I See What You See:

Interaction Design of Shared Gaze Cues in Collocated AR Environment

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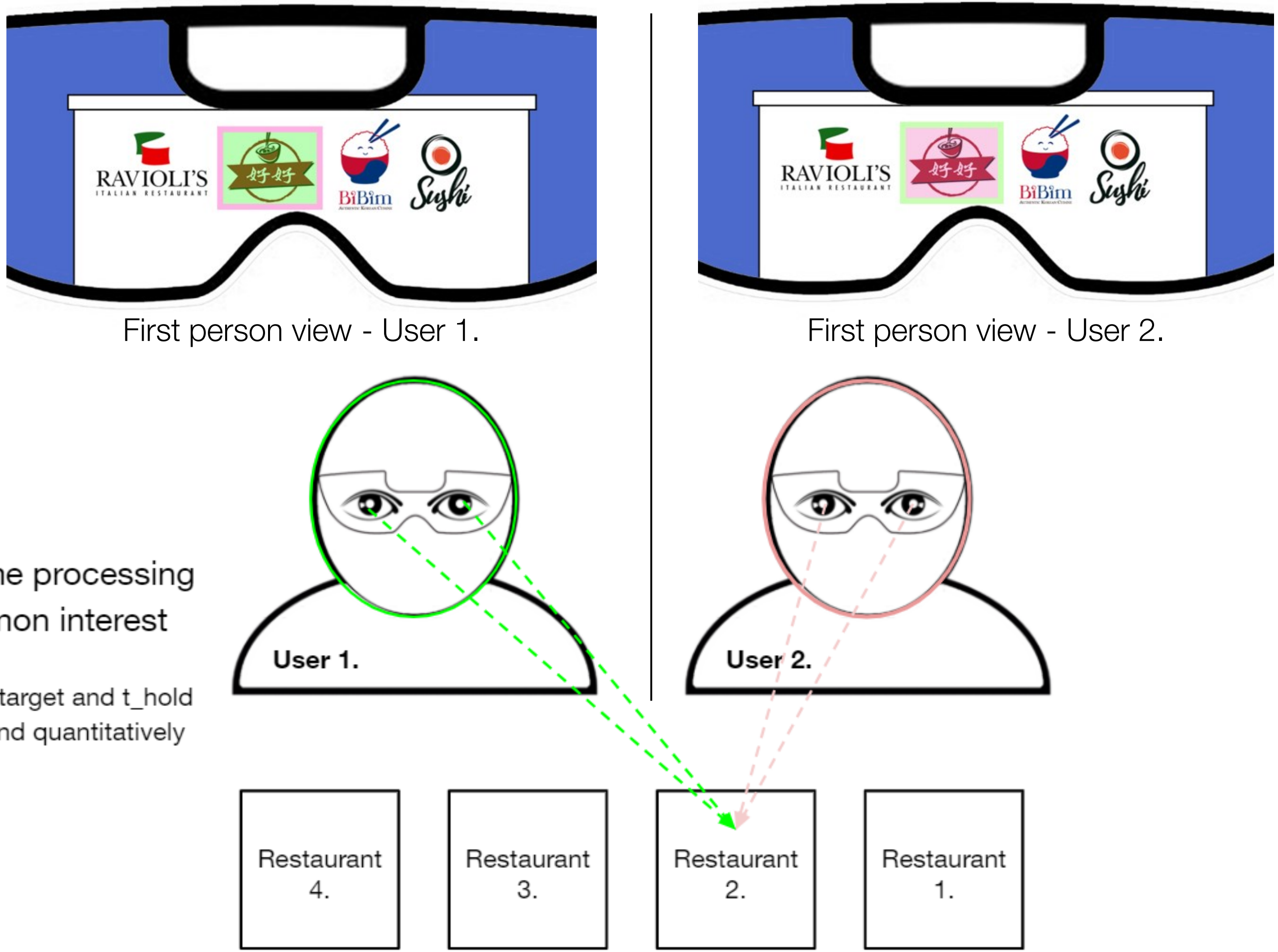
Purpose



Real-time processing of common interest

Individual target and t_hold spatially and quantitatively equivalent

NEEDS

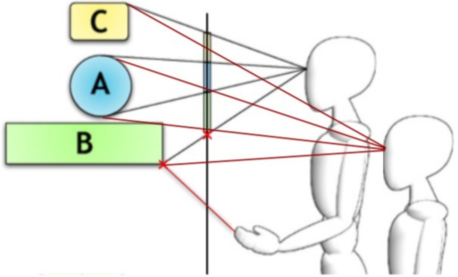
“How do we tell distant objects to others?”

