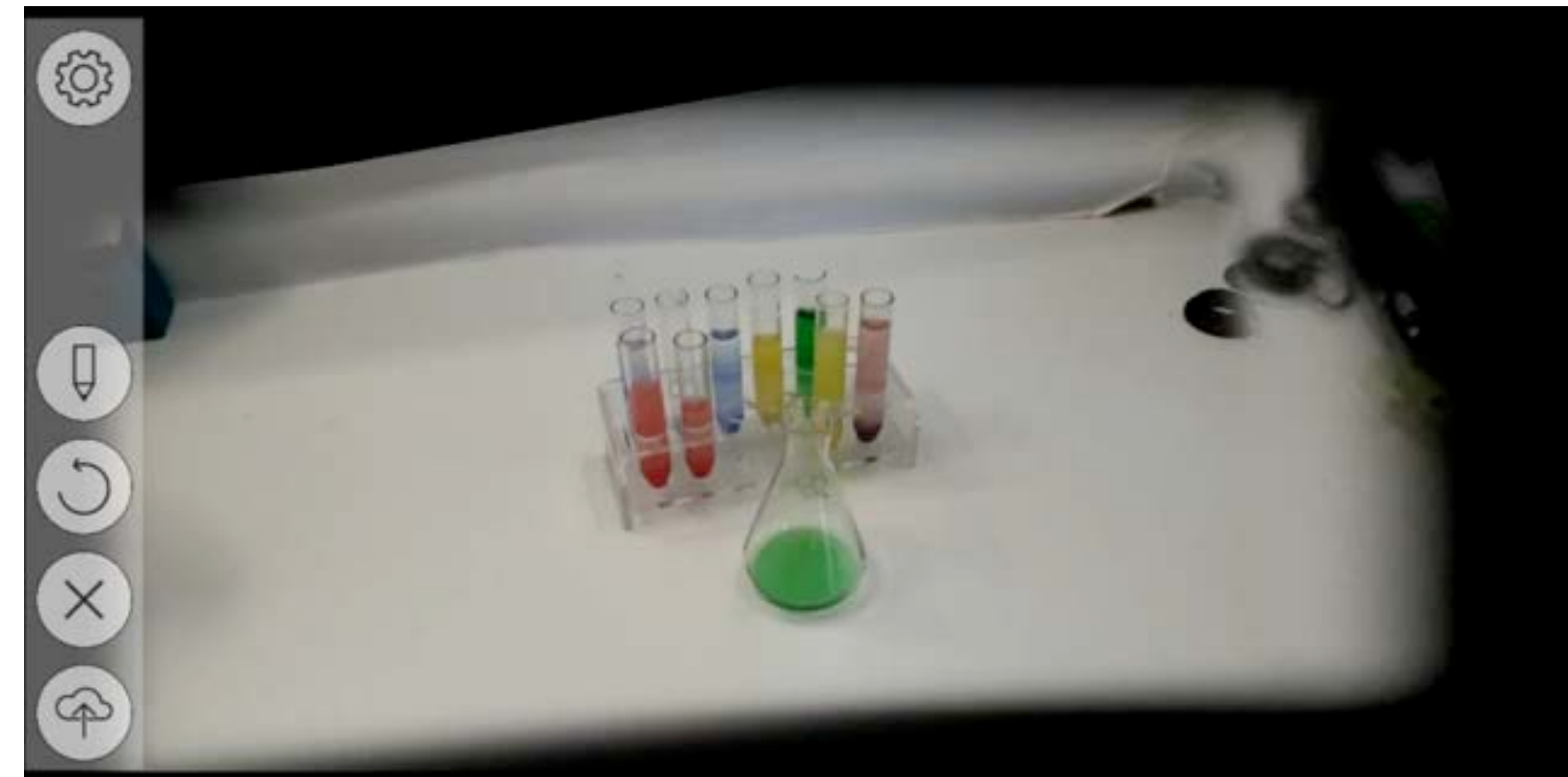
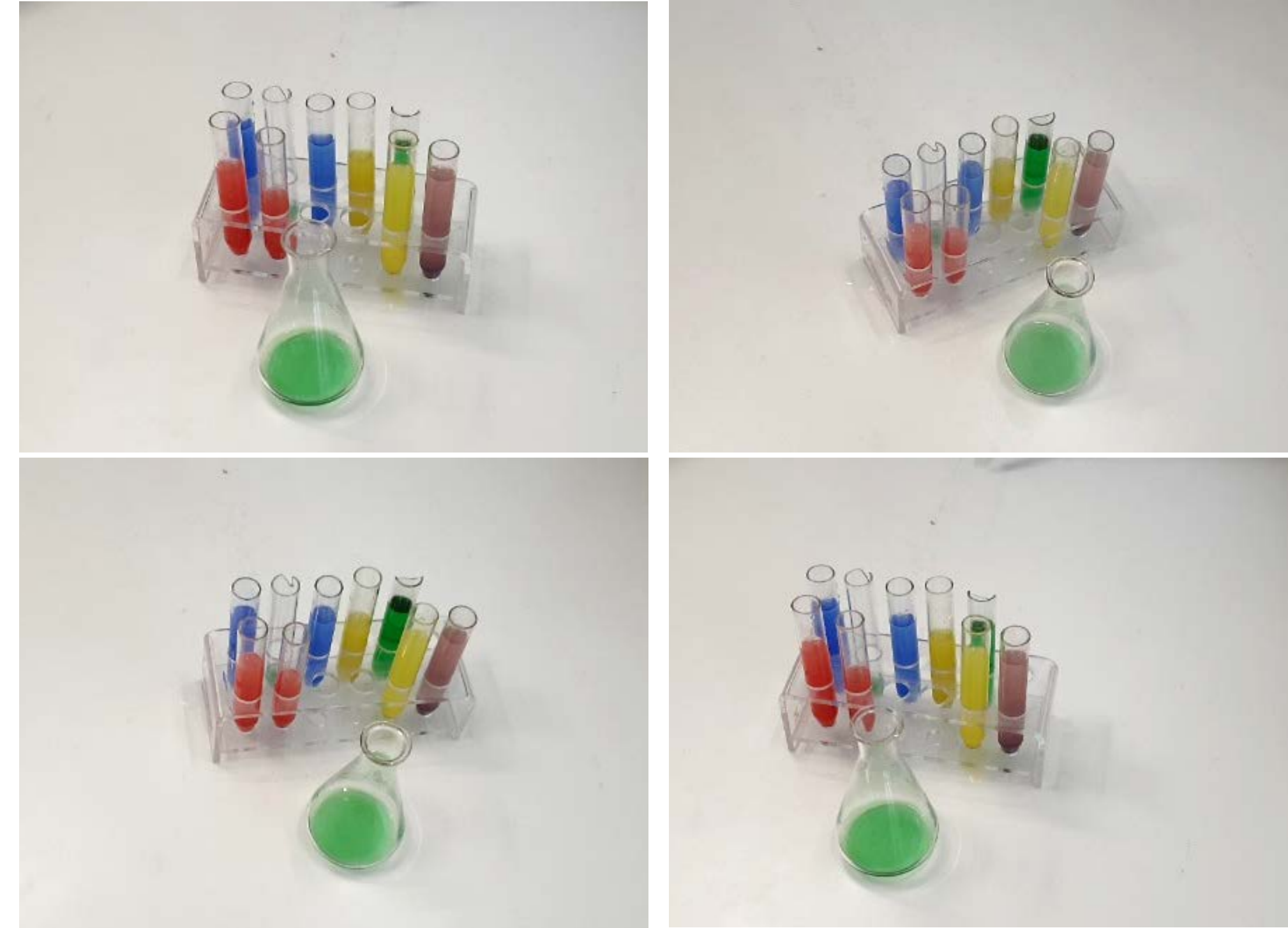


