

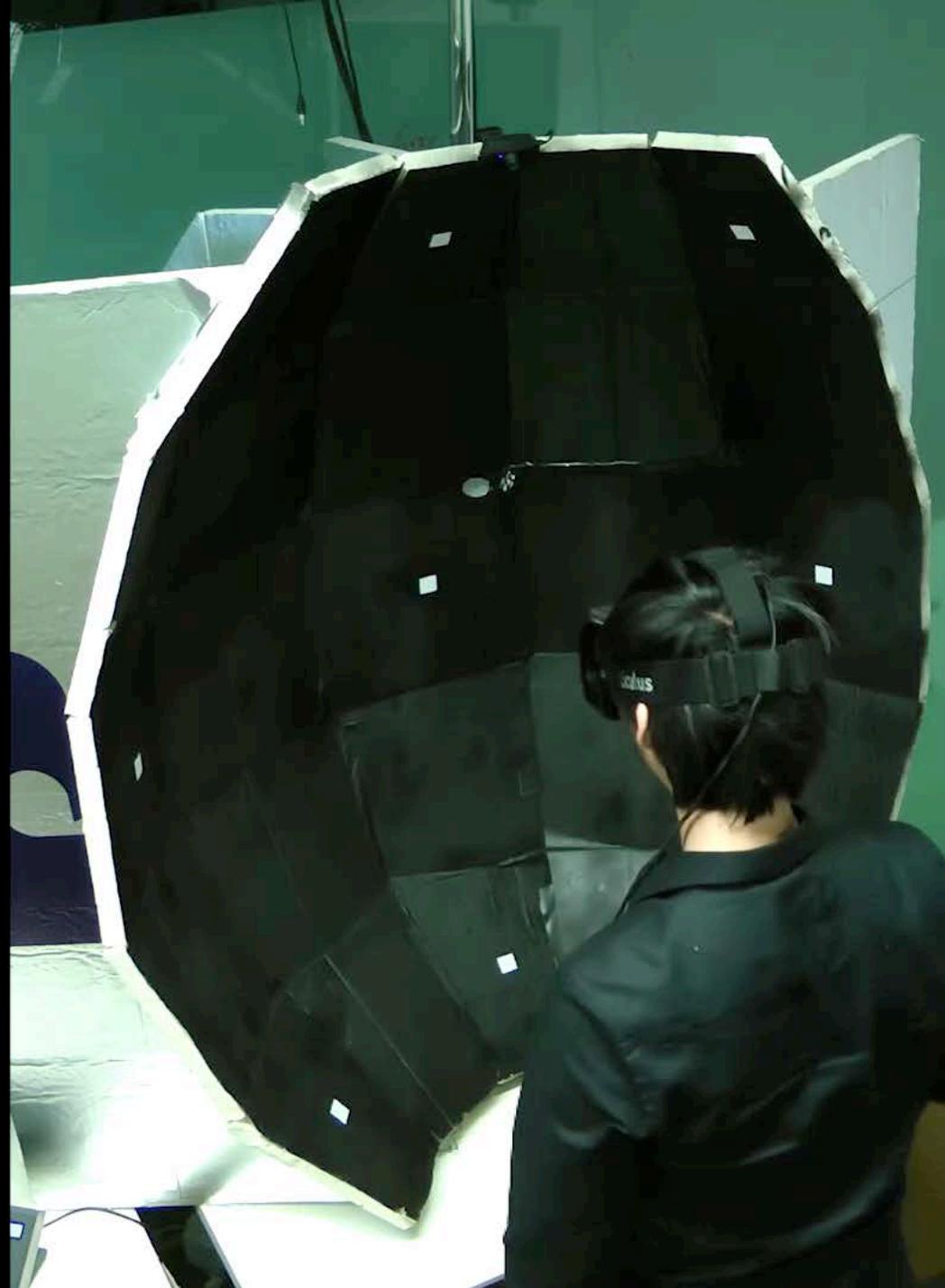


Sparse Haptic Proxy

Touch Feedback in Virtual Environments Using a General Passive Prop
Lung-Pan Cheng, Eyal Ofek, Christian Holz, Hrvoje Benko, Andrew D. Wilson

Microsoft Research

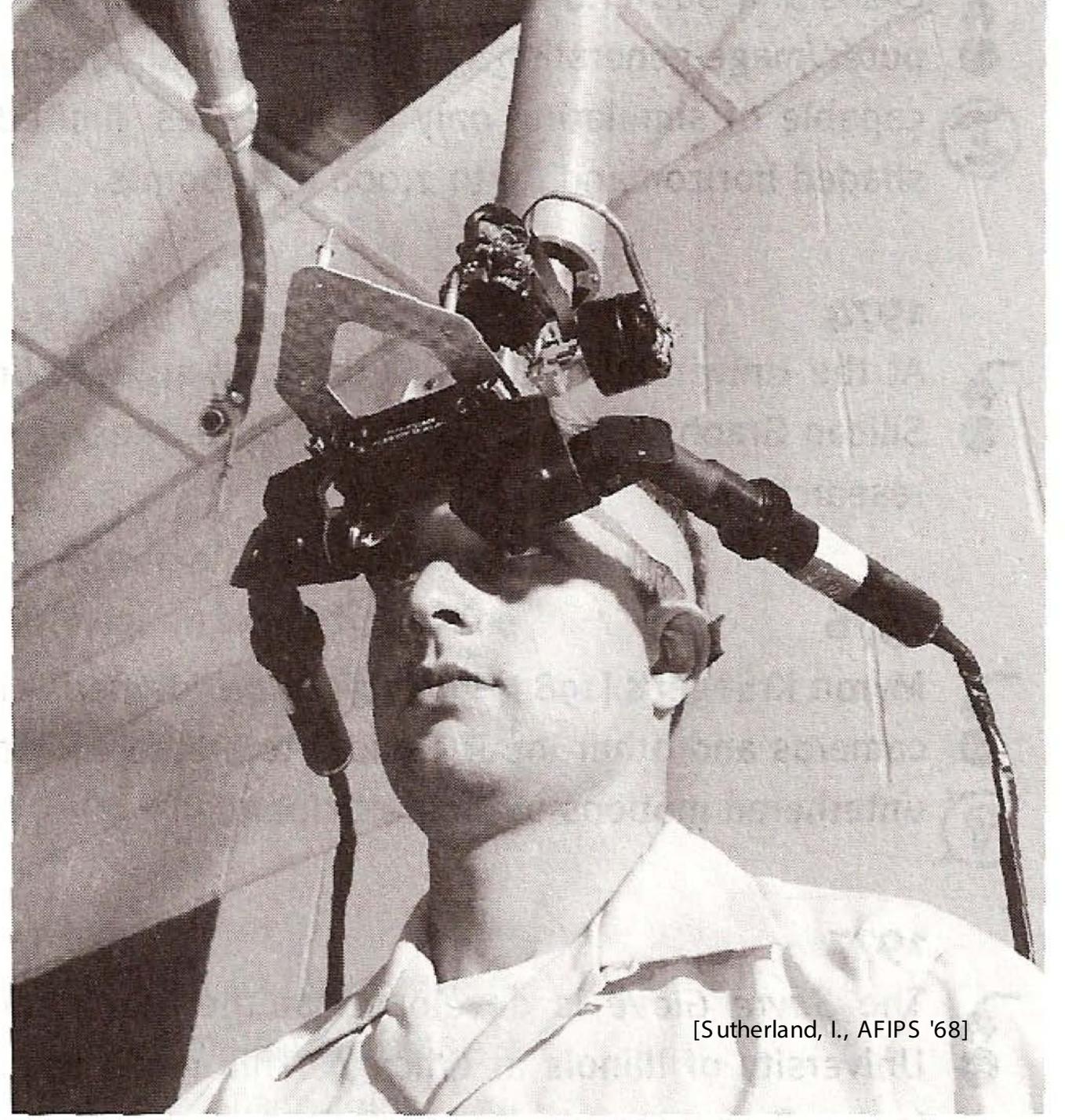
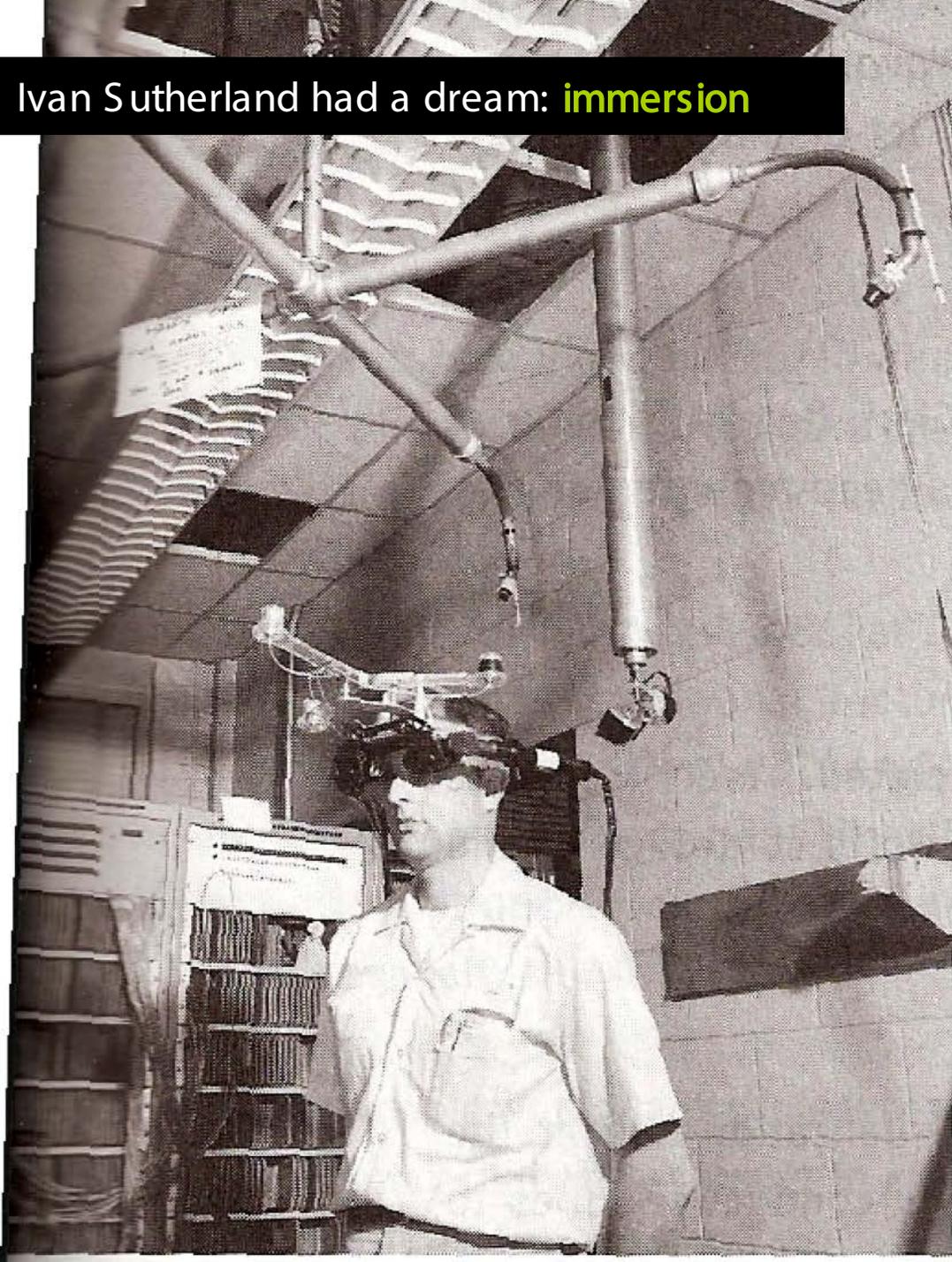






introduction

Ivan Sutherland had a dream: **immersion**



[Sutherland, I., AFIPS '68]

photo realistic graphics



[Performer Town on SGI Onyx 350]

surrounding sound



[The Air Force Research Laboratory]

give users their body back



[CAVE, EVL, 1993]



graphics, tracking and sounds are almost ready to every one

but **touch** is not...