Distance Interactions in Physical World

Modalities for Selecting Distant Target = {Verbal, Pointing}

Verbal communication has
Dimensional Limitation

Pointing distant target results
Eye-Hand Visibility Conflicts



NEEDS | Also critical in collocated AR Environments

Radu, I., Joy, T., Bowman, Y., Bott, I., & Schneider, B. (2021). **A Survey of Needs and Features for Augmented Reality Collaborations in Collocated Spaces.** Proceedings of the ACM on Human-Computer Interaction, 5(CSCW1), 1-21.

Categories of collaborative needs	Example features
4.1 Collaborators need to be aware of others' attention and activities	
Collaborators need to stay socially aware of each other's presence, location and intention of action.	[2,39,42,45,46,63,74,85,92]
Collaborators need to see each other's emotions	[19,66,67]
Collaborators need to stay aware of the progress of synchronized tasks	[18,23,58,63]
Collaborators need to show/hide layers of the environment	[2,26,31,48,53]
Collaborators need to have information on demand	[7,29,32,40,48,63,89,97]
4.2 Collaborators need to be aware of the past	
Collaborators need to remember actions	[8,27,49,95]
Collaborators need to remember conversations	[4,15,27]
4.3 Collaborators need to coordinate attention	
Collaborators need to specify direction of attention	[5,41,45,53,64,76,84,85,92]
Collaborators need to specify objects of attention	[3,6,13,37,55,69,91]
Collaborators need to manipulate objects at the same time	[35,61,63]
4.4 Collaborators need to coordinate instructions	
Collaborators need to annotate objects	[9,30,41,76,82,85]
Collaborators need to guide others	[13,23,31,40,41,55,74,86,92]
4.5 Collaborators need privacy	
Collaborators need personalized information	[39,68,96]
Users need private space within a collaborative space	[27,38,44,75,82]
4.6 Collaborators need to manipulate virtual objects	
Collaborators need to move virtual objects	[6,8,13,21,30,59,70,78,79,82]
Collaborators need to modify virtual objects	[30,32,69,72]
4.7 Collaborators need to share the same environment	
Collaborators need to see the same virtual content	[74,83,92]
Collaborators need to have a smooth networked experience	[26,46,56,63,80]

Surveyed 92 studies of AR and VR collaborations

Taxonomy with 18 categories of AR features on demand

Needs notable for our project

- coordinate attention towards objects
- coordinate attention towards instructions
- aware of other's attention and activities