Remote expert

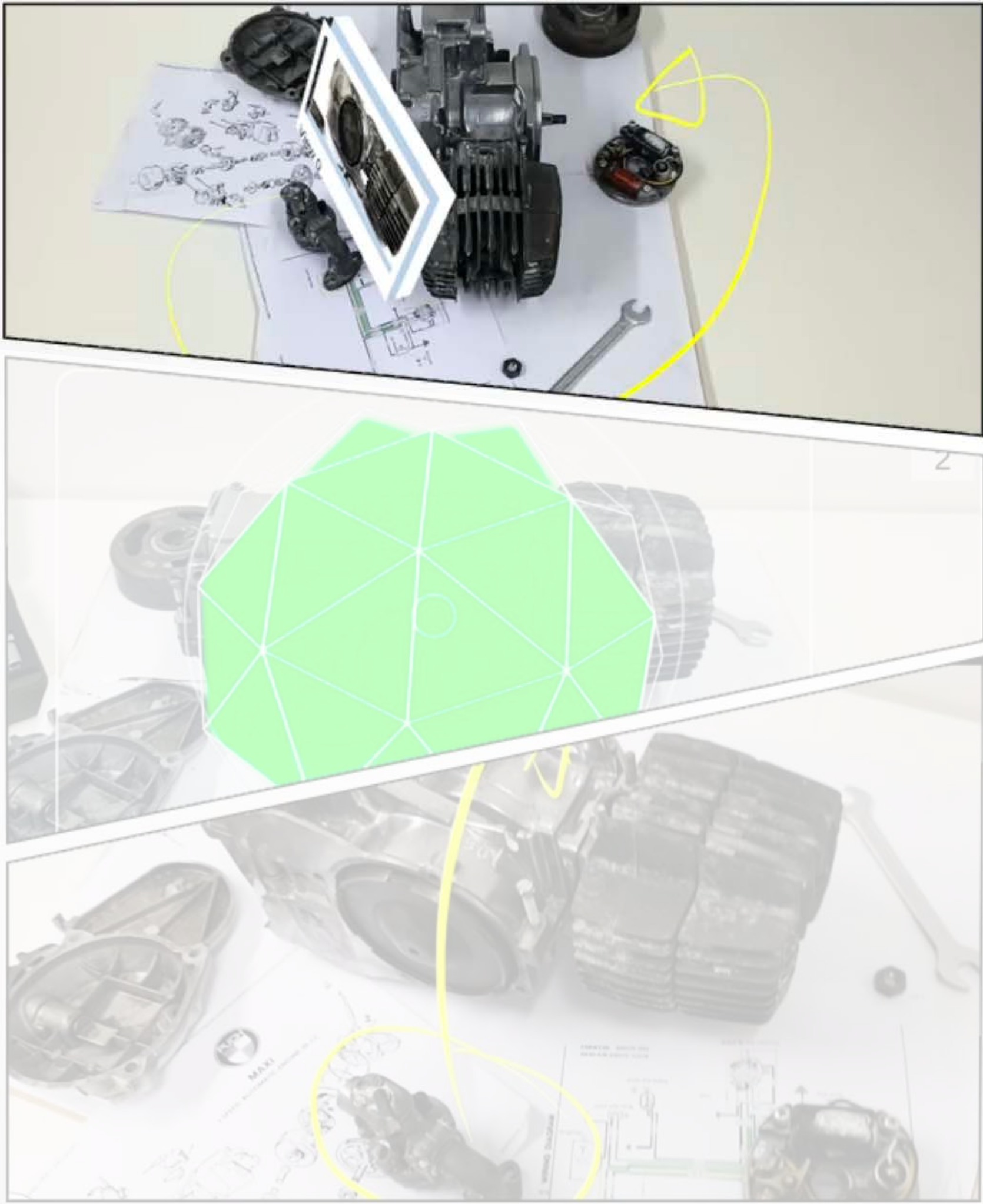


Share 3D representation with remote expert ↔ Share annotations with local worker

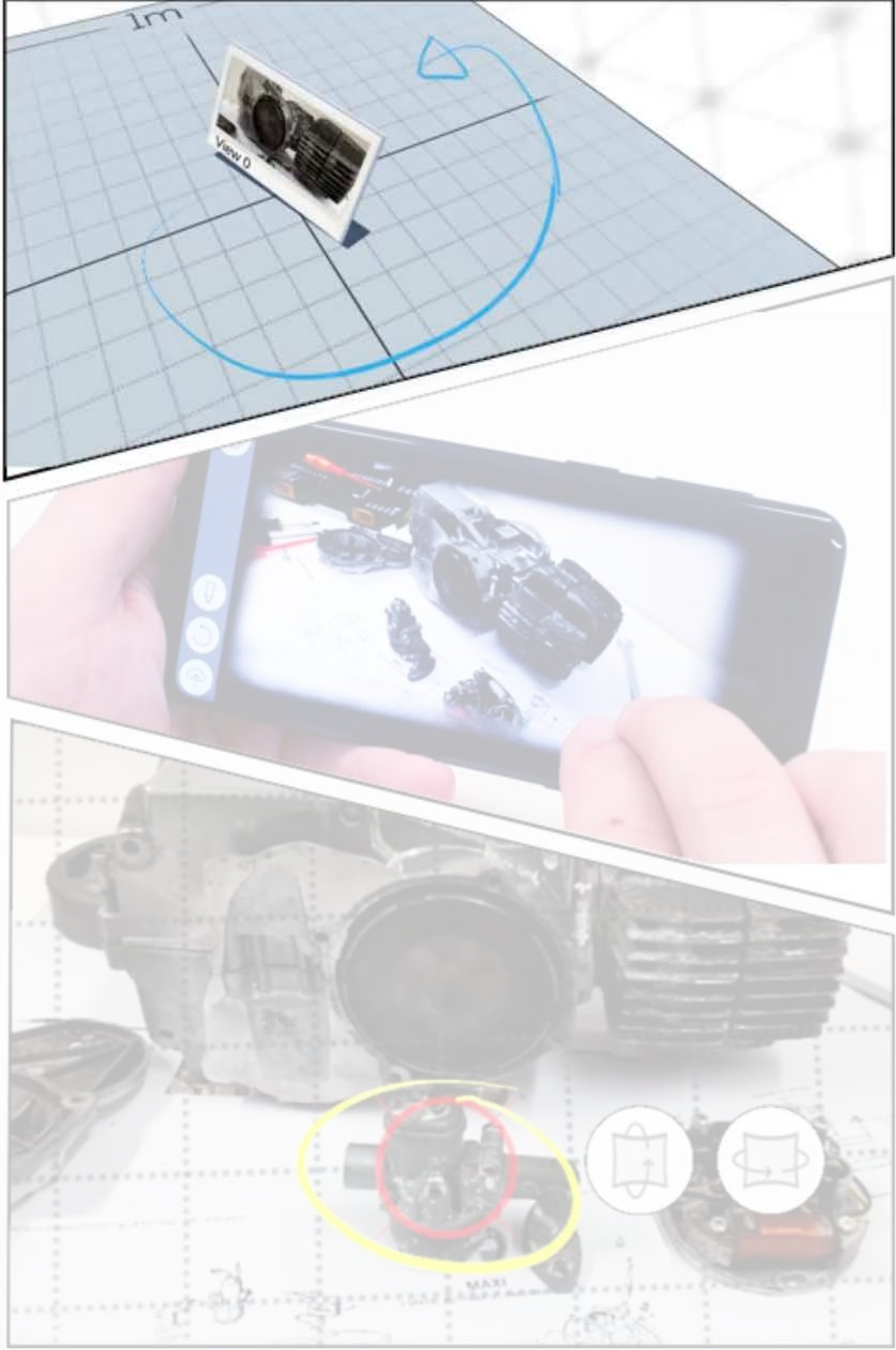
- Mixed Reality Light Fields
 - Do not rely on an explicit 3D model
 - Generate a database of spatially registered images
 - Scene generation ‘only’ requires interpolating between nearby images
- Advantages:
 - High quality representation of the remote environment
 - Independent of object of interest
- Disadvantages:
 - No depth data for annotation placement
 - No established interfaces for creating and annotating light fields
 - Large model size