How do we advance haptic feedback to the same **level of fidelity?**

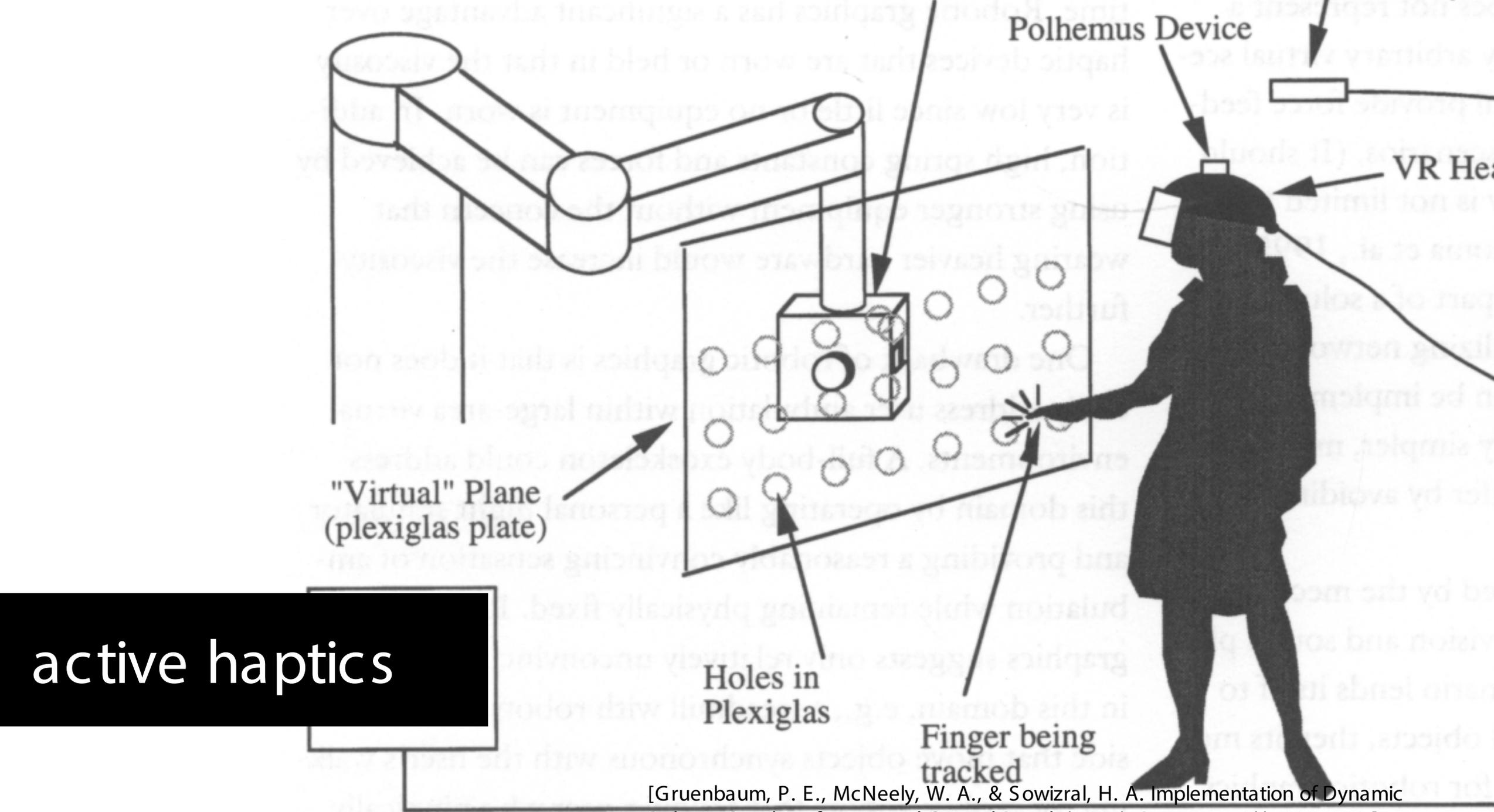
related work

active haptics:=

provide haptic feedback by means of **machinery**



active haptics



[Gruenbaum, P. E., McNeely, W. A., & Sowizral, H. A. Implementation of Dynamic Robotic Graphics for a Virtual Control Panel. (1997). Presence, 6(1), 118-126.]

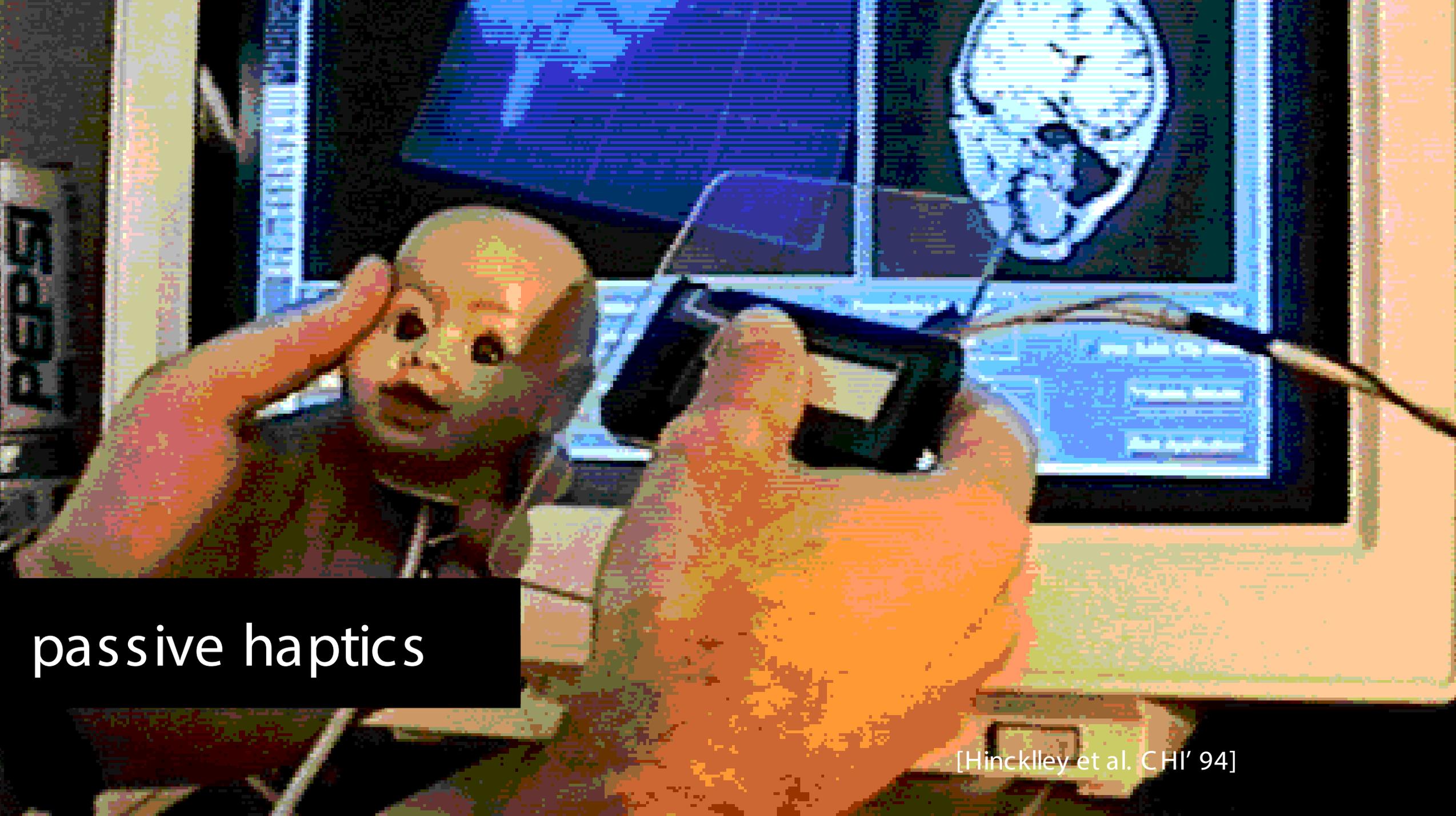
active haptics:=

provide haptic feedback by means of **machinery**

→ **complex, expensive, dangerous**

passive haptics:=

provide haptic feedback by means of **props**



passive haptics

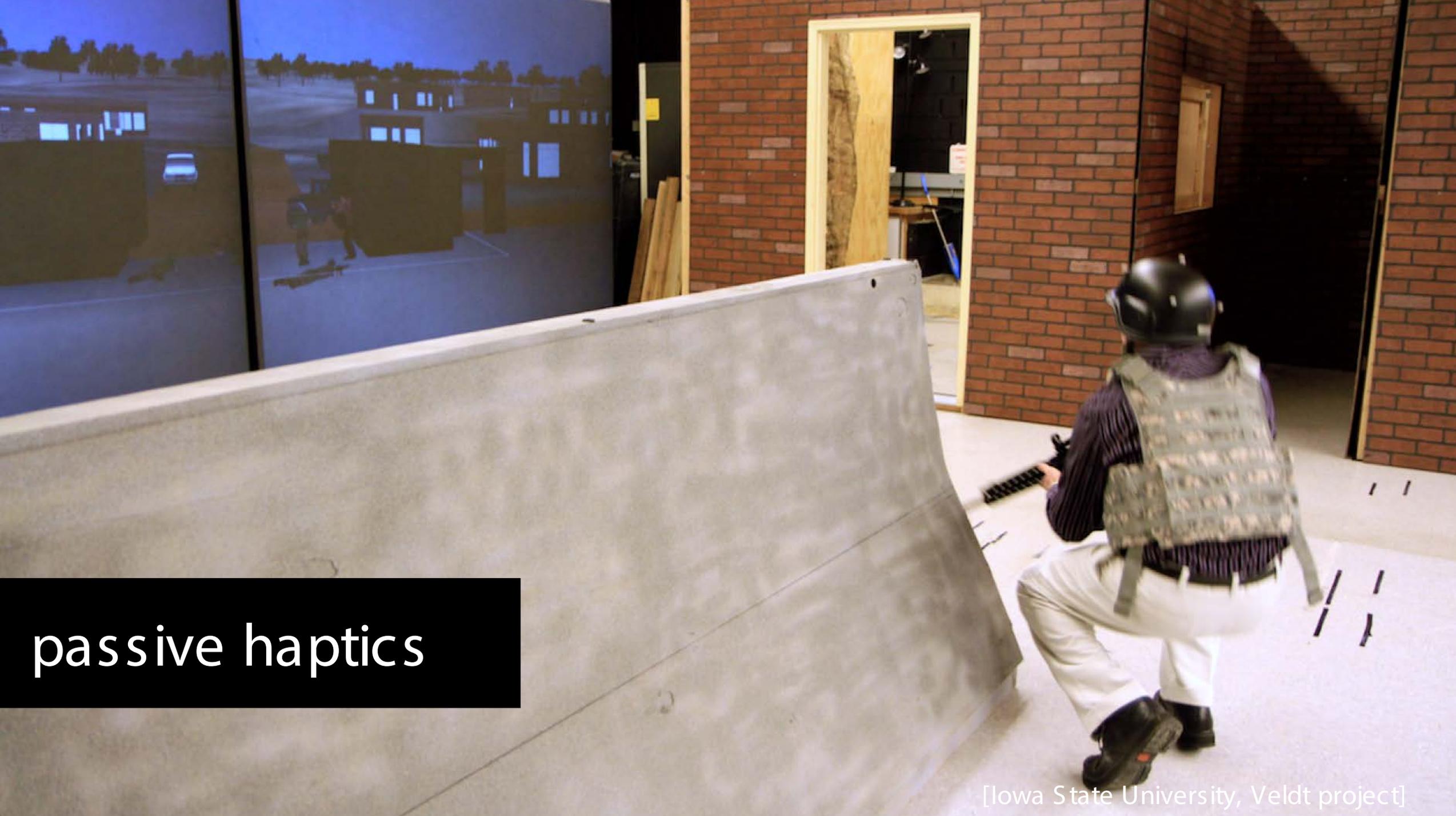
[Hinckley et al. CHI' 94]

passive haptics

highly increase immersion



[Insko, 2001]



passive haptics

[Iowa State University, Veldt project]



passive haptics



passive haptics

passive haptics:=

conveying **high-fidelity shape** information by means of props

→ one prop for one virtual object at one position



TYPE FEDERAL FIGHTER

[Elite: Dangerous]

body warping



one physical cube for **many** virtual cubes (at **many** positions)

how about other objects (walls, floor, etc.) in **more complex scenes?**

our goal:

all objects should be touchable

all touch feedback comes from passive haptics + body warping

for single-finger input:

many objects consist of **surfaces**

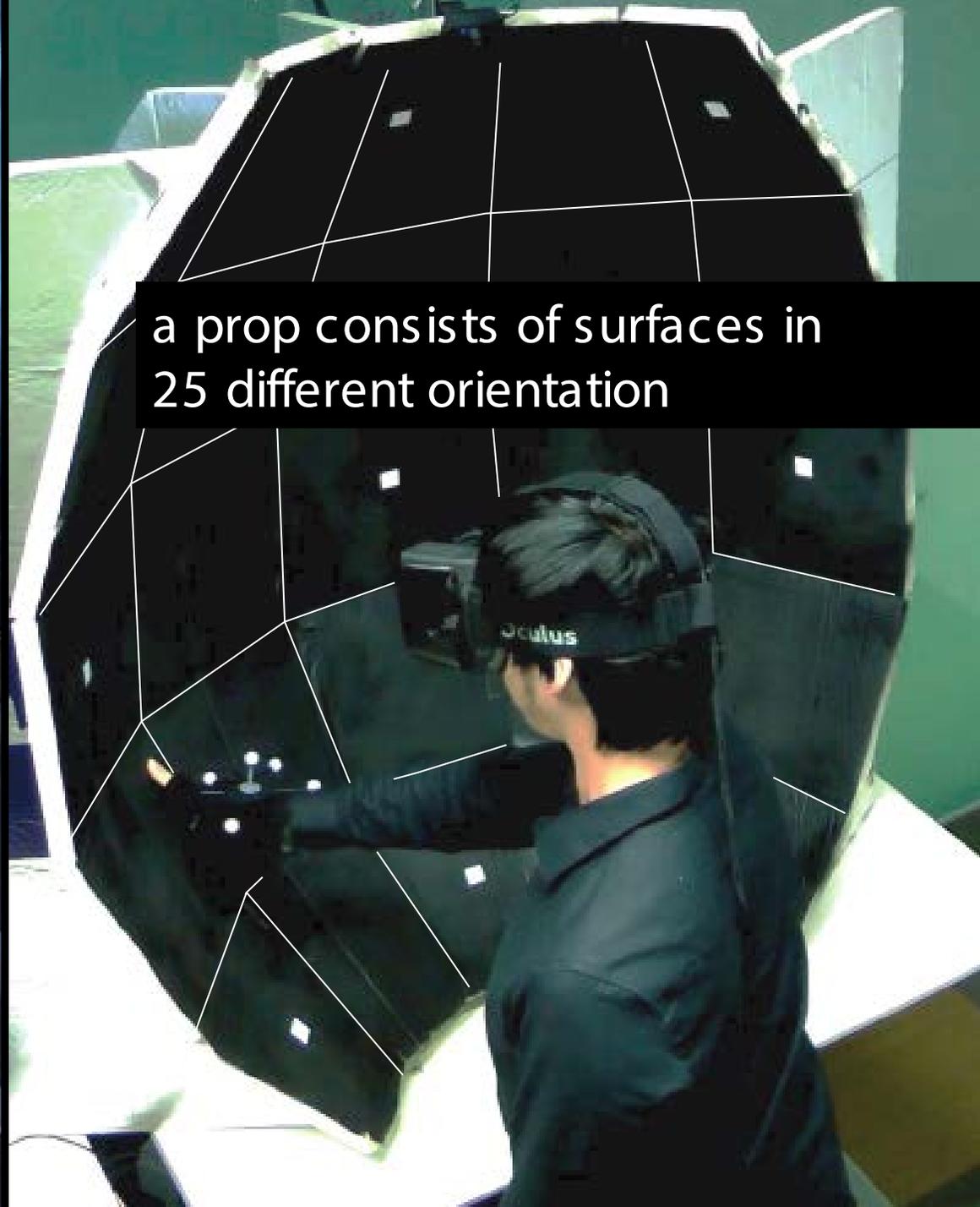
(e.g., a cube has **6 surfaces** at different orientations)