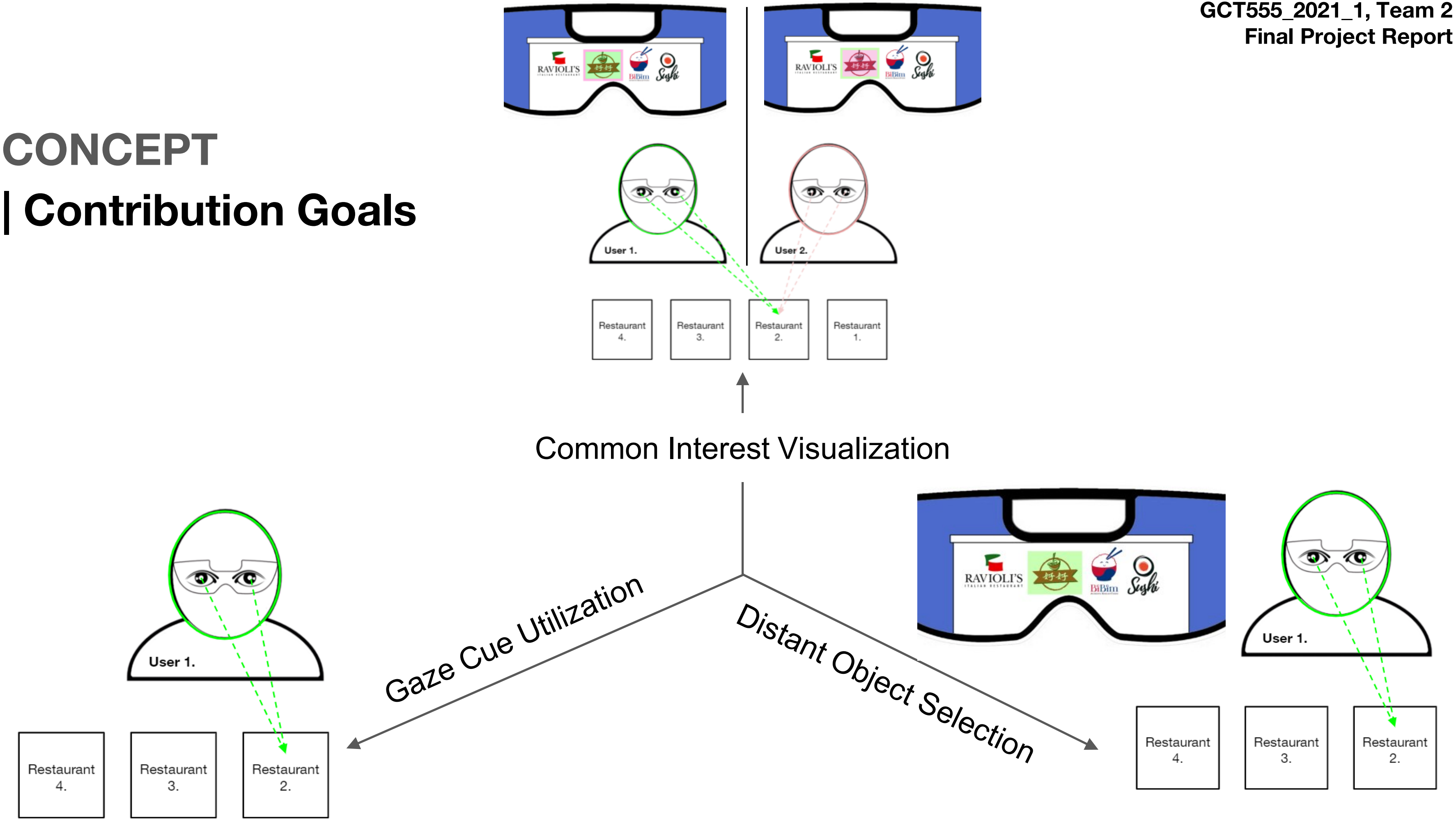
NEEDS | Visualizing Itself is Not Enough!!!

https://youtu.be/-zEALCdrlUg

→ Context-aware visualization is necessary, especially in collocated AR environment.

→ Between hand gestures and eye gaze, which would be appropriate to visualize as an input modality ?