Local worker

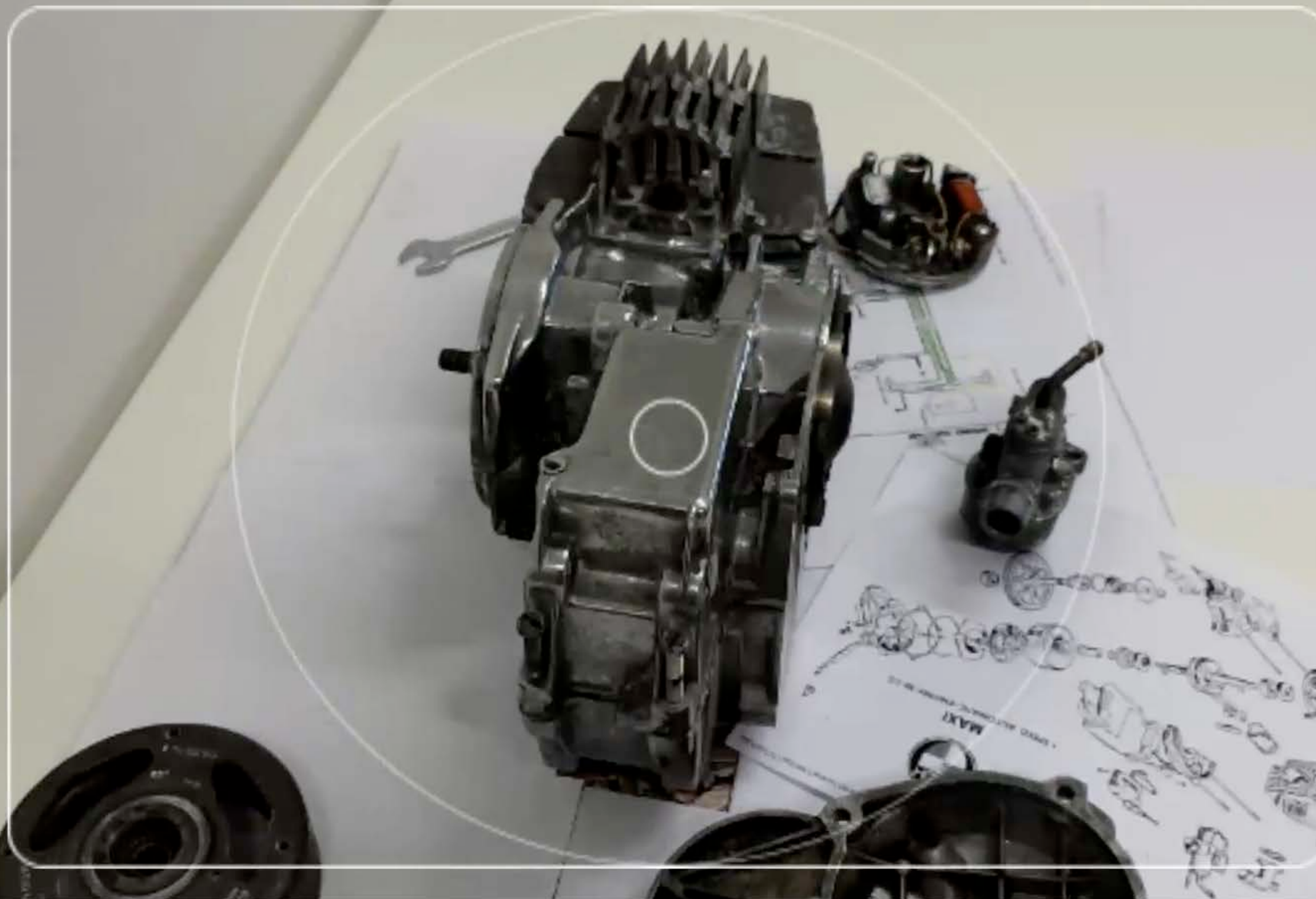


Remote expert



1.
Spatial guidance for
generating local light
field

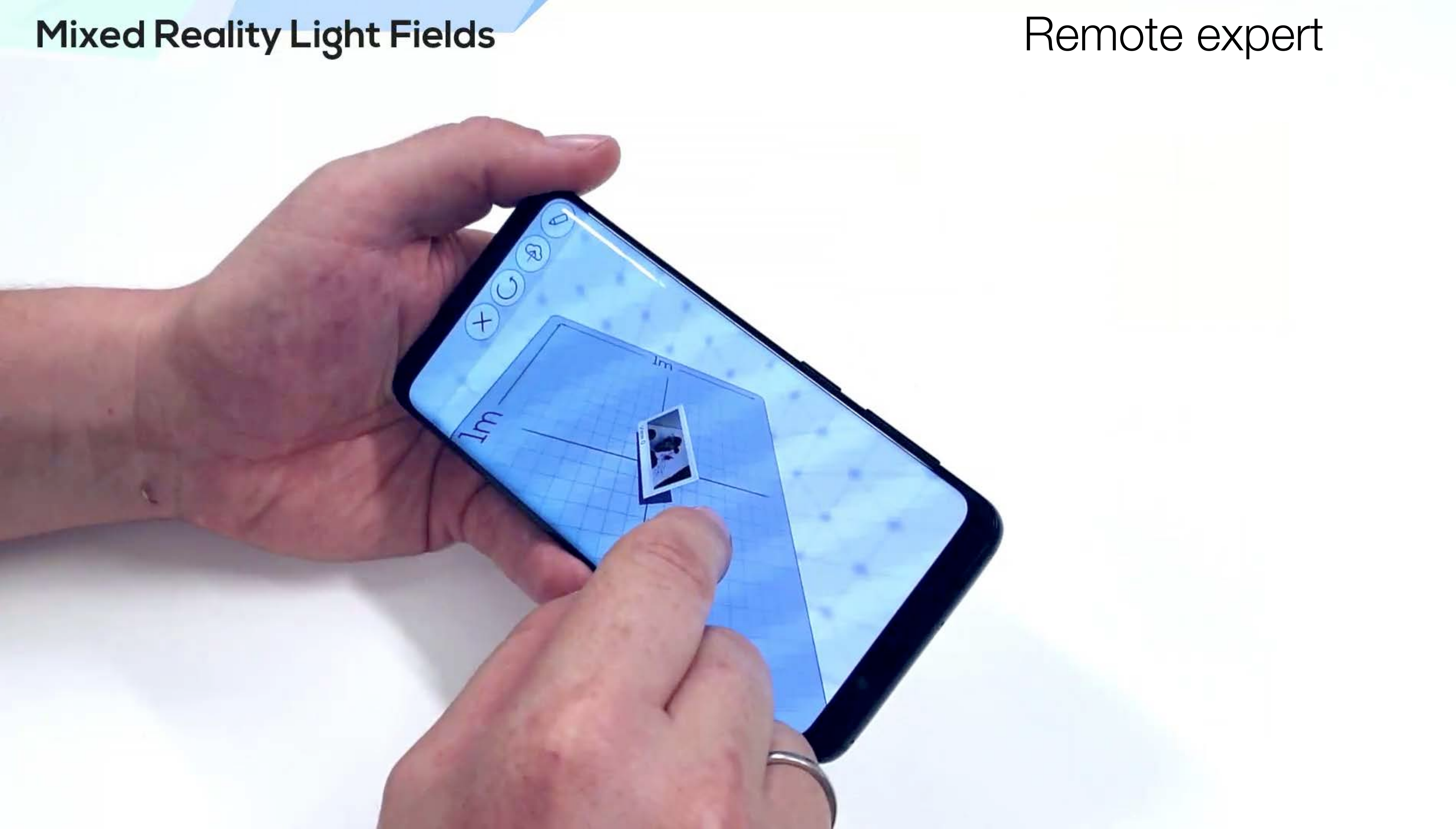
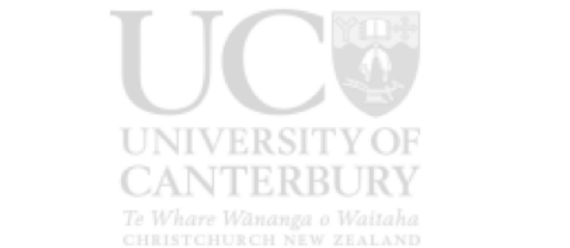