→ let's approximate all objects with **surfaces!**



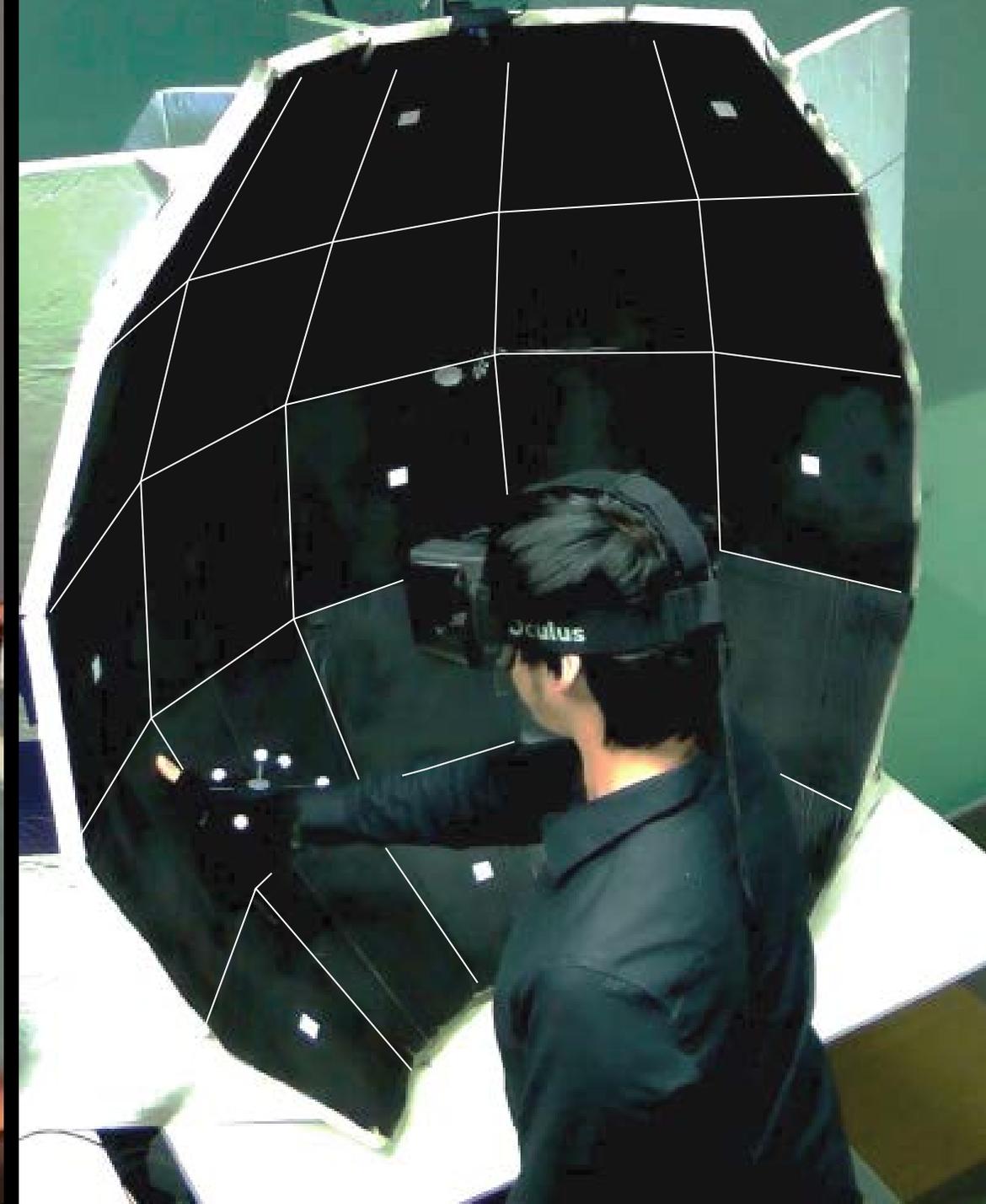
Sparse Haptic Proxy

a library of different surfaces that approximates **all objects** by redirecting the user's finger to touch an appropriate surface



a prop consists of surfaces in 25 different orientation

approximates different virtual scenes





debug view of the spaceship cockpit

Oculus camera

SMI eye-tracking
Oculus DK2

marker glove

OptiTrack
v120Trio



1

Target prediction

2

Mapping to proxy

3

Redirection range

implementation

1

Target prediction

2

Mapping to proxy

3

Redirection range

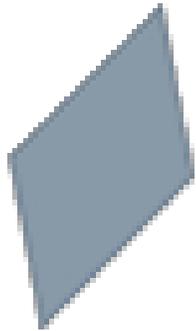
implementation

body warping

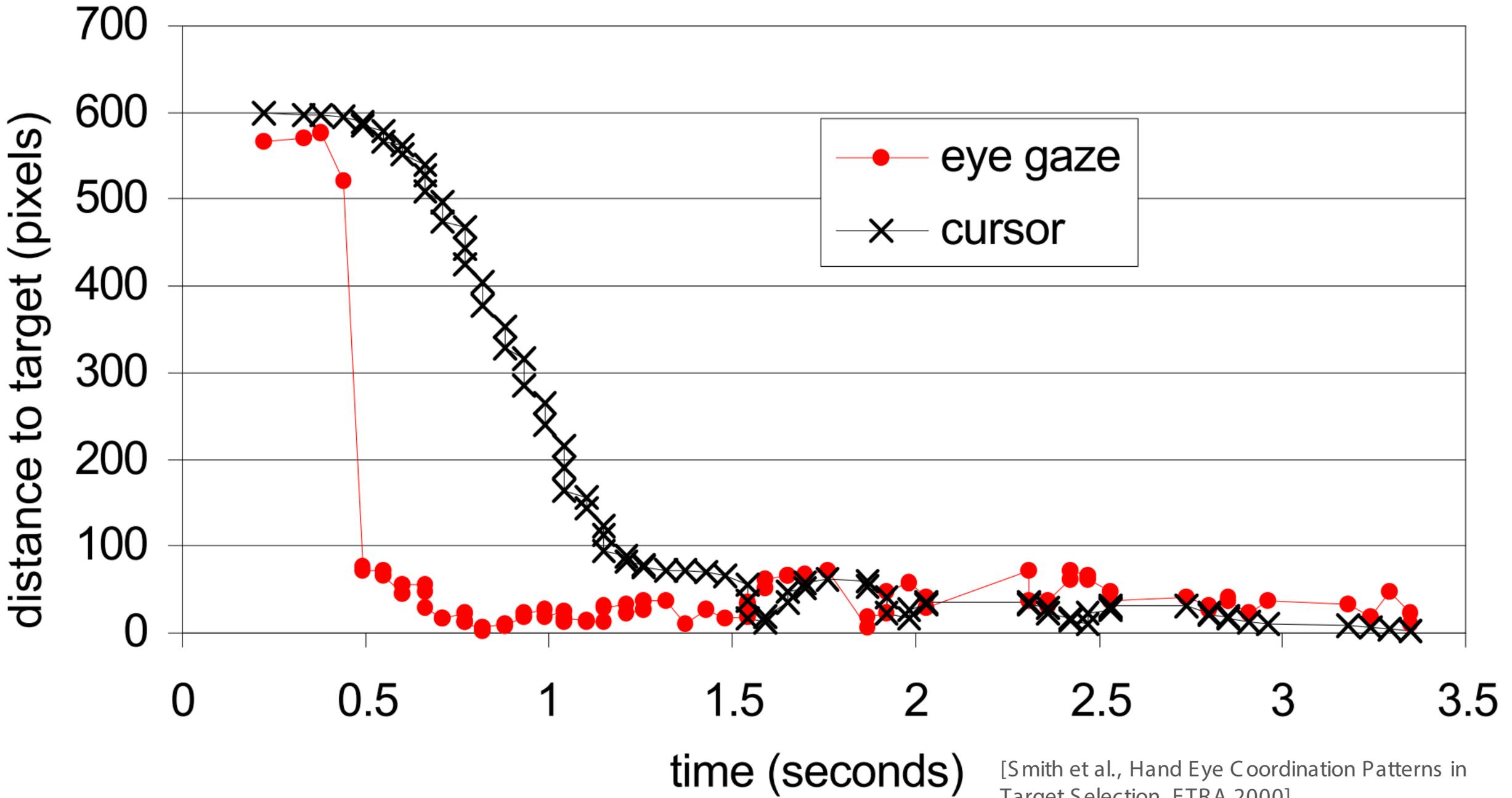
known
virtual target



known
physical target







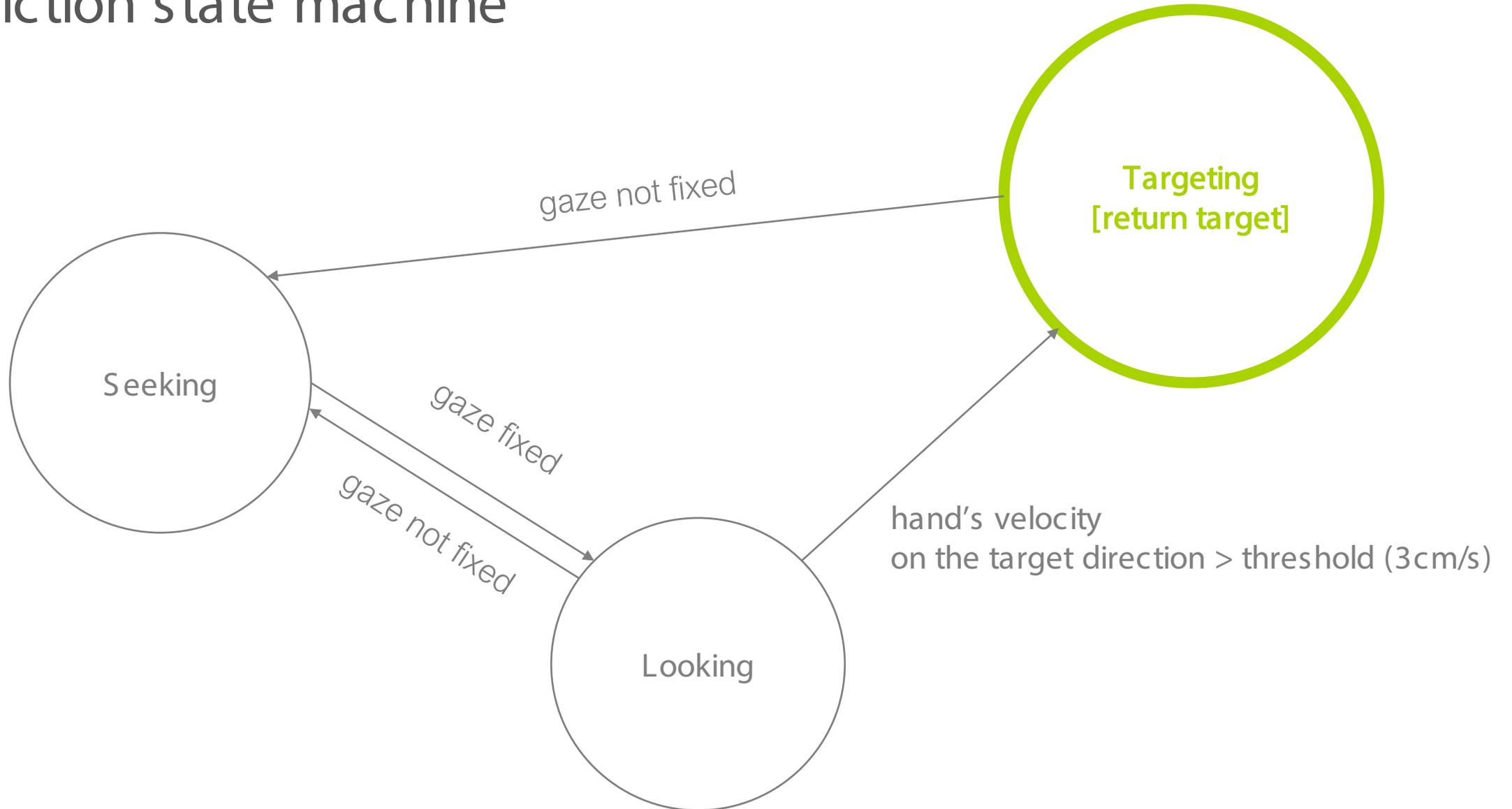
[Smith et al., Hand Eye Coordination Patterns in Target Selection, ETRA 2000]