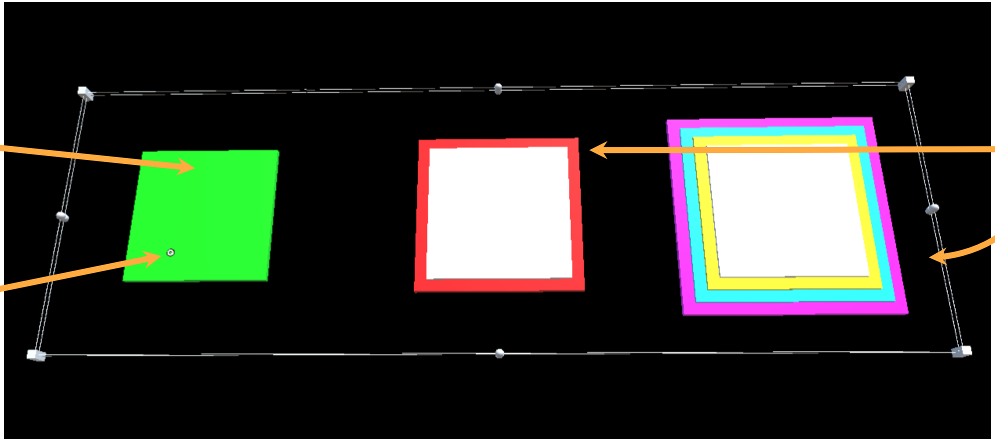
CONCEPT
| Contribution Goals



CONCEPT | Gaze Cue Interaction

One’s own selection

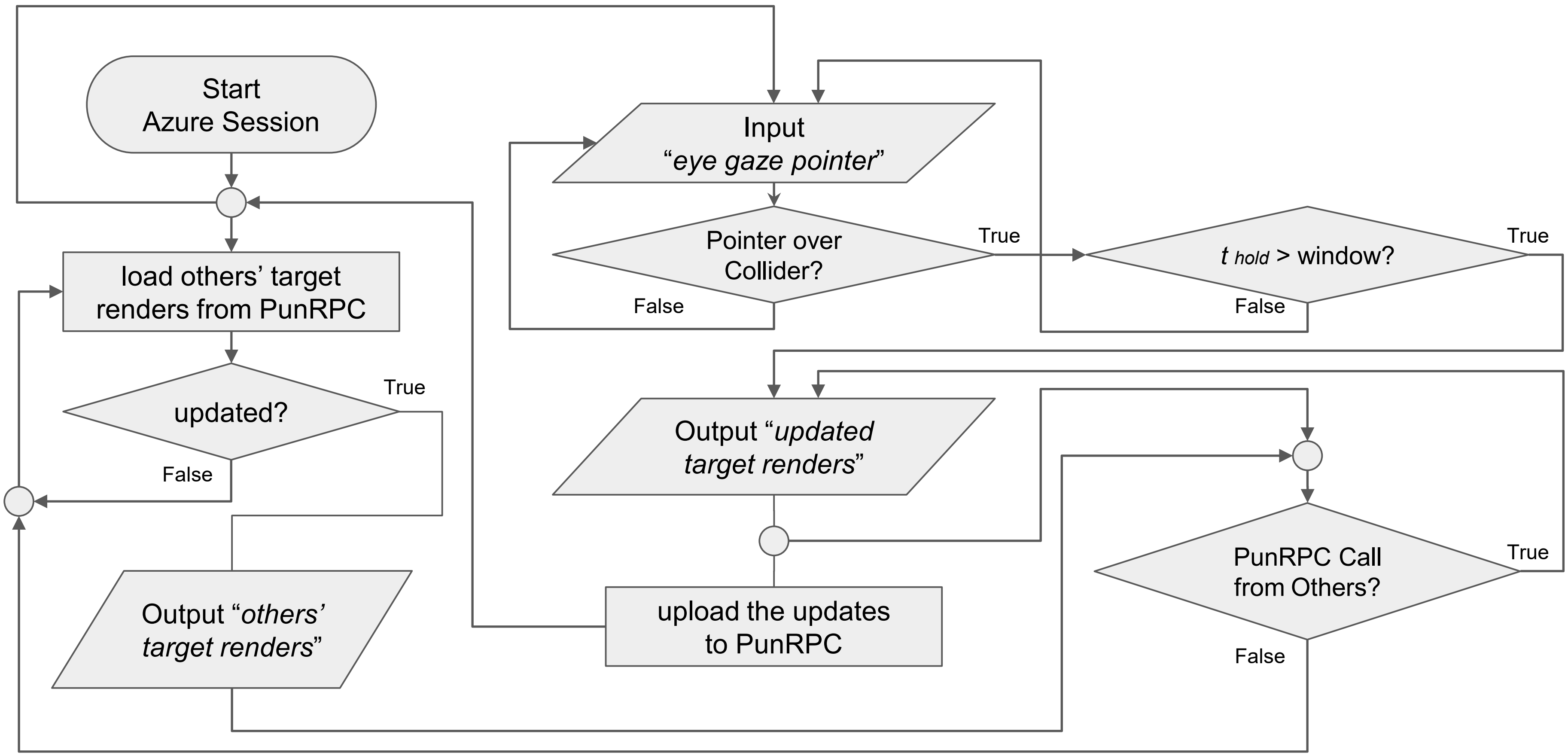
One’s own eye gaze



Selection of others

1. Visual separation between selection(s) of one’s own and the others
2. Selection tendencies also visualized as histogram (aiding context-awareness)
3. Real-time interaction in collocated environment

APPROACH | Logics for Synchronizing Target Renders



Benefits

- **Proposed a new design space** of interaction between visualized gaze cues in collocated AR spaces.

- **Context-aware** UI for collaborative and collocated tasks.

- **Aids attention cueing interactions** where it is hardly possible with conventional finger pointing gestures.