Tracking Quality

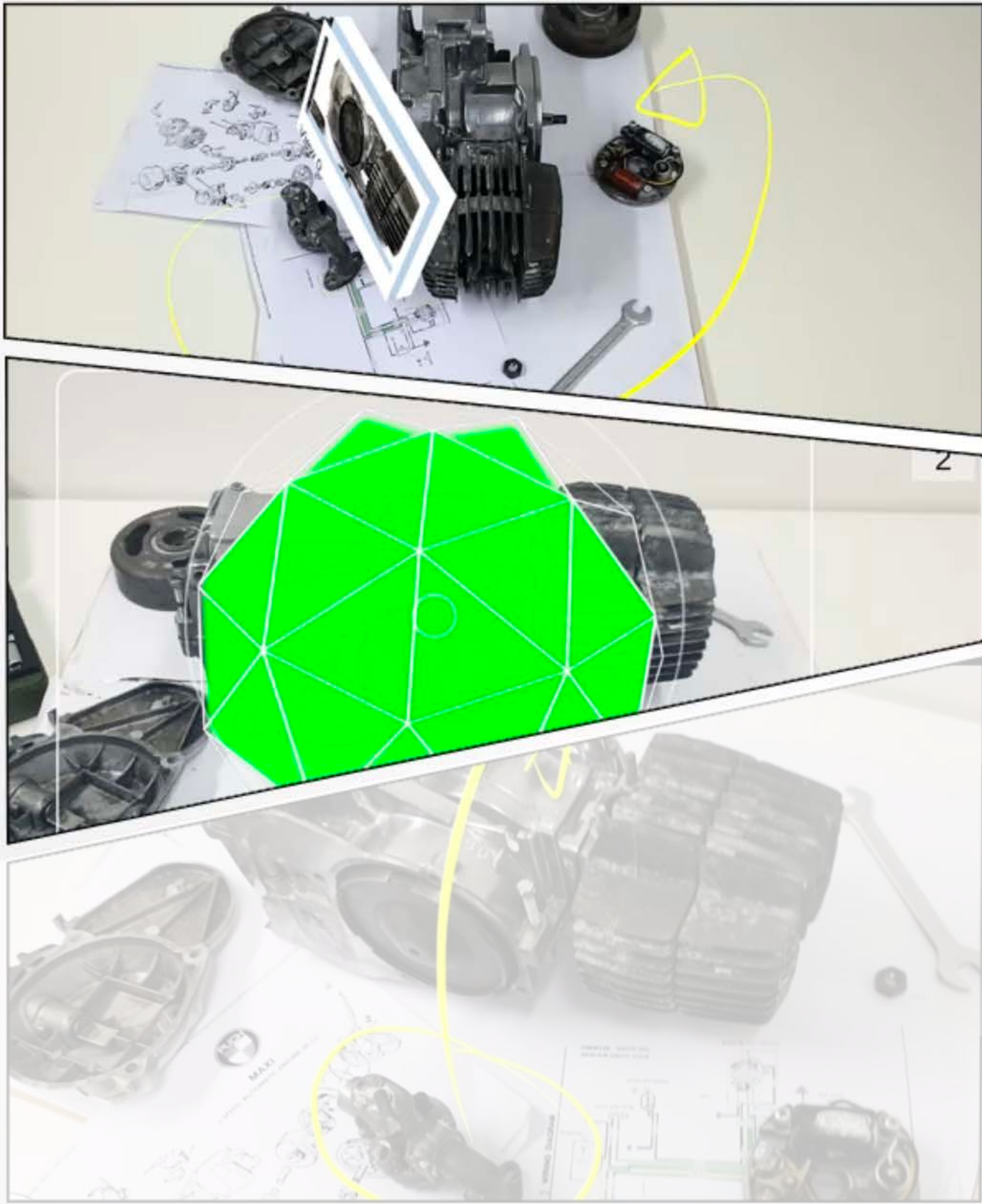
Images
255

Peter Mohr, Shohei Mori, Tobias Langlotz, Bruce Thomas, Dieter Schmalstieg, Denis Kalkofen (2020) Mixed Reality Light Fields for Interactive Remote Assistance
ACM CHI'20 Conference on Human Factors in Computing Systems (ACM CHI 2020), Honolulu, 2020.