S MI eye-tracking module

250 hz eye-tracker
on Oculus DK2

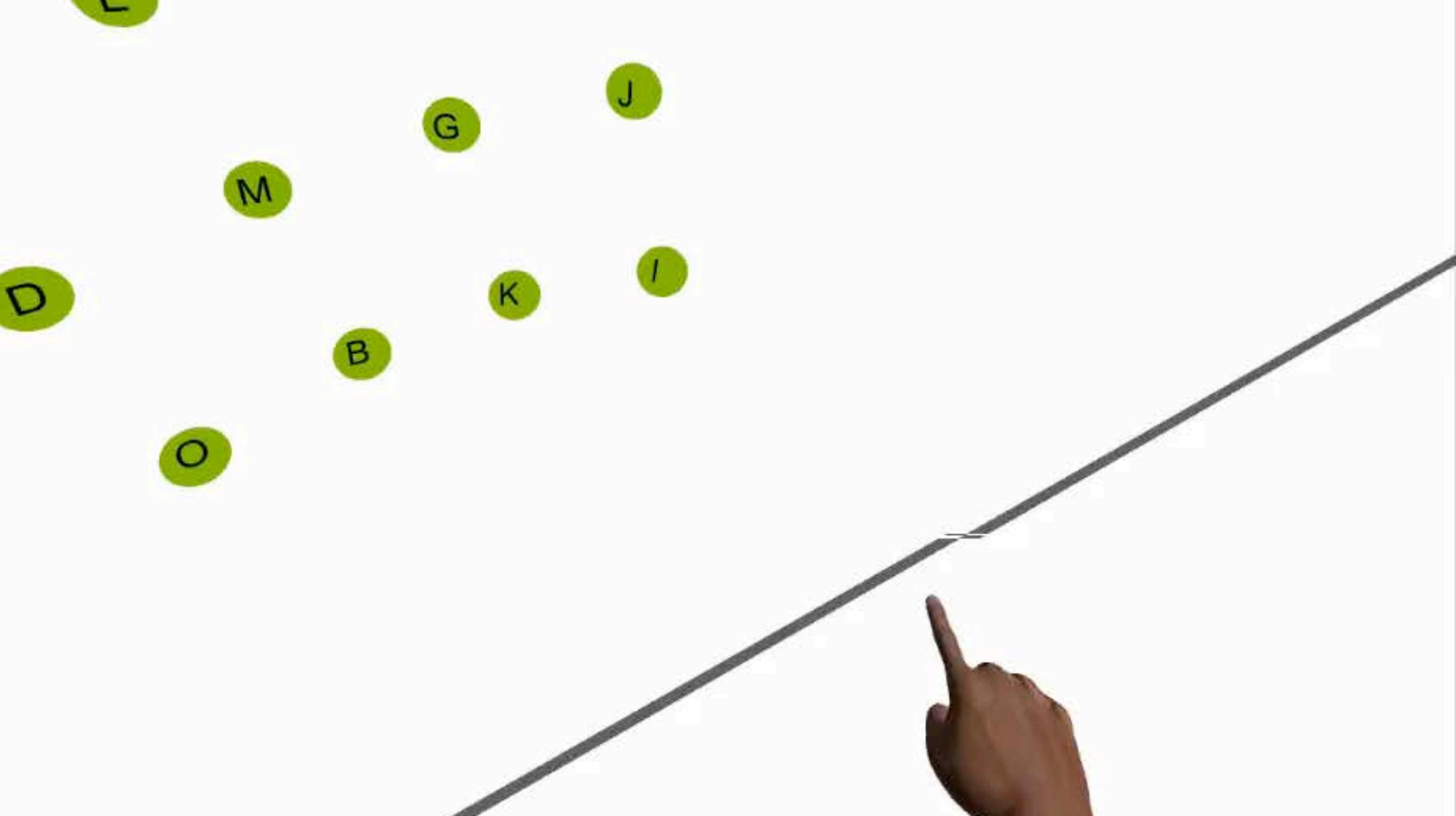


prediction state machine



Study 1

evaluating prediction during body warping





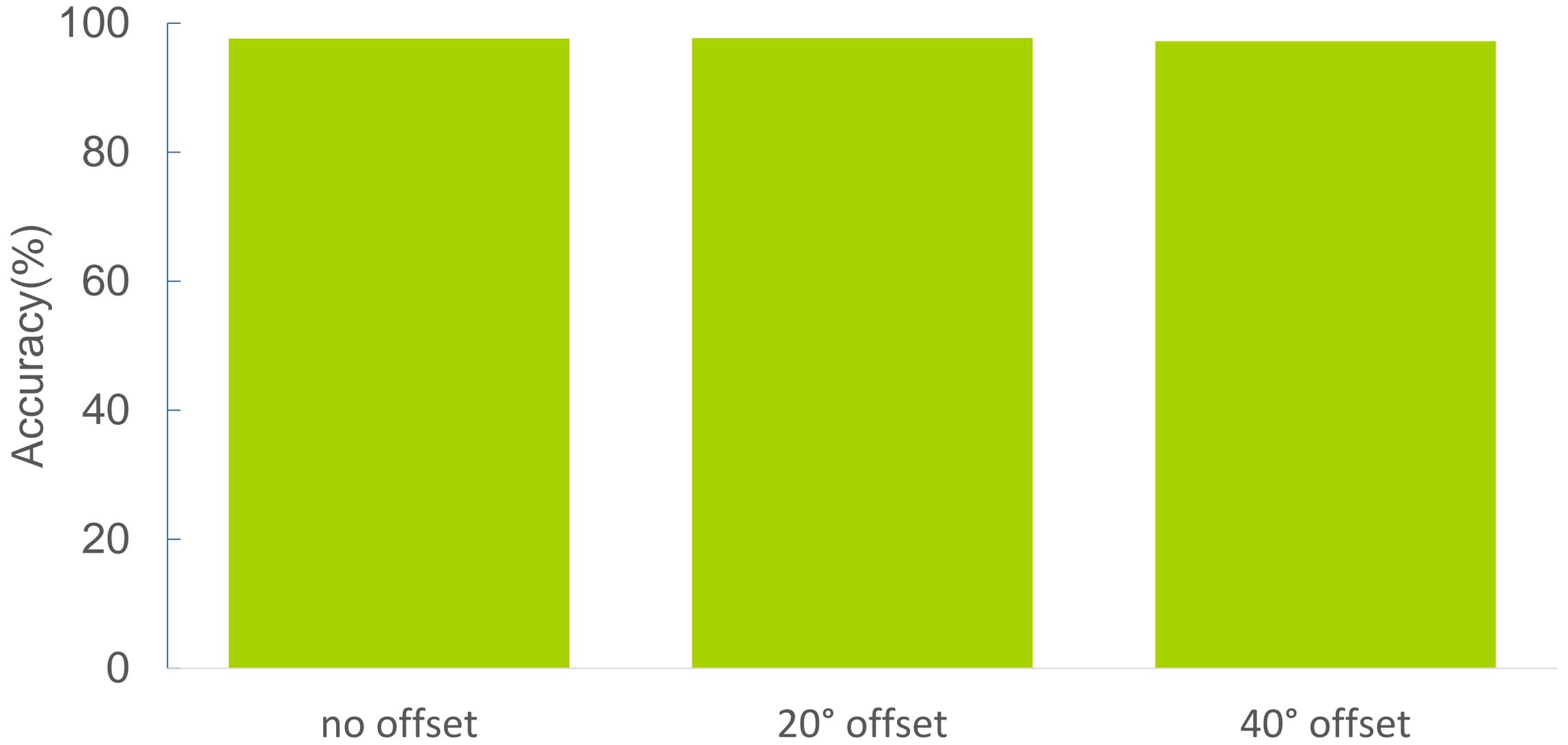
predicted target

actual
target

	p0	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15
a0	106	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
a1	0	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a2	0	1	107	0	0	0	0	0	0	0	0	0	0	0	0	0
a3	0	0	0	108	0	0	0	0	0	0	0	0	0	0	0	0
a4	0	0	0	0	108	0	0	0	0	0	0	0	0	0	0	0
a5	0	0	0	0	0	107	0	1	0	0	0	0	0	0	0	0
a6	0	0	0	0	0	0	107	0	0	0	0	1	0	0	0	0
a7	0	0	0	0	0	1	0	106	0	0	0	0	0	0	0	1
a8	0	0	0	0	1	0	0	1	104	1	0	0	1	0	0	0
a9	0	0	0	0	0	0	0	0	0	107	0	0	0	0	0	1
a10	0	0	0	0	0	0	0	0	0	0	108	0	0	0	0	0
a11	0	0	0	0	0	0	0	0	0	0	1	106	0	1	0	0
a12	0	0	0	0	1	0	1	0	5	3	0	0	95	1	1	1
a13	0	0	0	0	0	0	0	0	1	2	1	0	0	104	0	0
a14	0	0	0	1	0	0	0	0	0	1	1	0	0	1	104	0
a15	0	1	0	0	0	0	1	0	0	1	1	1	1	0	2	100

12 participants (7 female), ages 24-30 (M=27.6)