- Can be utilized even under highly-densed spatiotemporal domain; commercially valuable **targeted advertisements**

COMPARISON | Sharing Gaze Cue Improves Collaborative Work

Novelty	Gaze Visualization	Highlighted ROI	Interface
Piumsomboon (2017)	Frustum	-	Fixed 2D GUI
Gupta (2016)	Marker	-	-
Bai (2020)	Frustum & Ray	-	3D Pin Arrow
Yao (2018)	Marker	-	2D Scroll Bar
Osmers (2020)	-	Augmented 3D	Compass, X-RAY, Map

COMPARISON | No Interaction has Provided for Collaborative Gaze

The efficiency of collaborative gaze interaction have been repetitively proposed, but few research studies have been investigated about their **interactive feedback**.

CoVAR (Piumsomboon et al., 2017)

- ➔ one of the first research studies proposing collaborative gaze interaction
- ➔ does not offer feedback when occlusion of gaze frustum

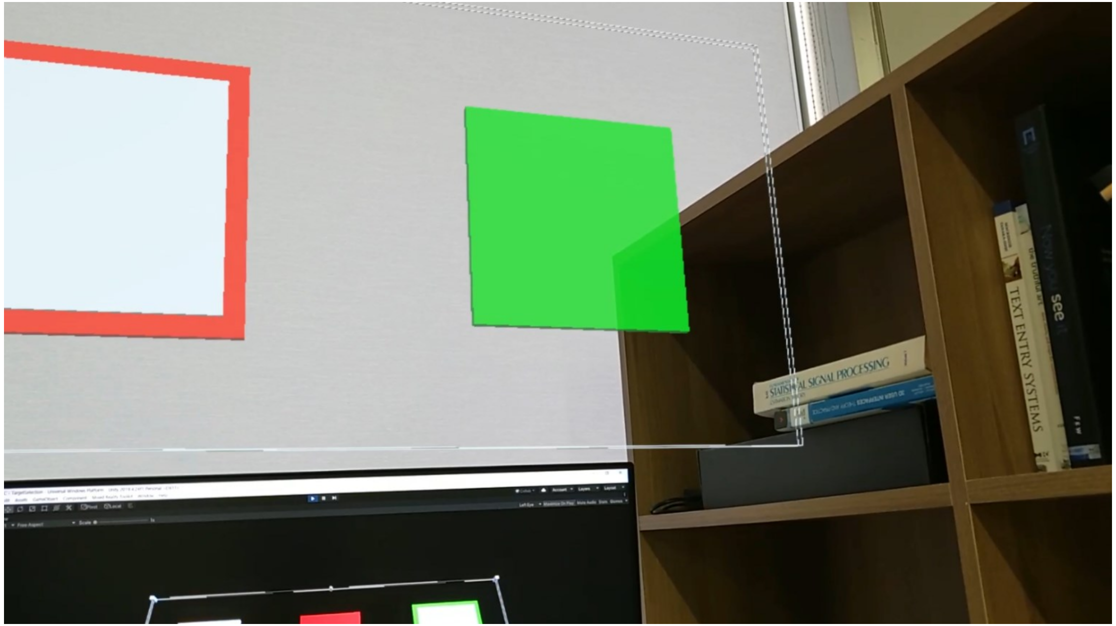
Sharing Gaze Rays (Erickson et al., 2020)

- ➔ difference in FOV of HMD can affect performance in collaborative gaze interaction

Effects of Depth Information (Erickson et al., 2020)

- ➔ tries to compensate head-eye gaze conflict between users in collaborative environment
- ➔ visualizing with ray-casted points, but without occlusion feedback

RESULTS | Working Demo



https://youtu.be/BD0OUcZOQbI

RESULTS | Evaluation Process

Simulation Study

- to find the efficacy of finger pointing methodology in collaborative AR environment.

Apparatus Validation

- to measure spatial and temporal performance of our system.