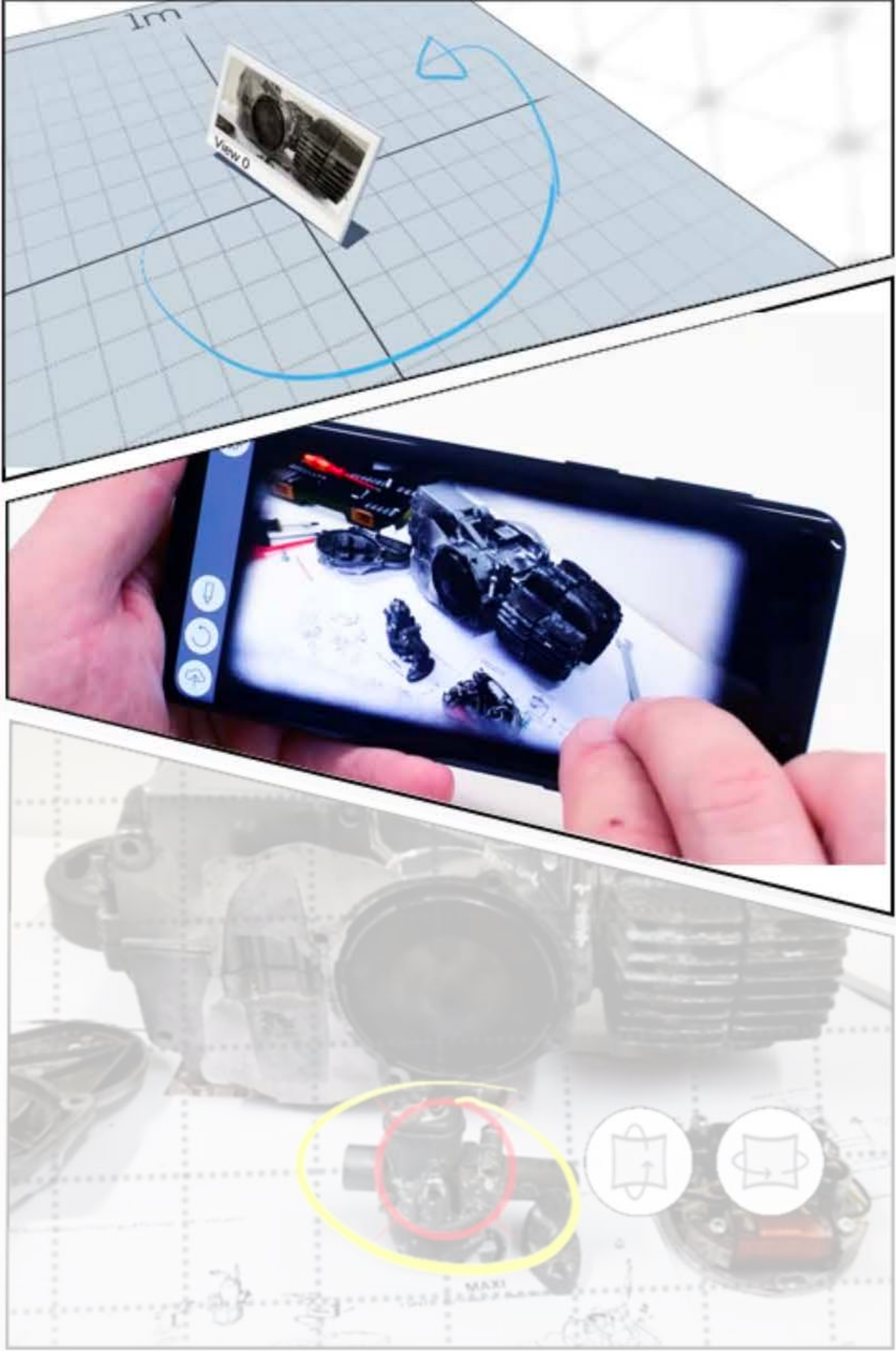


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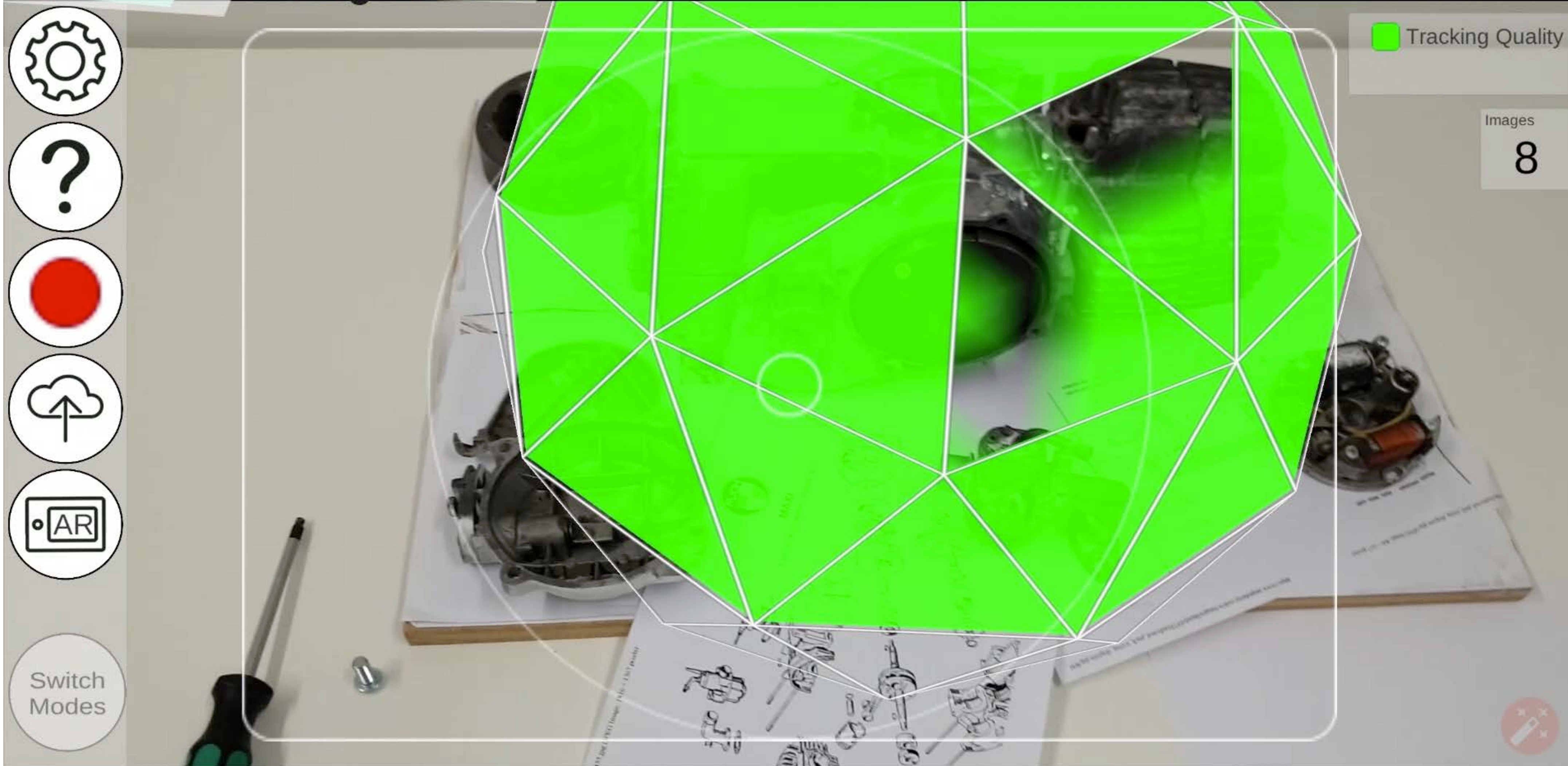
Local worker