prediction accuracy: **97.5%, 2.04 seconds before touching**



no significant difference between different offsets

1

Target prediction

2

Mapping to proxy

3

Redirection range

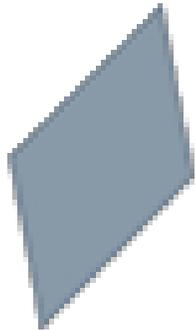
implementation

body warping

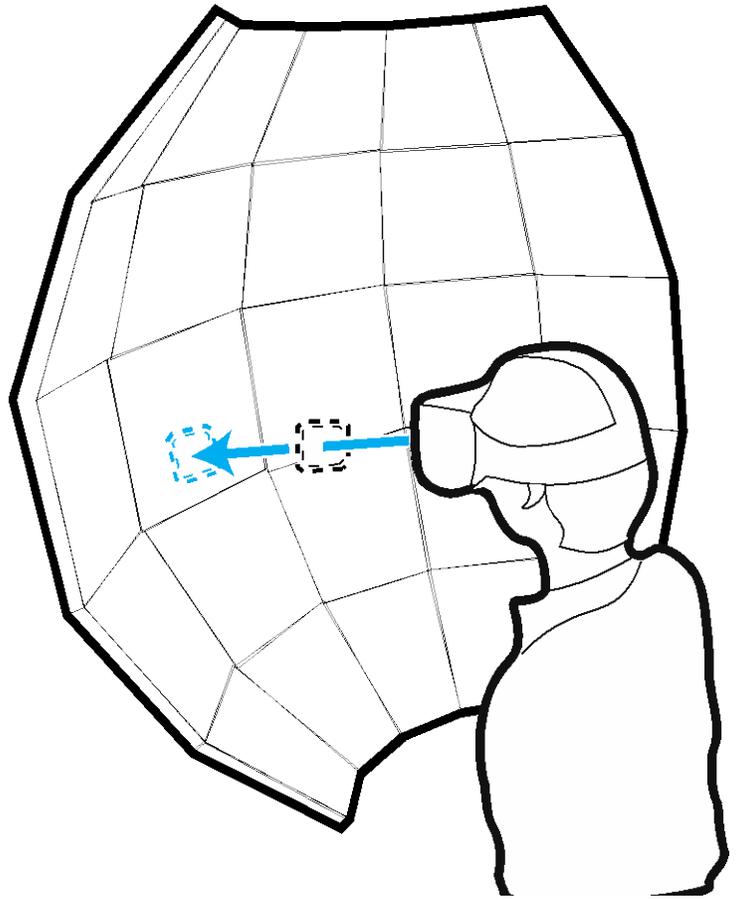
known
virtual target



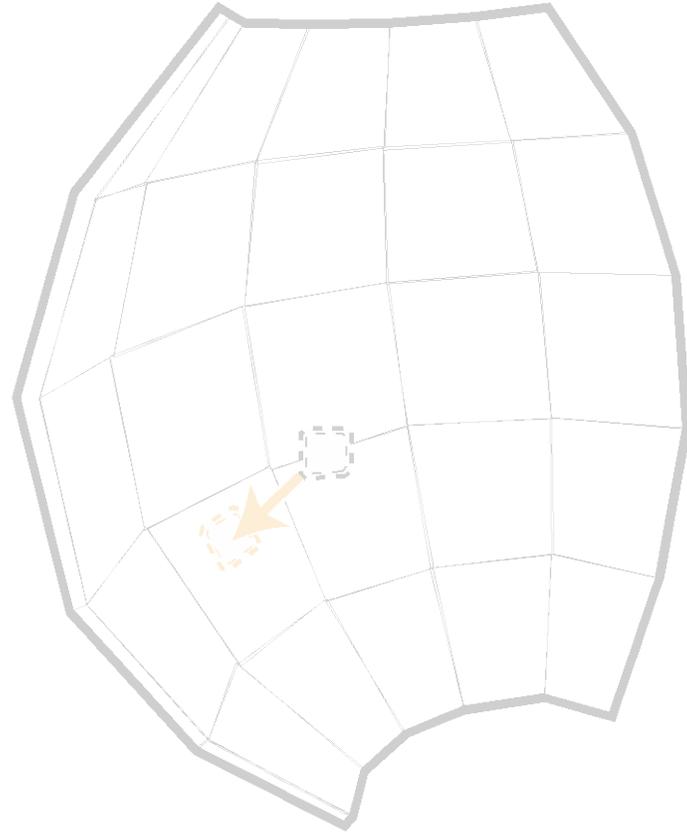
known
physical target



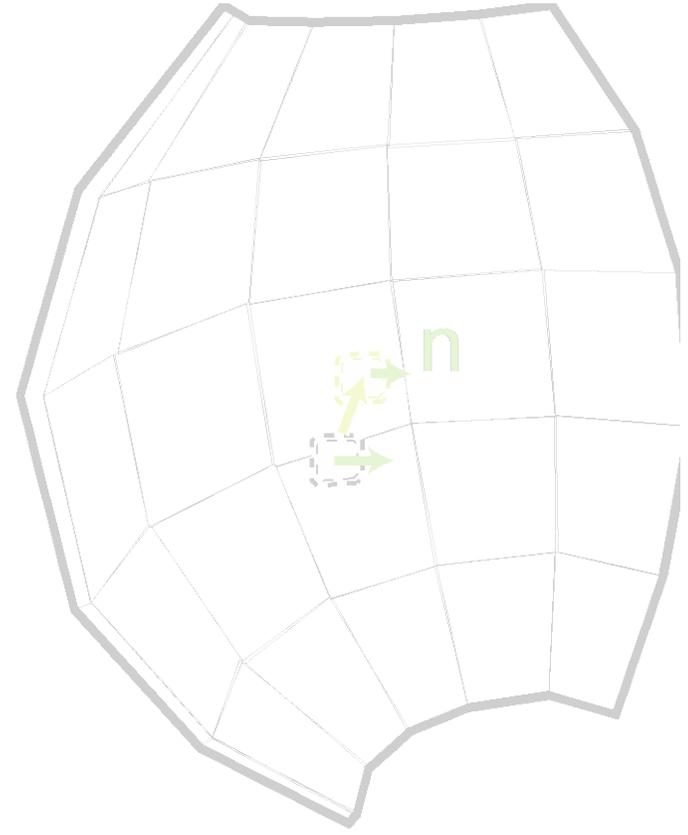
line-of-sight