User Study

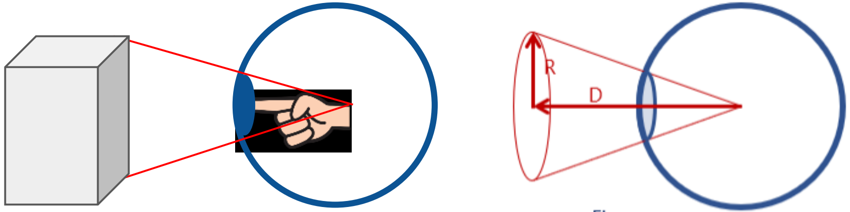
- to compare the performance of visual cue for different attention cueing methods.
- we simplified the experiment design of Akkil et al. (2016), UIST

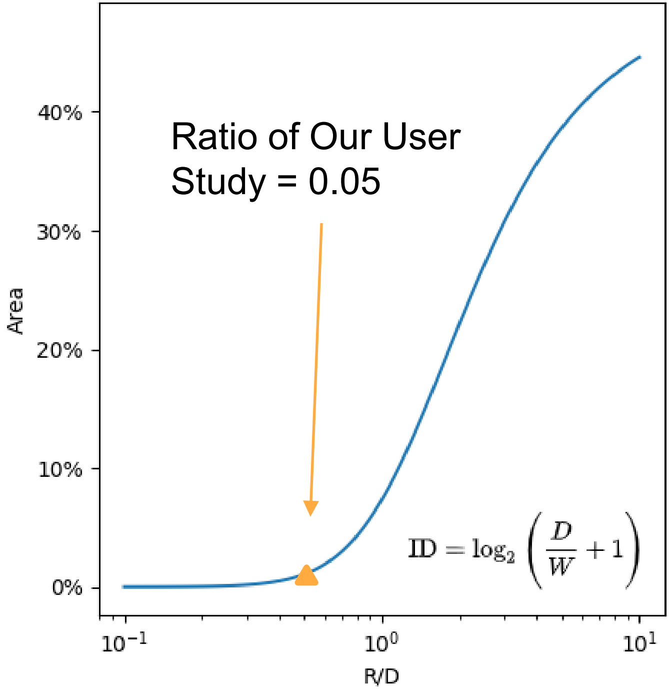
RESULTS | Simulation Study

How difficult to point a specific target?

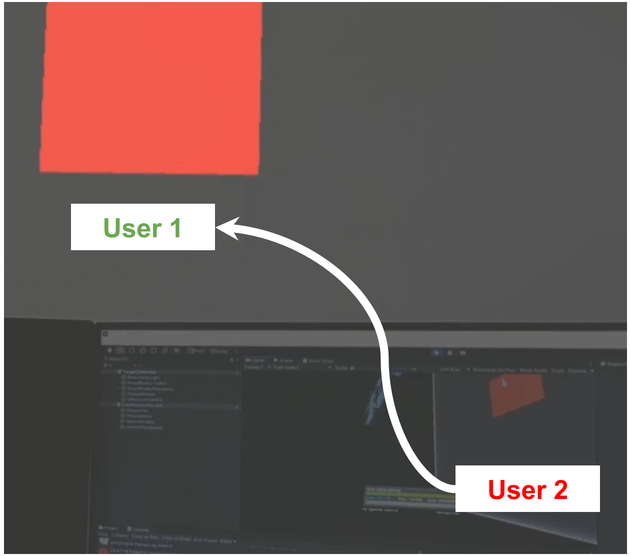
- assumption: uniform distribution of finger orientation
- calculated a ratio of selection range over FOV
- ratio drops almost zero even when R/D~=0.3