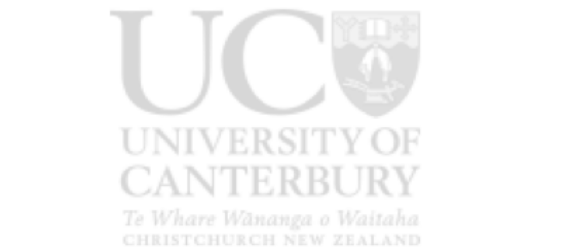
Remote expert



2.
Generation of shared
local light field



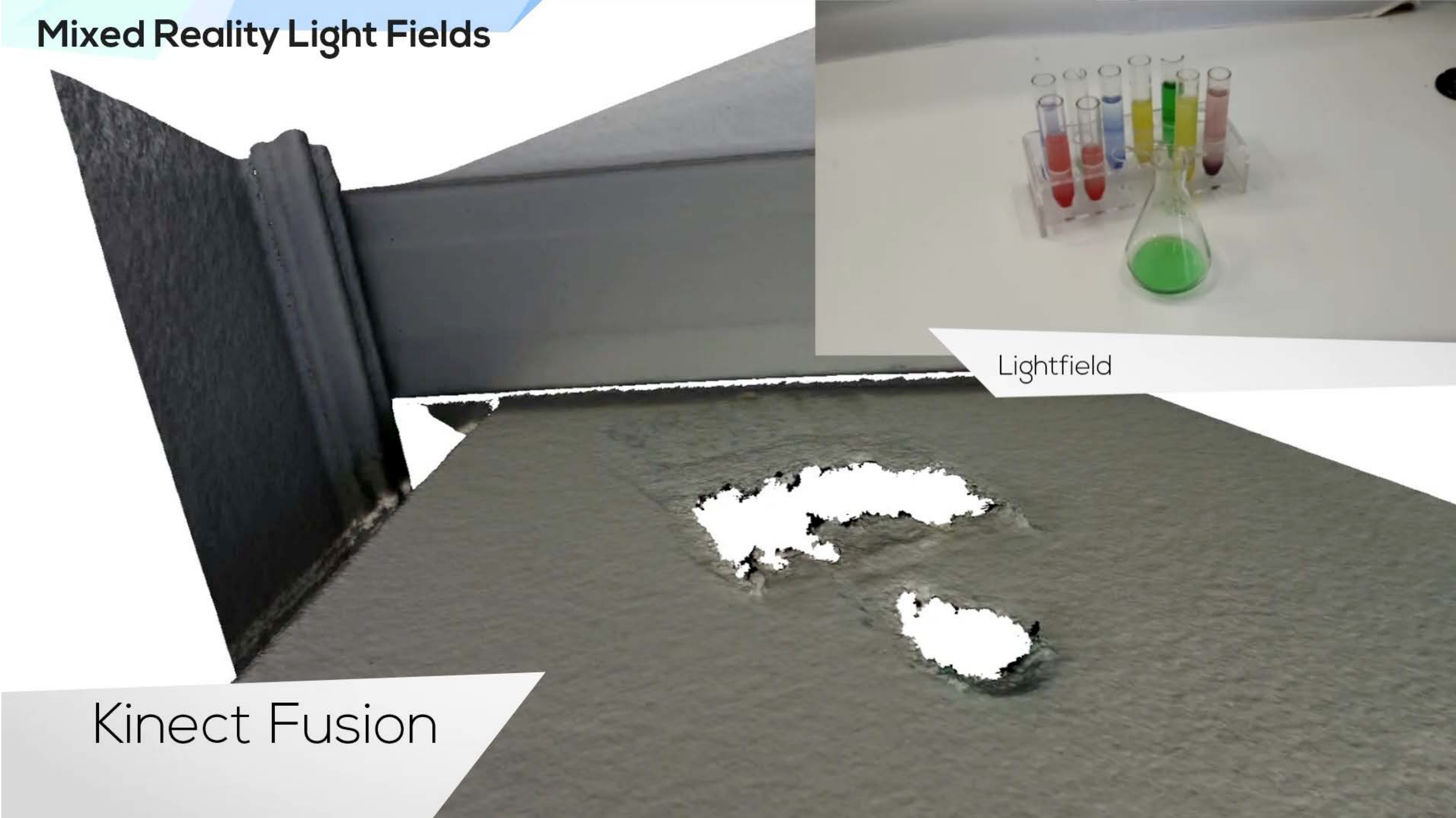
Peter Mohr, Shohei Mori, Tobias Langlotz, Bruce Thomas, Dieter Schmalstieg, Denis Kalkofen (2020) Mixed Reality Light Fields for Interactive Remote Assistance
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Peter Mohr, Shohei Mori, Tobias Langlotz, Bruce Thomas, Dieter Schmalstieg, Denis Kalkofen (2020) Mixed Reality Light Fields for Interactive Remote Assistance
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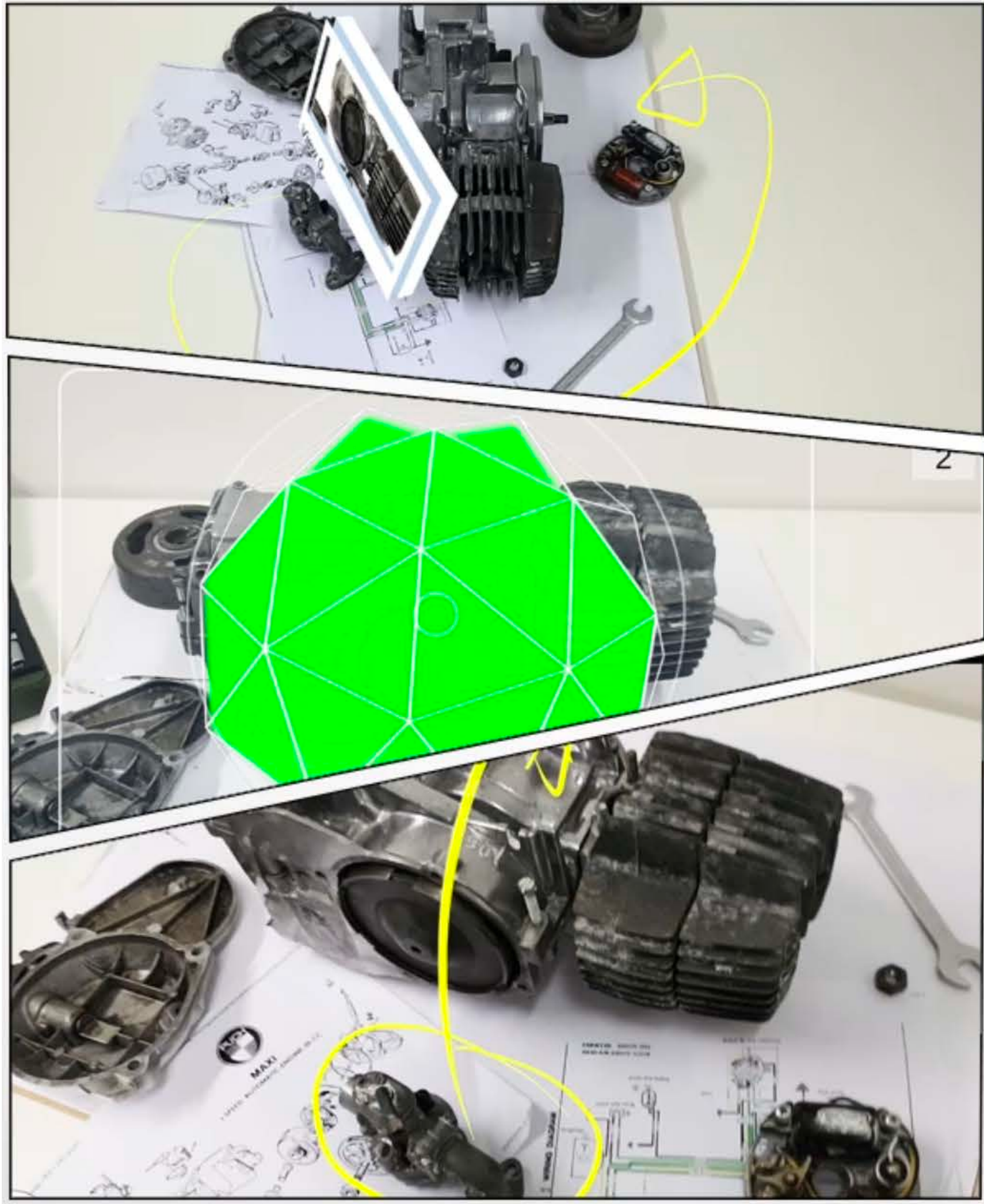
Lightfield



Kinect Fusion

Peter Mohr, Shohei Mori, Tobias Langlotz, Bruce Thomas, Dieter Schmalstieg, Denis Kalkofen (2020) Mixed Reality Light Fields for Interactive Remote Assistance
ACM CHI'20 Conference on Human Factors in Computing Systems (ACM CHI 2020), Honolulu, 2020.