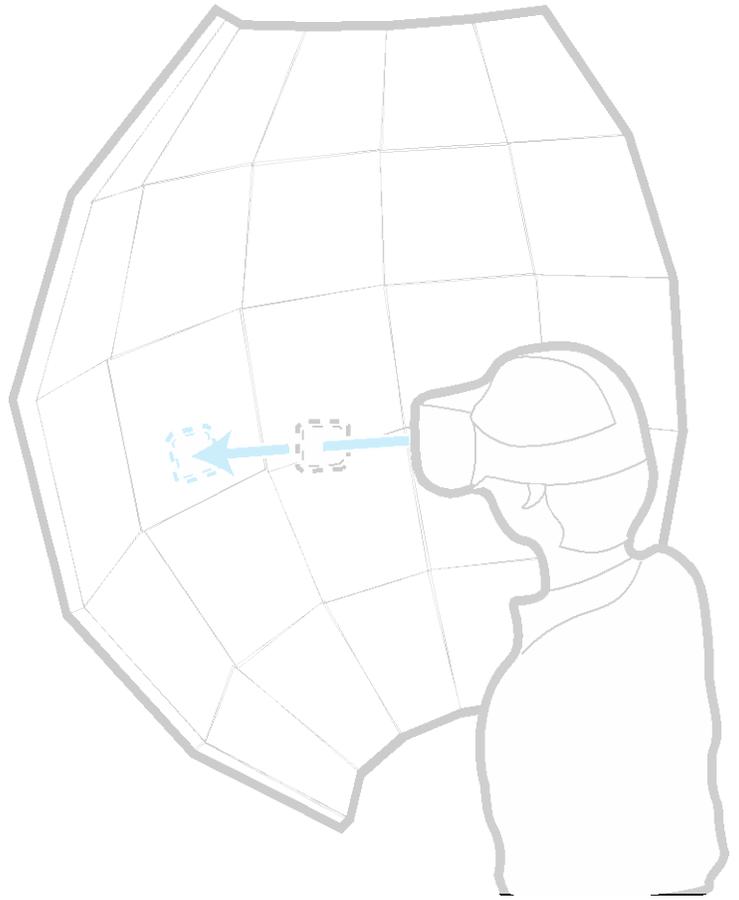
closest-point



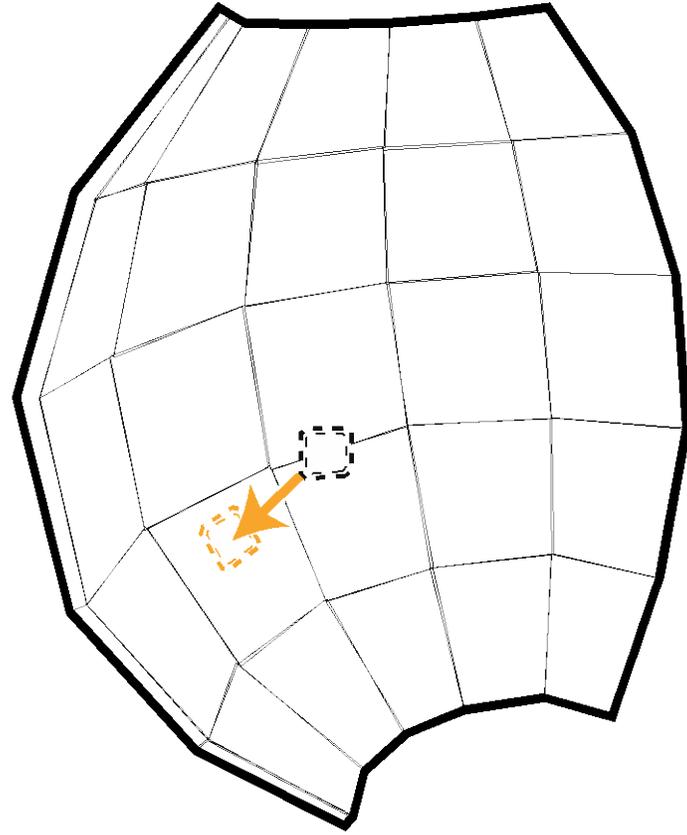
similar-normal



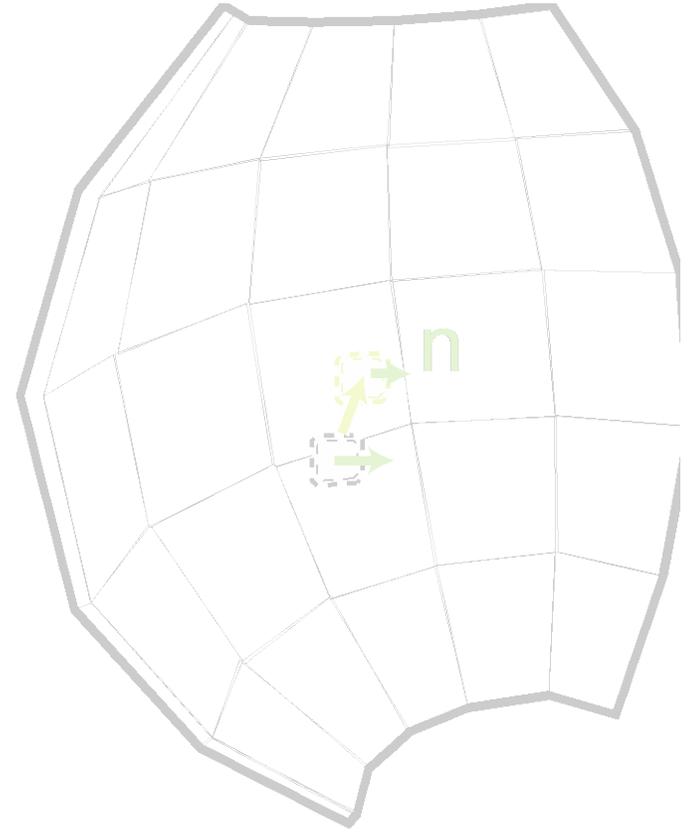
line-of-sight



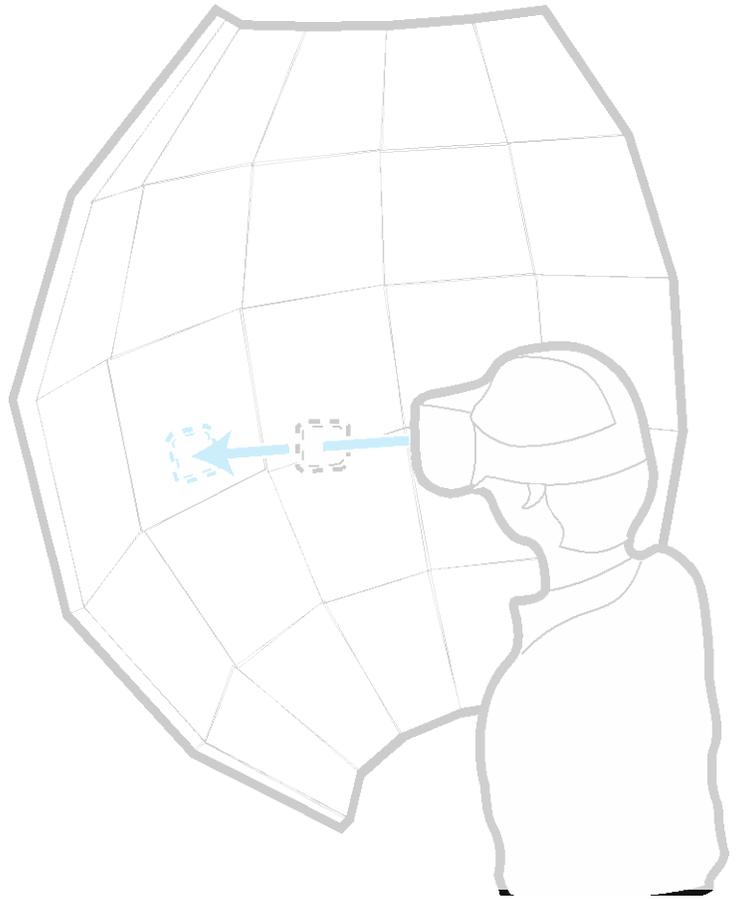
closest-point



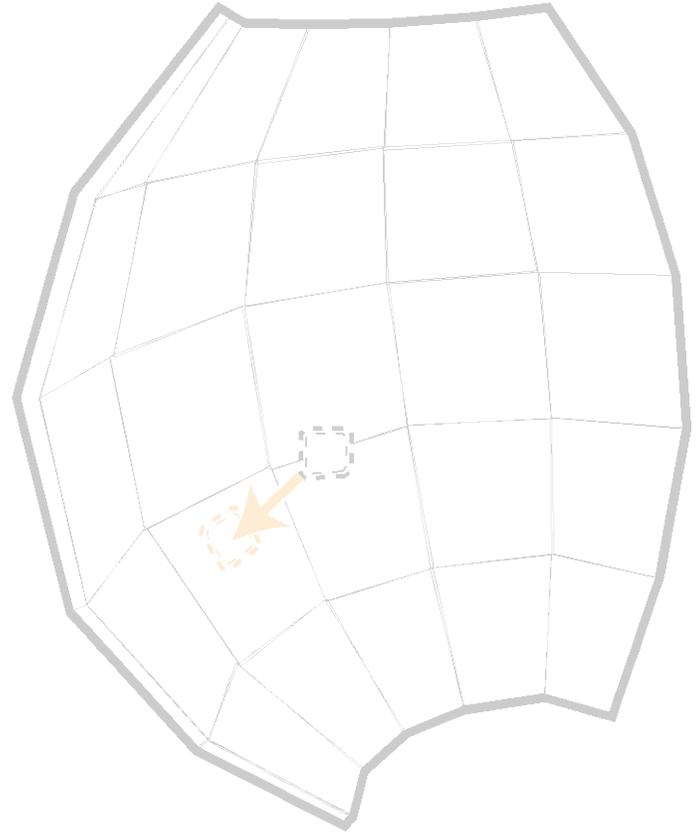
similar-normal



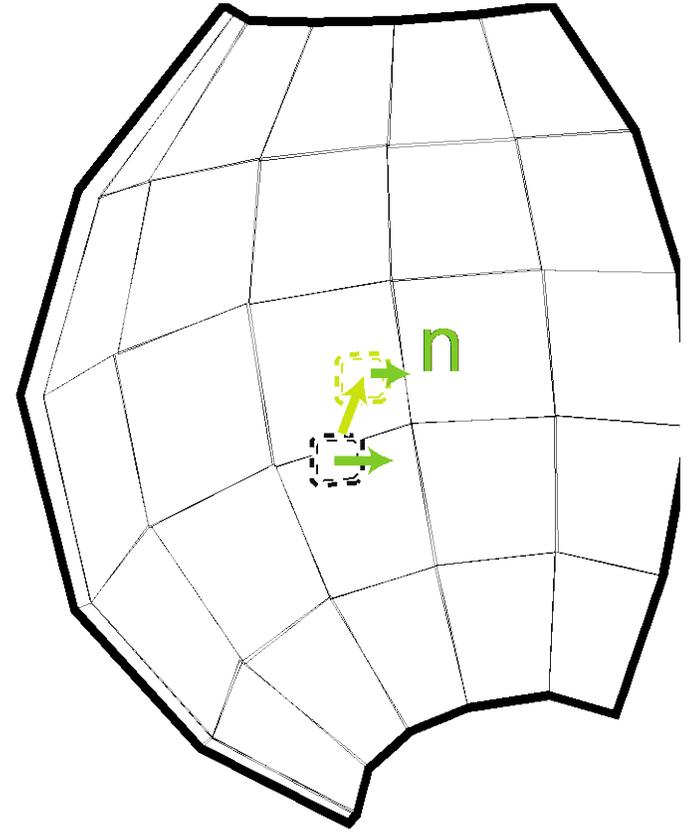
line-of-sight



closest-point



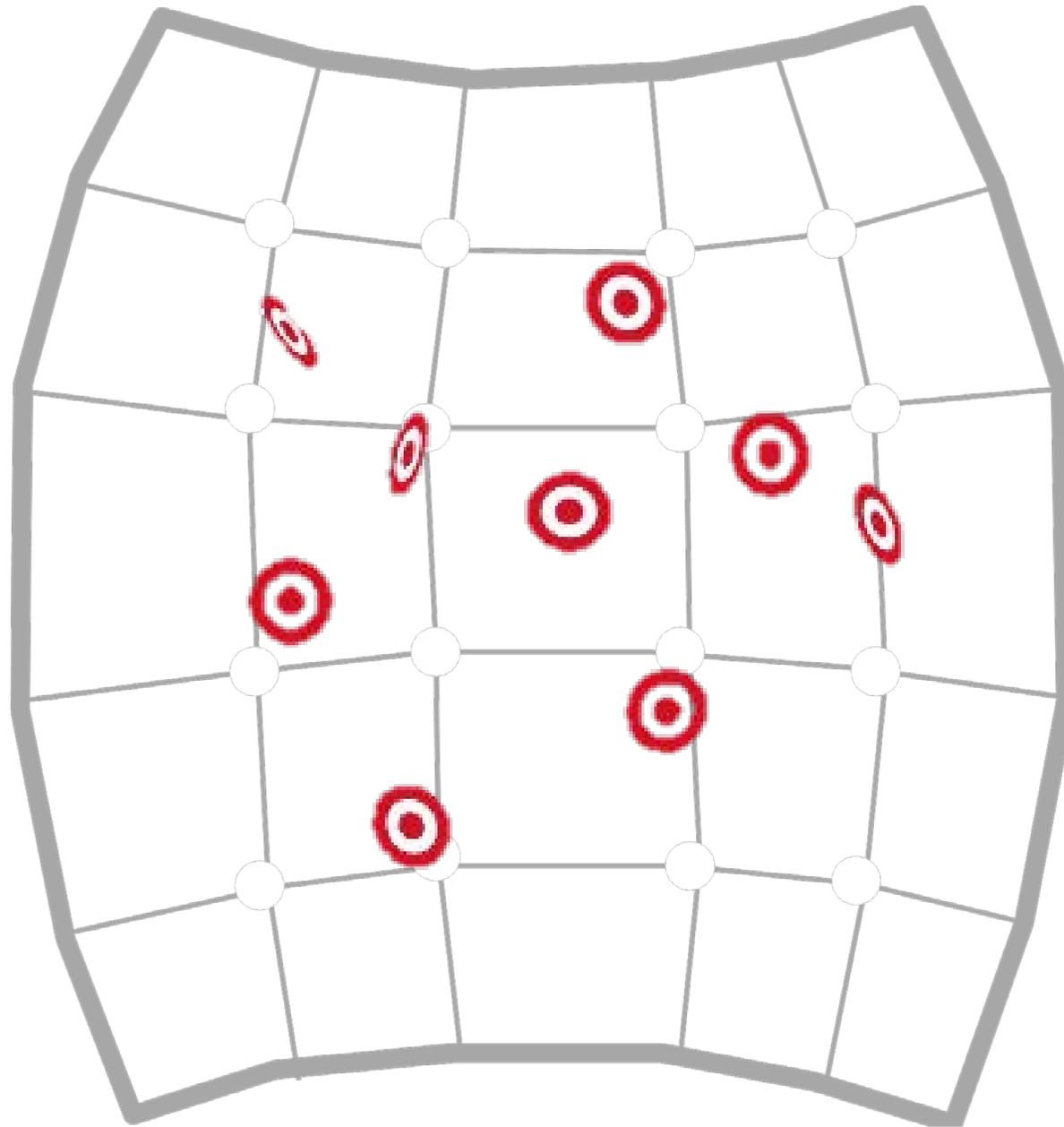
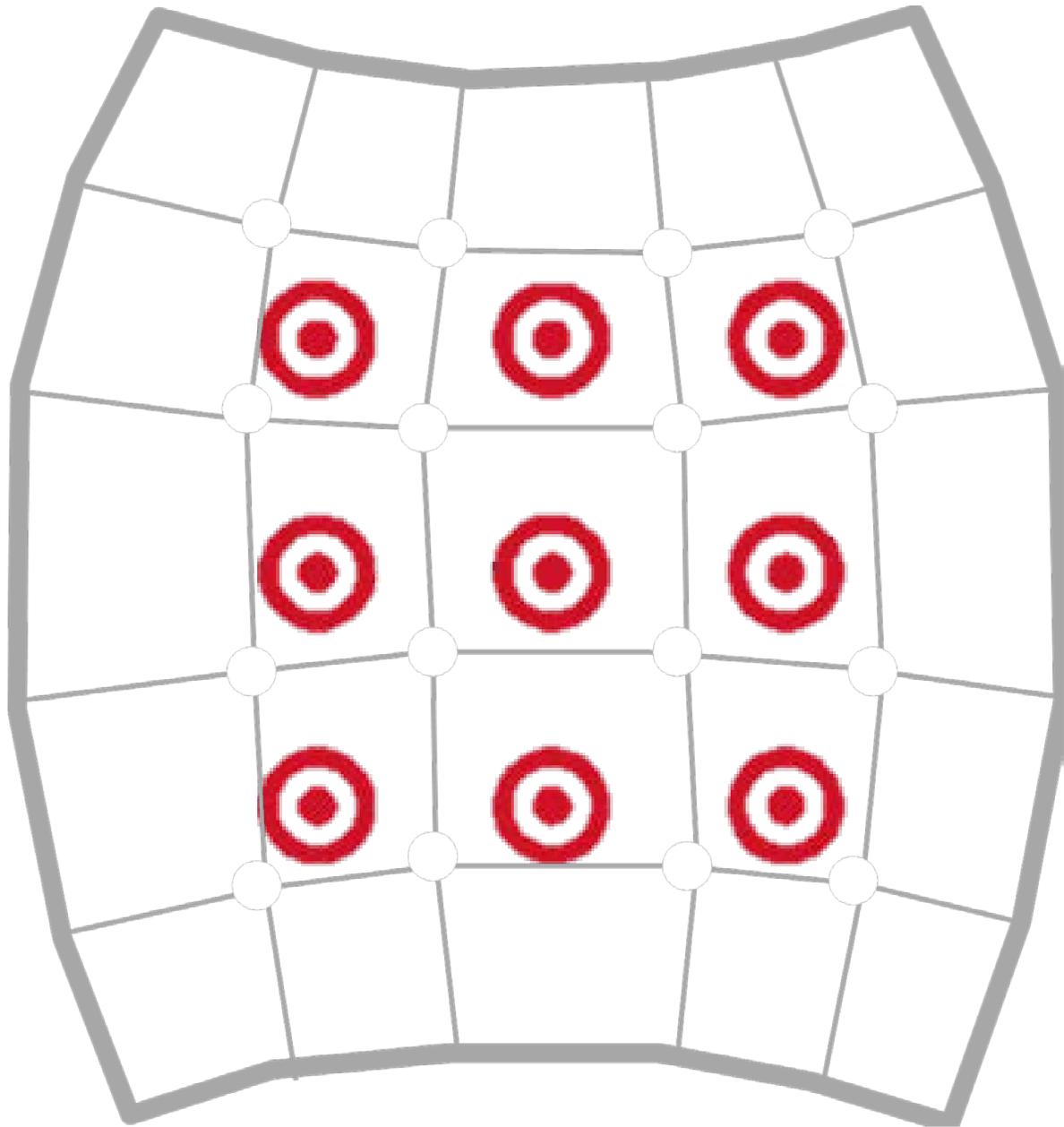
similar-normal