→ **finger pointing is not good for distant targets**



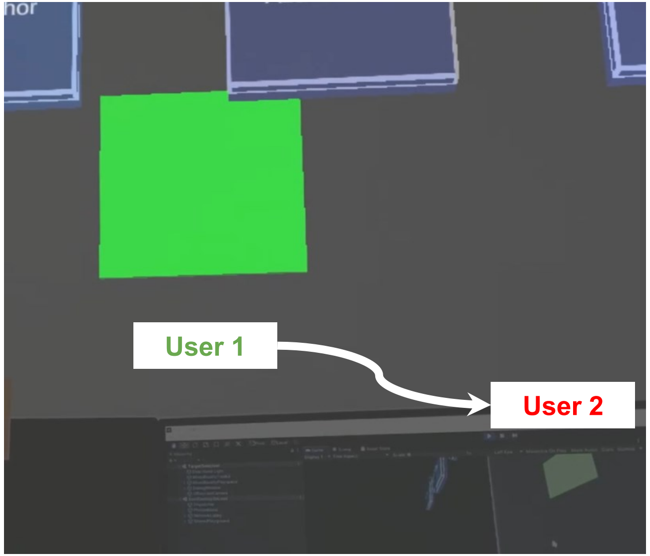


RESULTS | Performance of PunRPC Synchronization



PC → Photon → Hololens 2

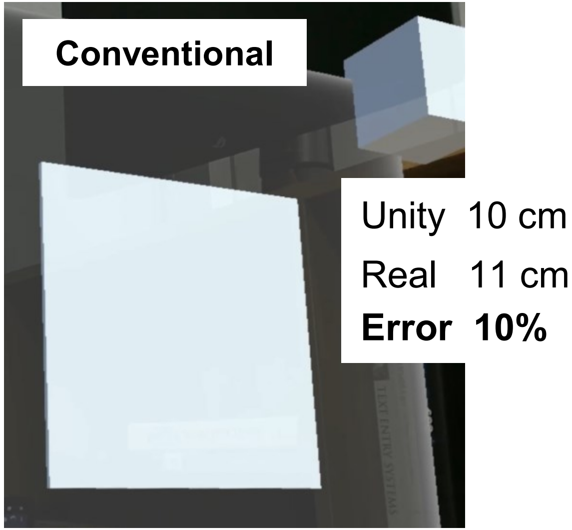
ΔT = **0.28 sec** (SD=0.12)



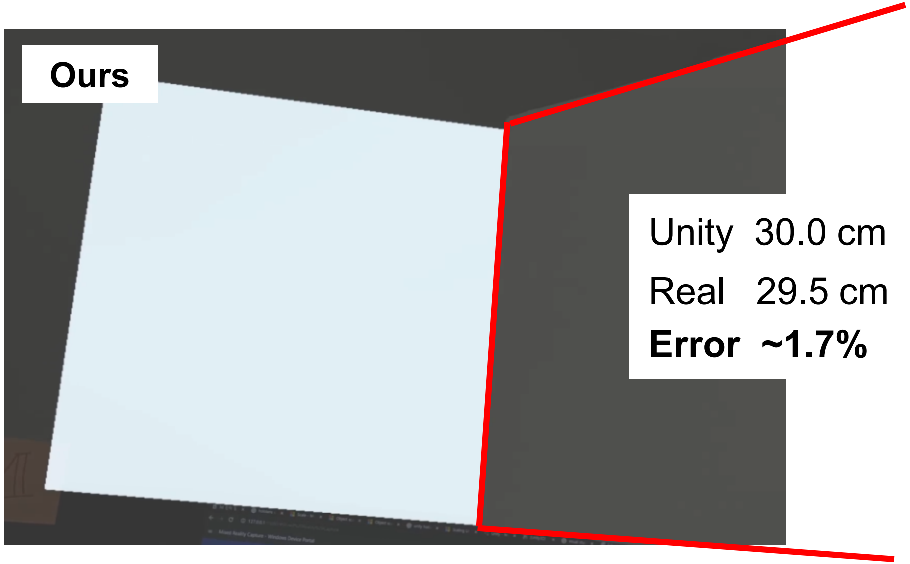
Hololens 2 → Photon → PC

ΔT = **0.35 sec** (SD=0.13)

RESULTS | Performance of Target Scale Augmentation



We measured real size of a unit sized cube from Unity.



Then we applied the ratio for instantiation to match the physical size of real target.

USER STUDY

Material: Video recordings of a demonstrator selecting one of three distant targets
utilizing one of two attention cueing methods (finger pointing and ICUC)

Randomly generated sequences of choices (N=12, controlled entropy of choice sequence)

Procedure: Providing a pair of video clips with different cueing methods
- Task: Writing down target selections from the demonstrator