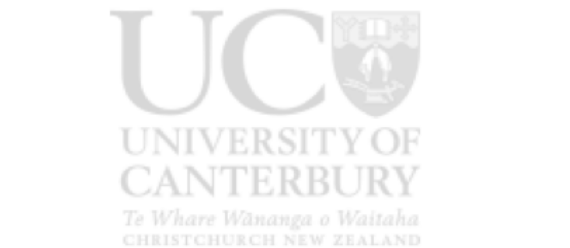
Local worker



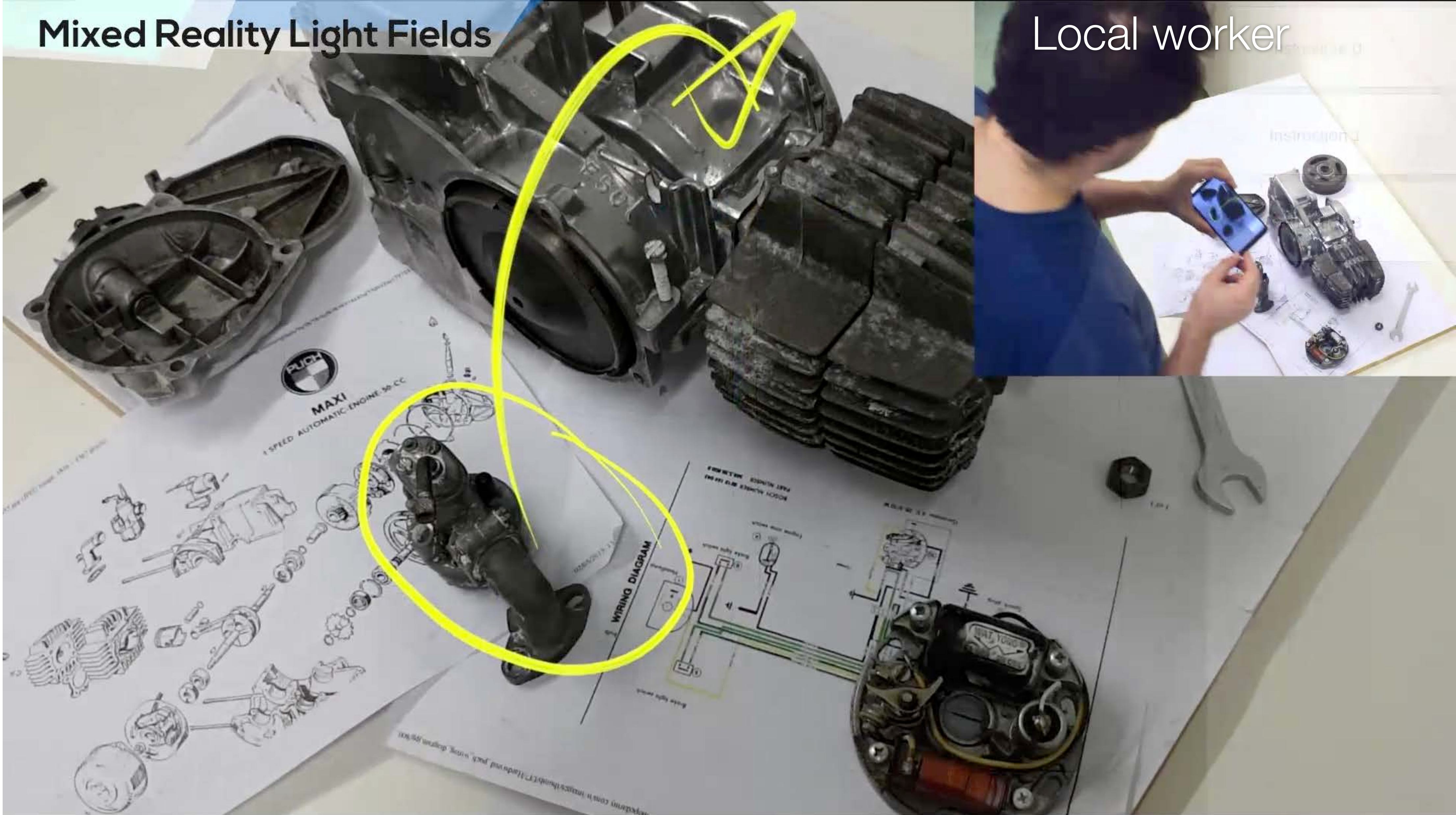
Remote expert



3.
Placement of shared
annotation

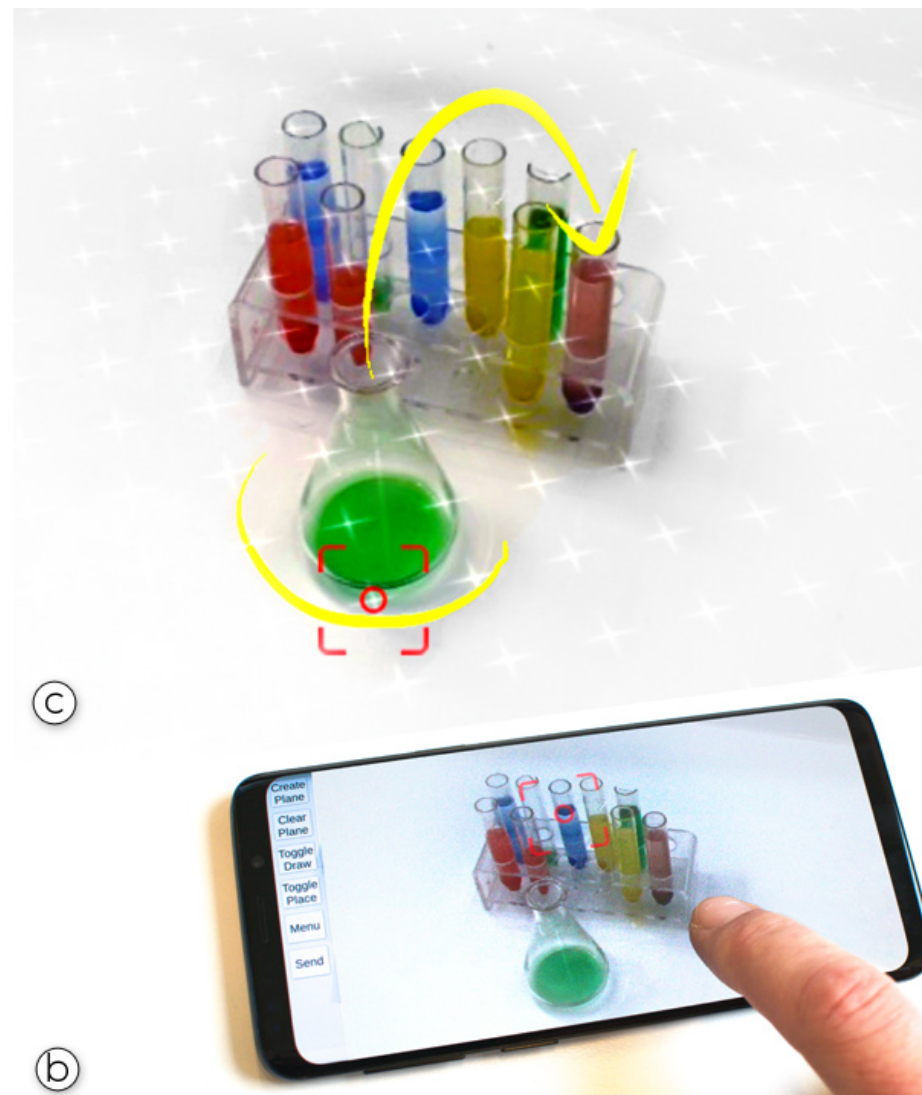
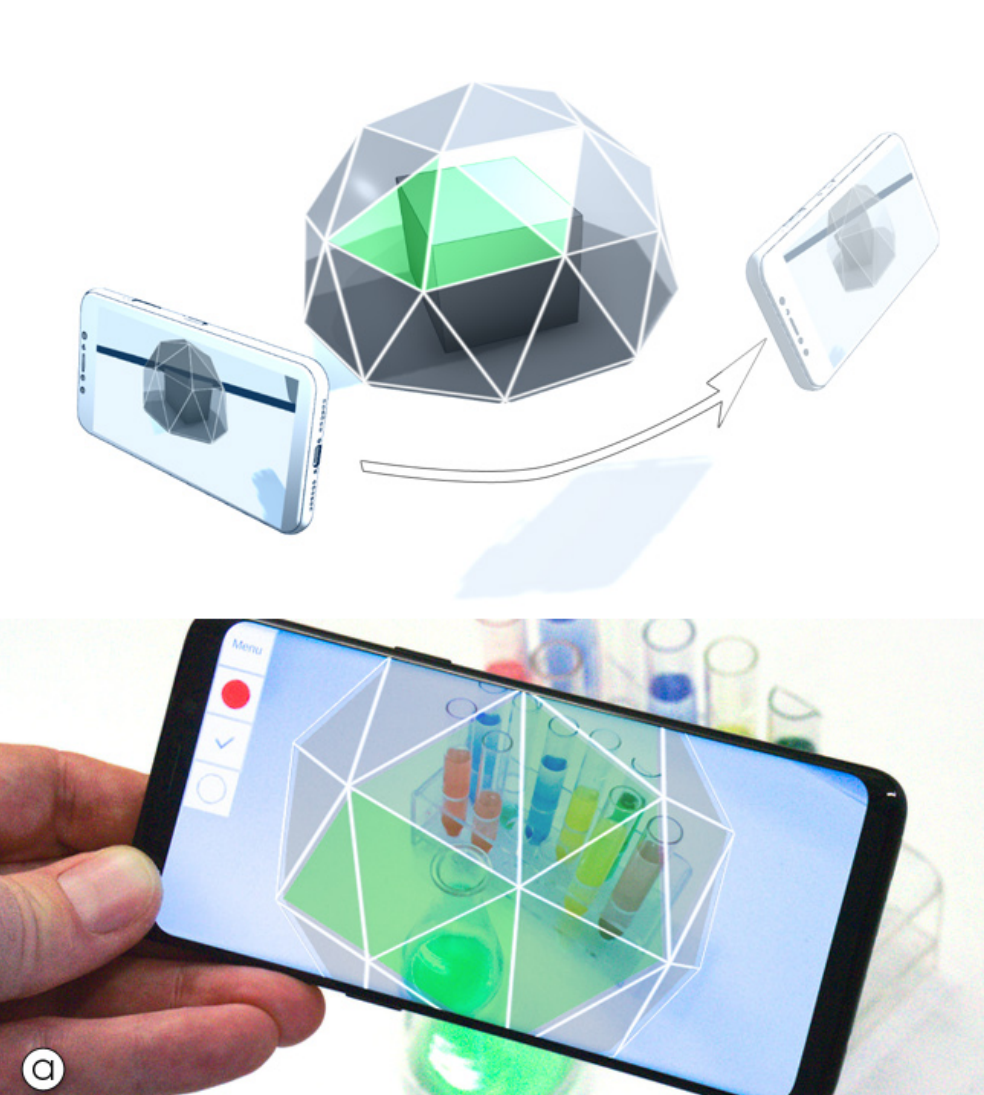
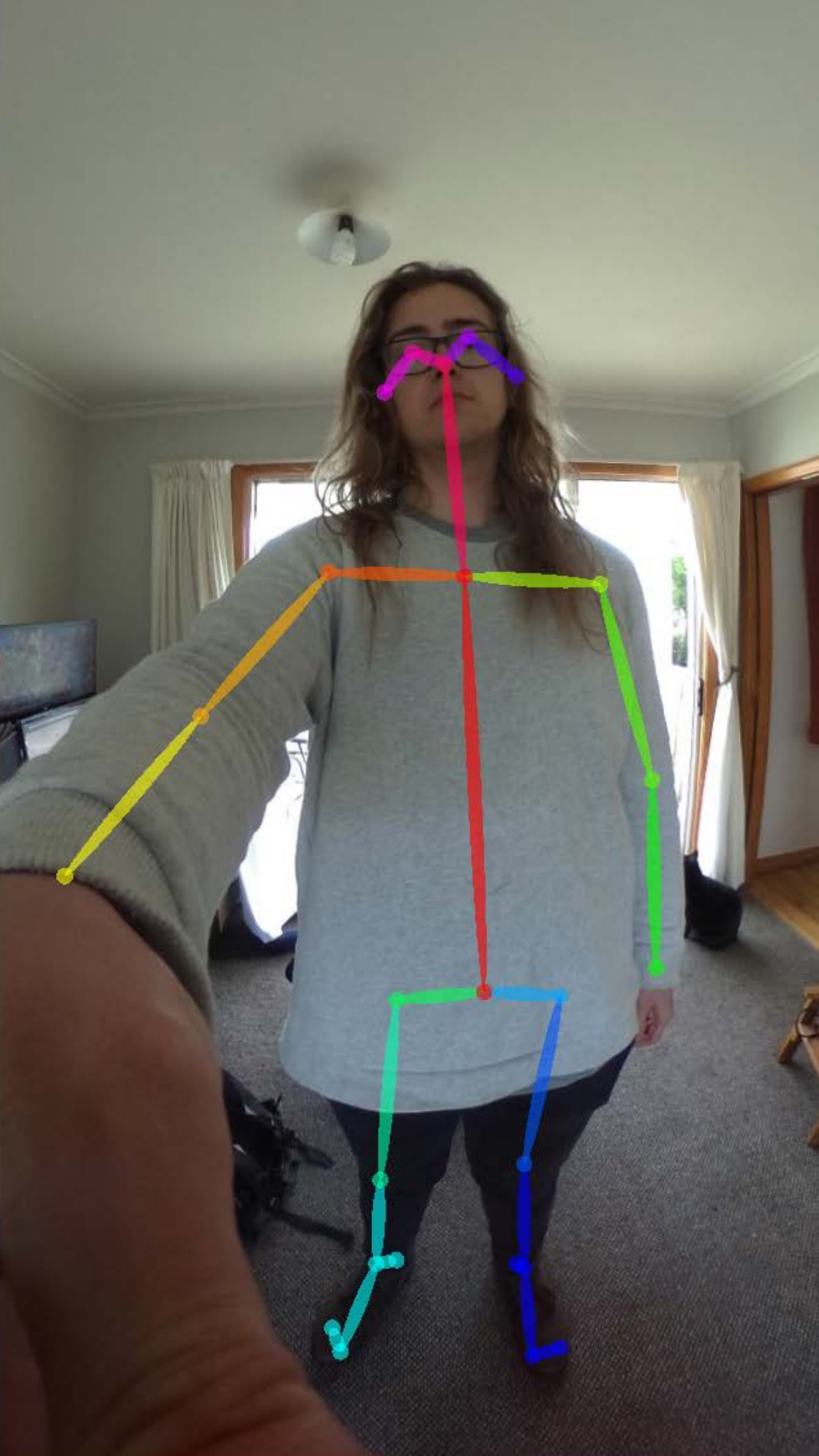
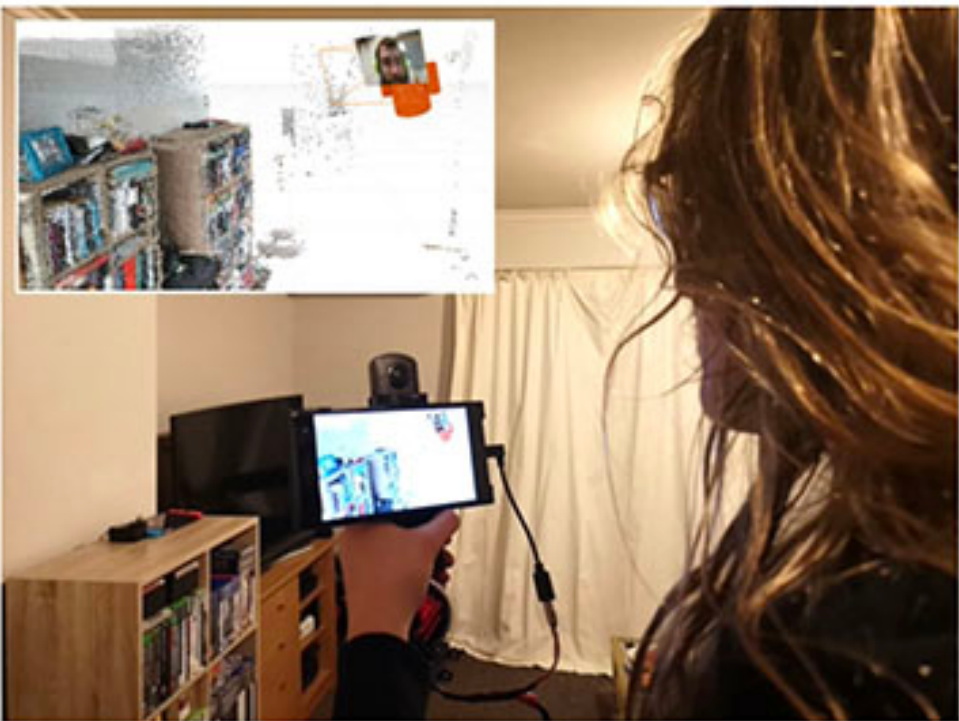


Peter Mohr, Shohei Mori, Tobias Langlotz, Bruce Thomas, Dieter Schmalstieg, Denis Kalkofen (2020) Mixed Reality Light Fields for Interactive Remote Assistance
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Mobileportation: Nomadic Telepresence for Mobile Devices

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