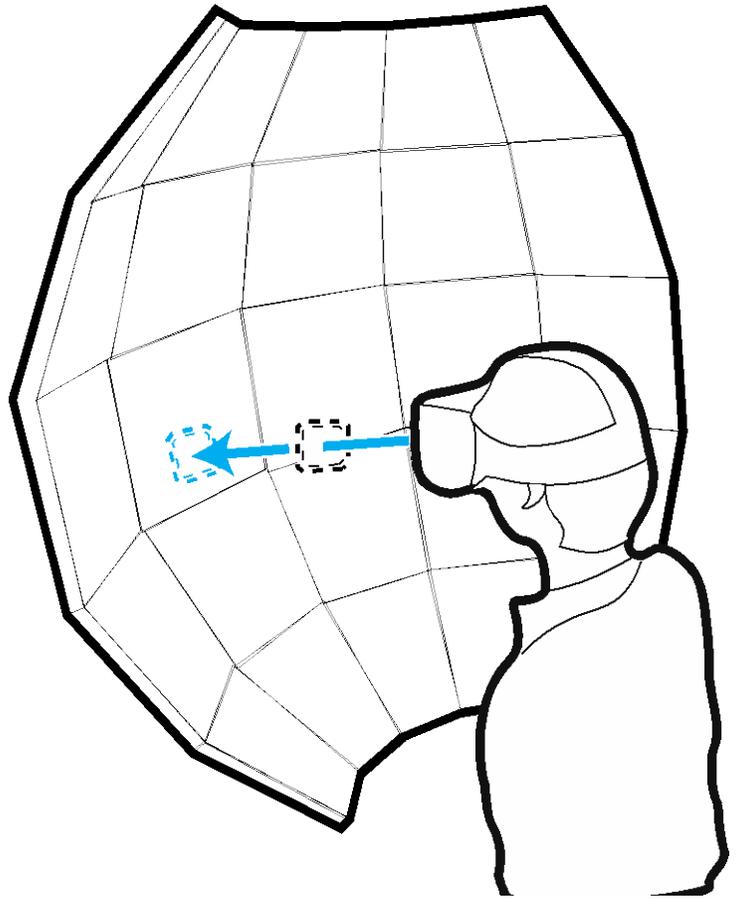
Study 2

comparing mapping strategies

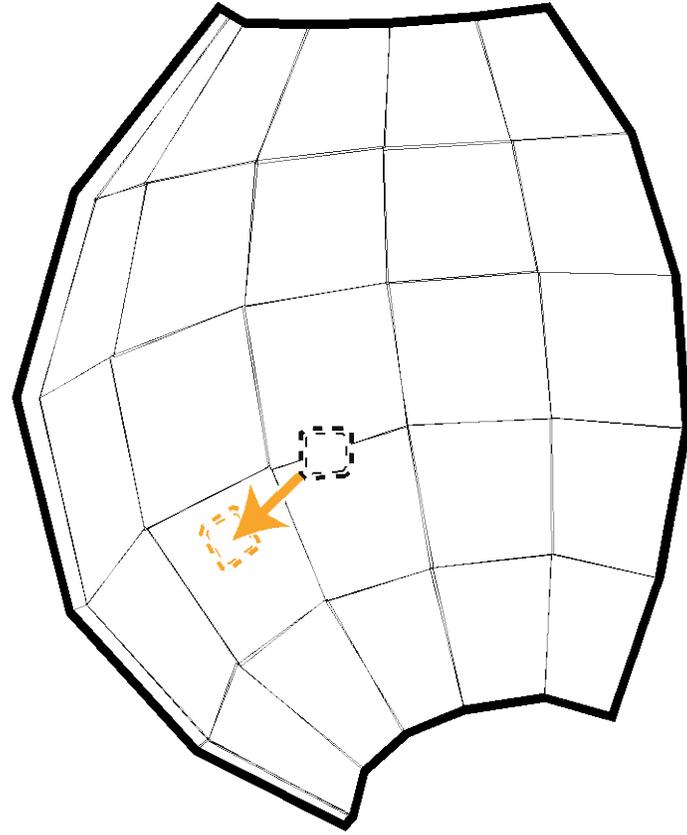




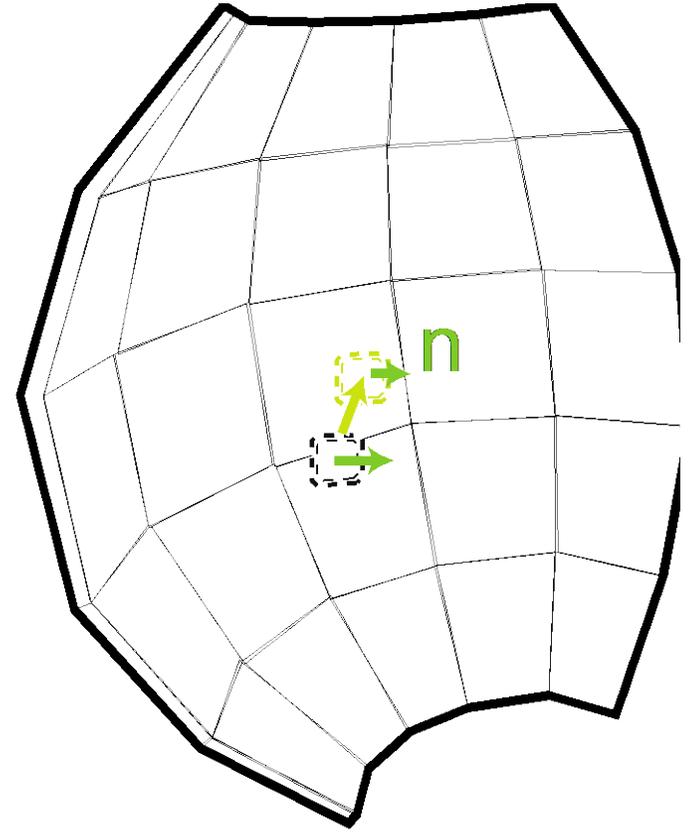
line-of-sight



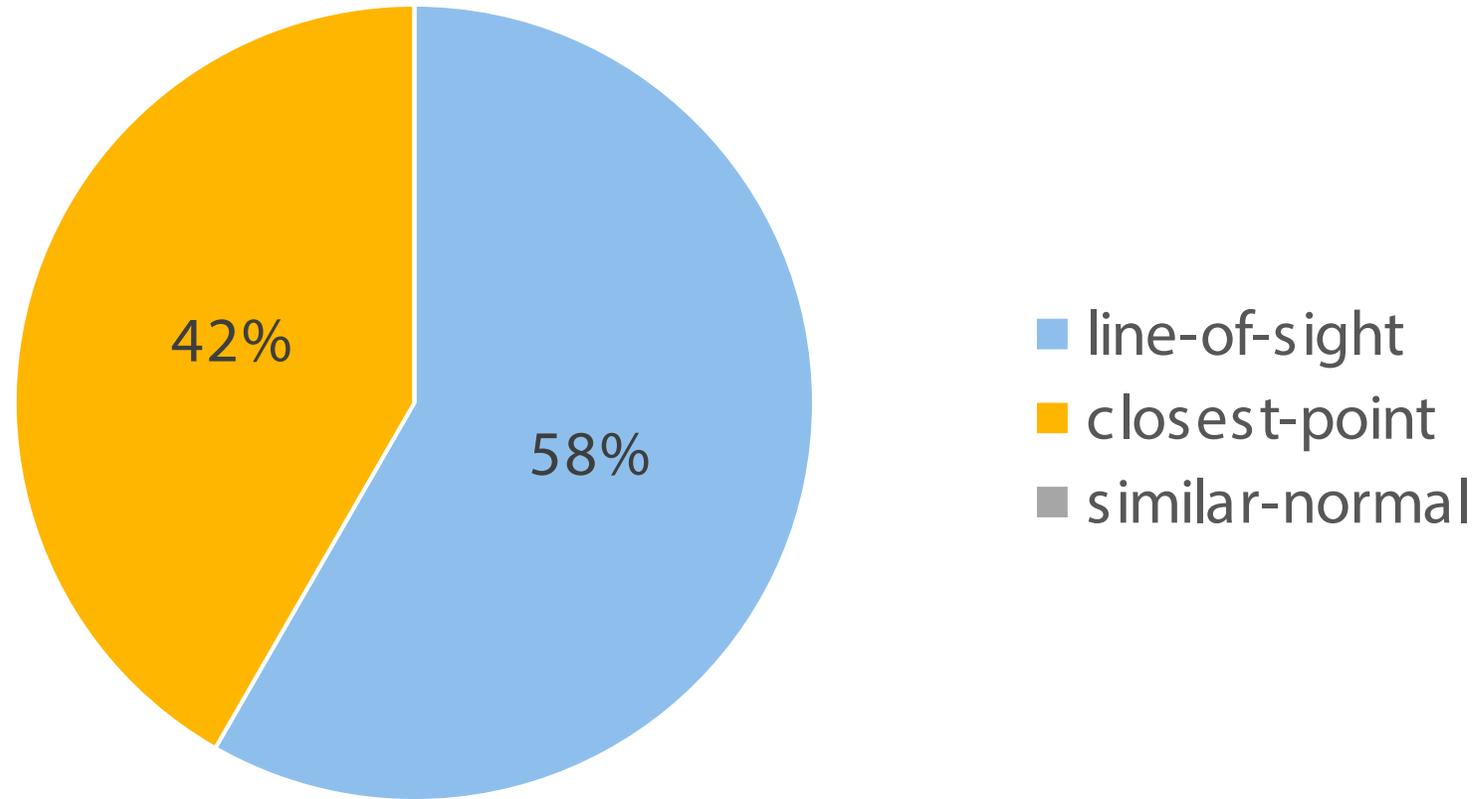
closest-point



similar-normal



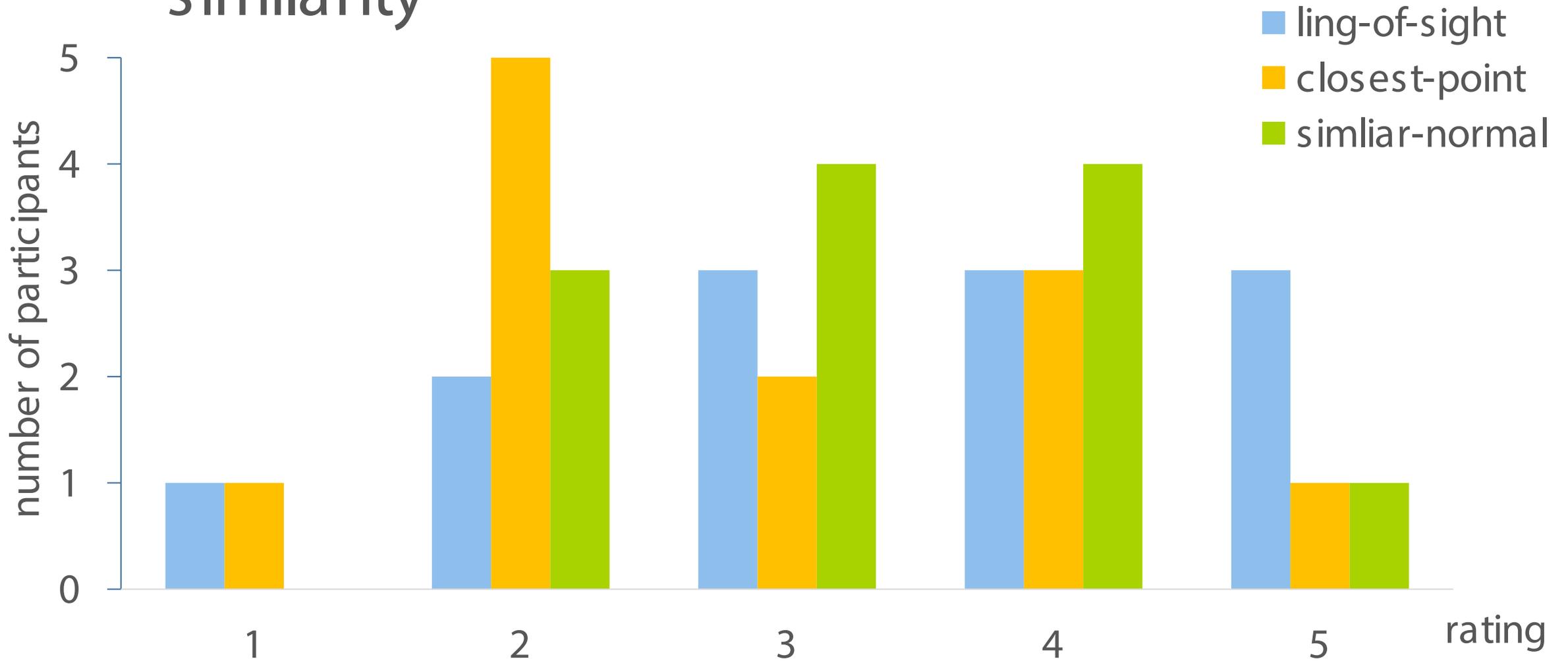
preference



a new group of 12 participants (2 female), ages 26-47 (M=30.8)