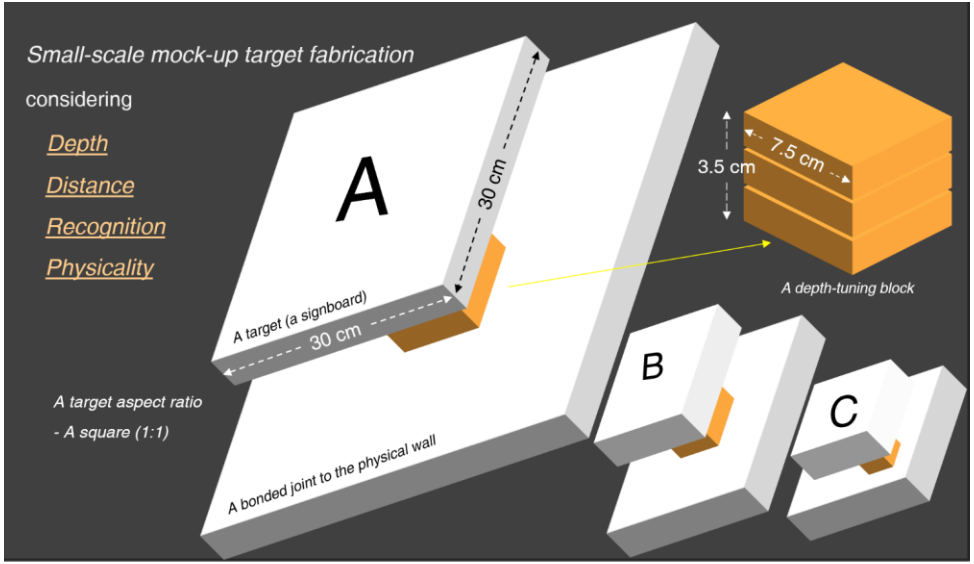
Analysis:

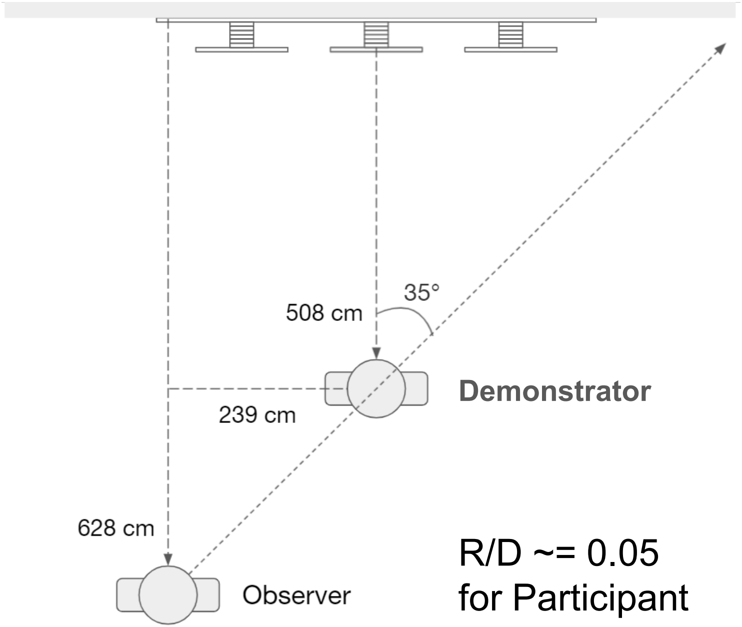
1) Comparison of participant scores
   - # of correctly selected targets for each clip

2) Order of demonstration videos considered as between subject factors (due to learning effect)

3) Significance validation through within-subject ANOVA (cue methods X video orders)

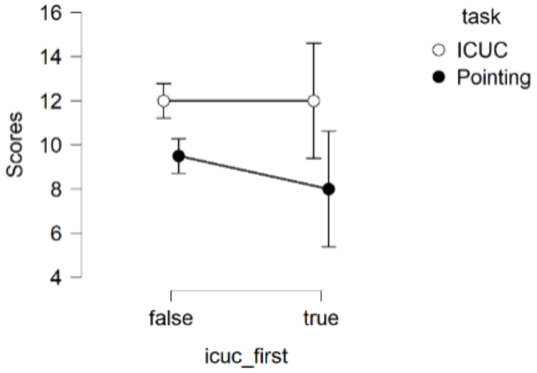
RESULTS | User Study





R/D ~= 0.05
for Participant

STUDY RESULTS



Descriptives

task	icuc_first	Mean	SD	N
ICUC	false	12.000	0.000	6
	true	12.000	0.000	6
Pointing	false	9.500	1.049	6
	true	8.000	3.521	6

Significantly higher scores (p=0.001) for observing ICUC > observing finger pointing.

No significant effects of video orders (p=0.341).

→ Participants can understand attention cues more accurate in ICUC than finger pointing.

Thank you

Q & A.