most of participants prefer less redirection than feeling the correct surface

similarity



the participants could hardly tell if the surface feels correct or not

1

Target prediction

2

Mapping to proxy

3

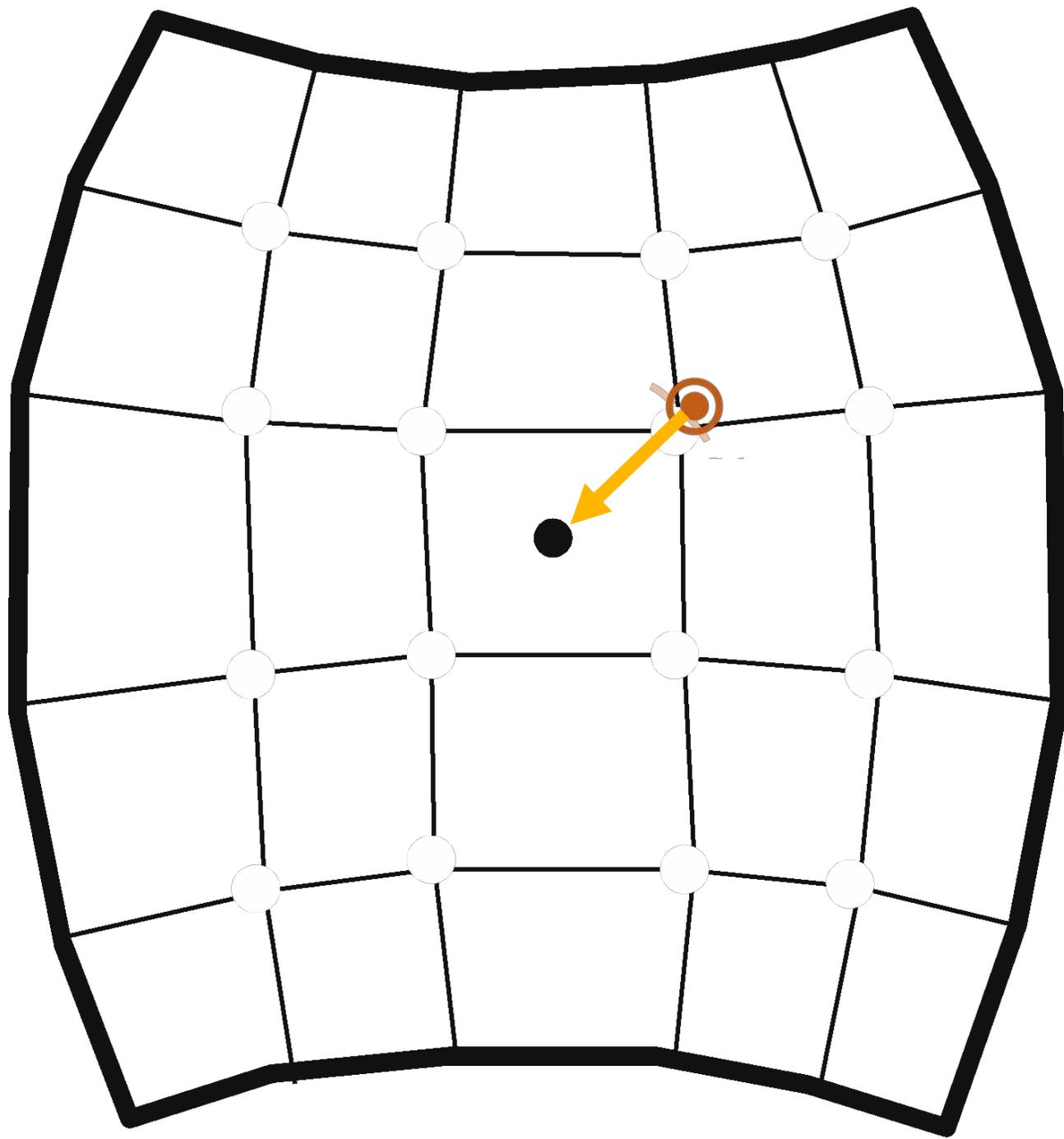
Redirection range

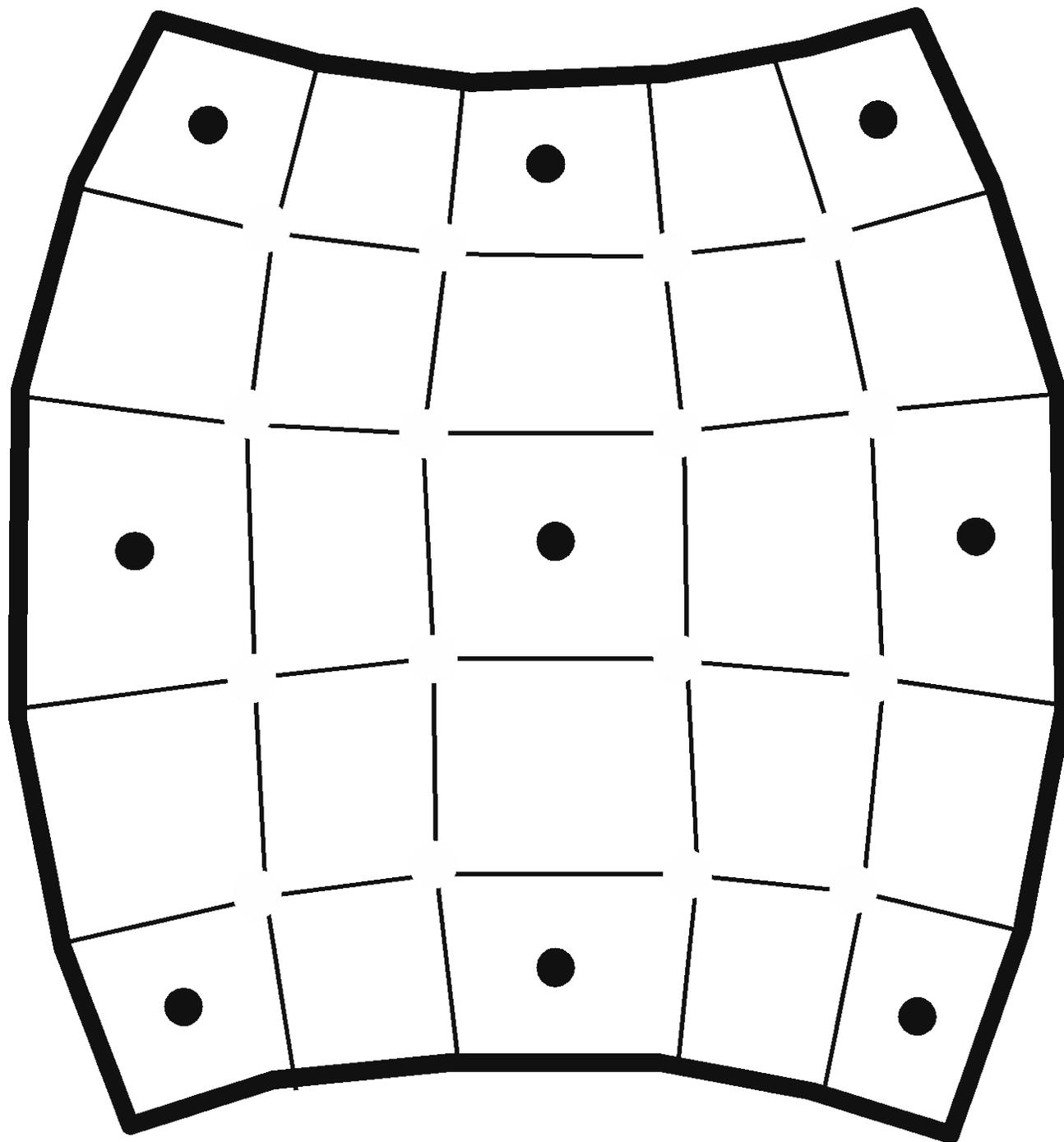
implementation

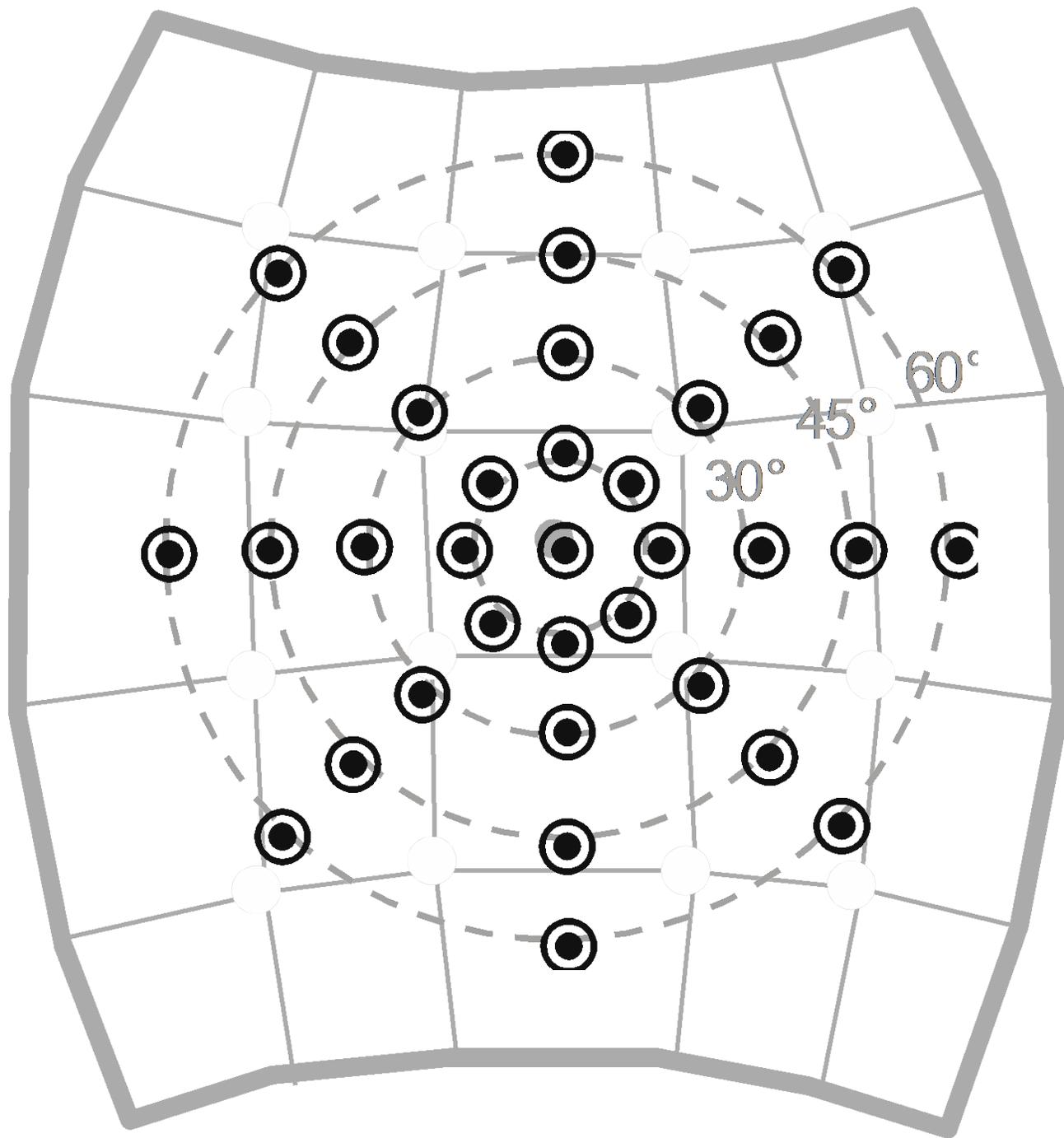
Study 3

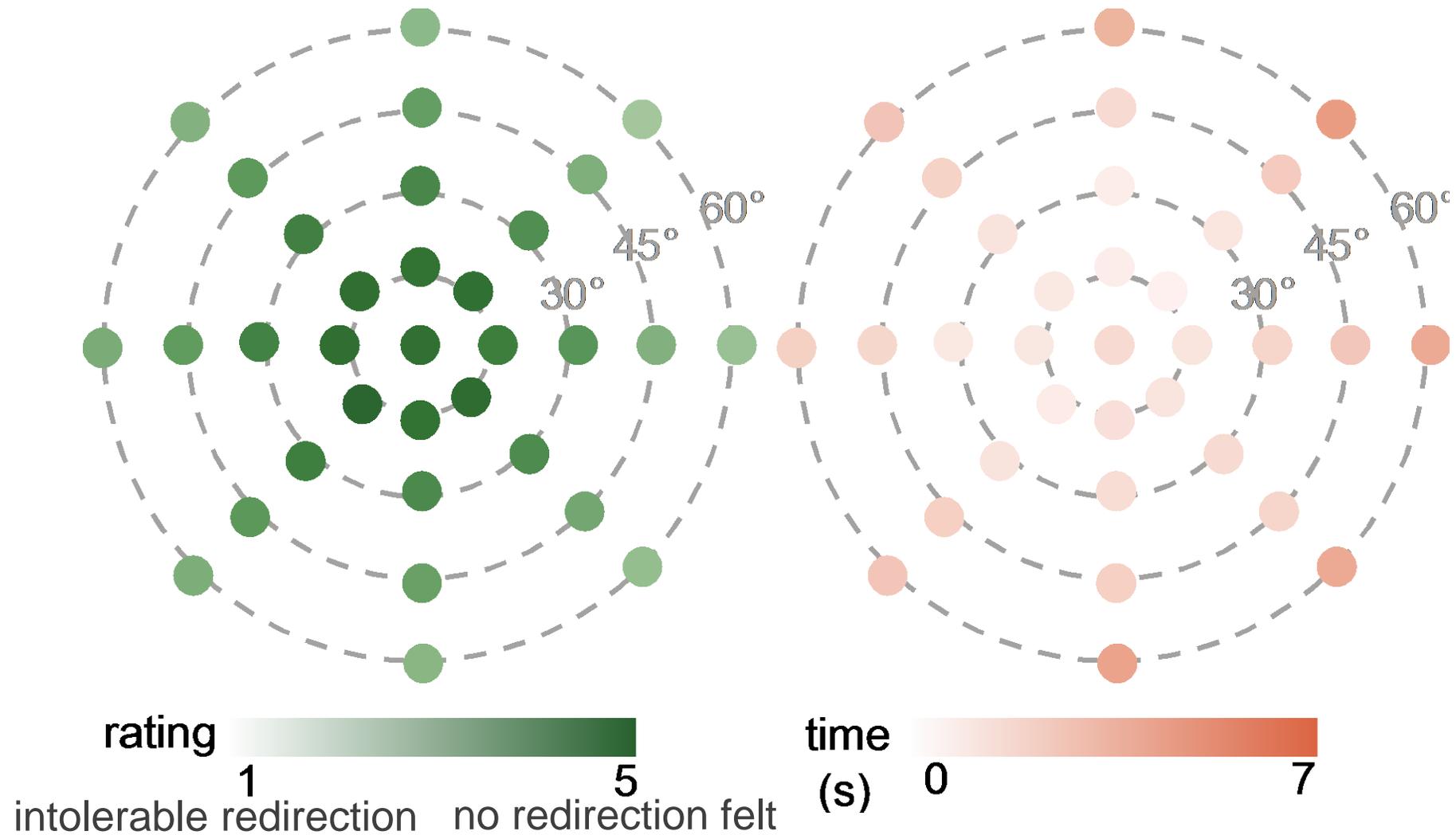
tolerable redirection range









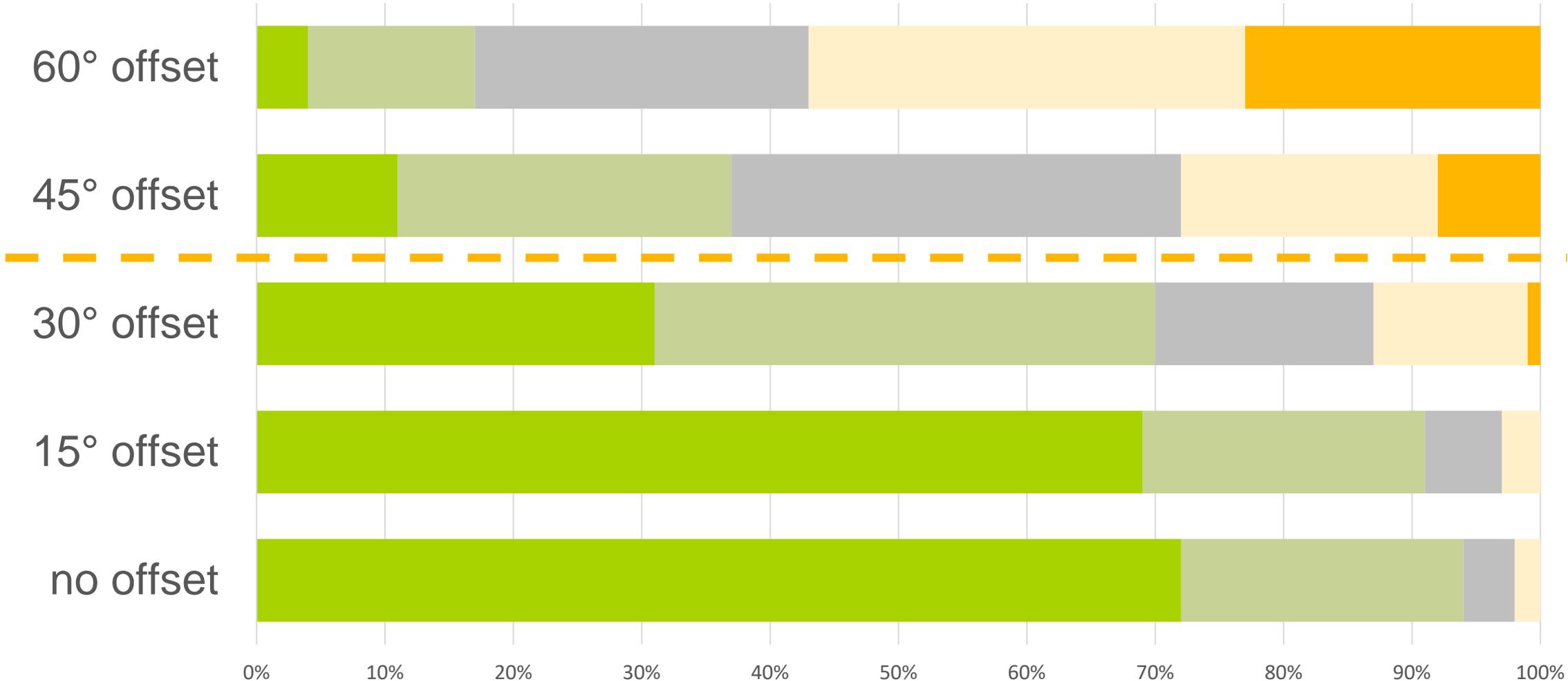


a new group of 12 participants (4 female), ages 21-30 (M=27.0)

no significant difference between 8 directions within the same offset

no significant difference between 9 physical locations

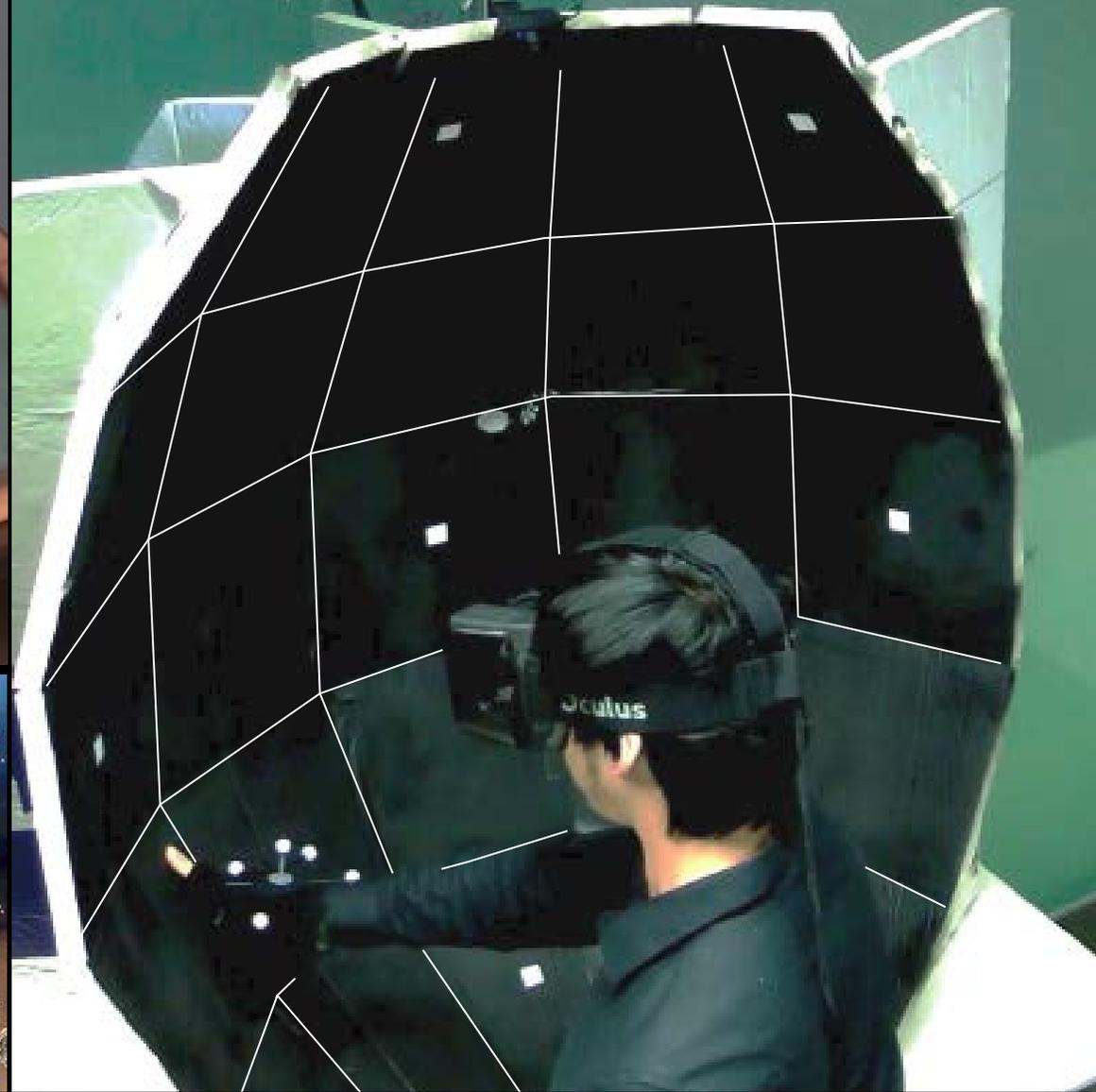
rating 5 4 3 2 1



we pick 40° for our final system and the later experiment

conclusion





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