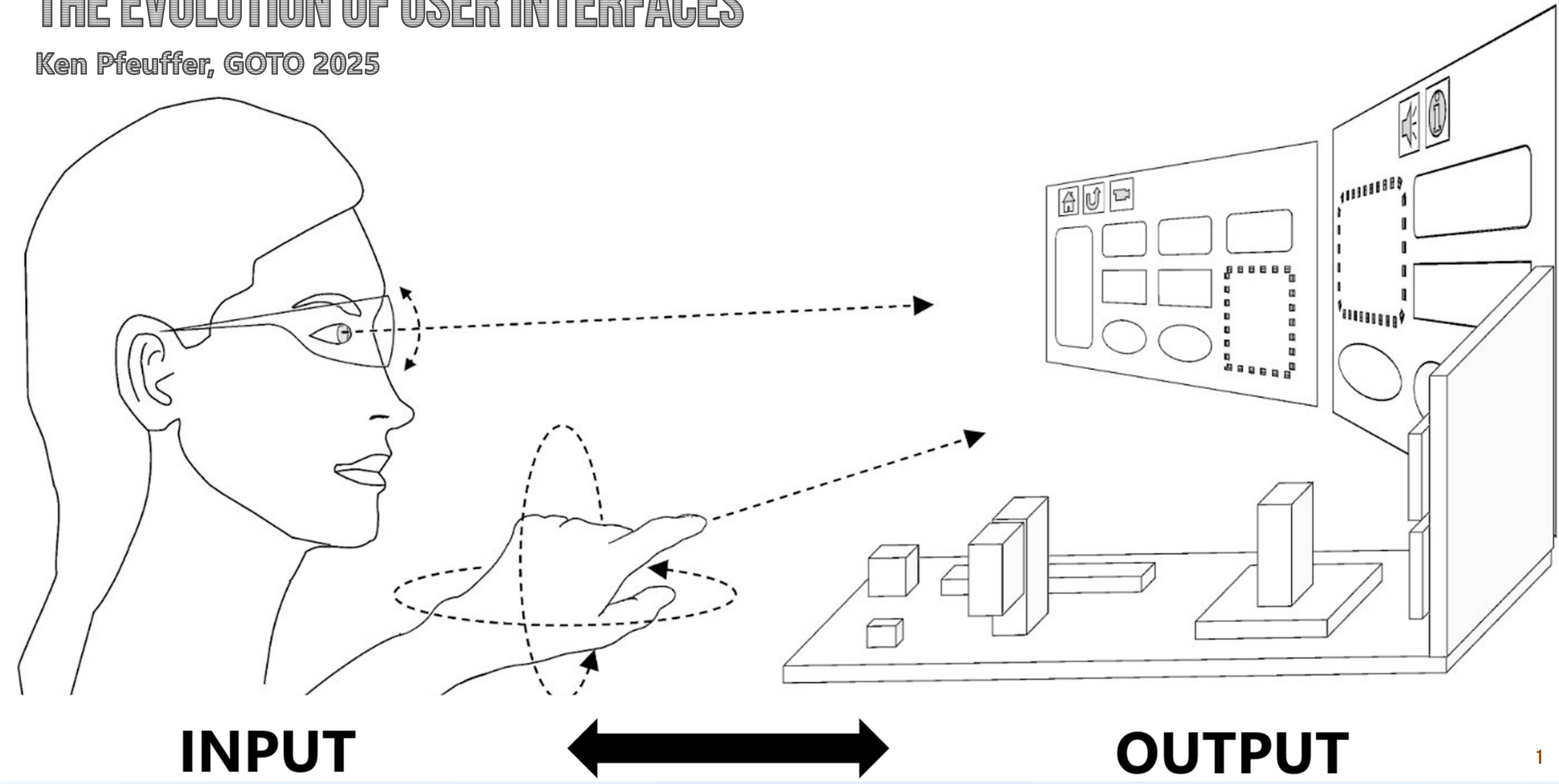


THE EVOLUTION OF USER INTERFACES

Ken Pfeuffer, GOTO 2025



HUMAN-COMPUTER INTERACTION (HCI) RESEARCH CONTEXT

- It's anywhere, anytime.
- Science: study & innovate the **use of tech**.
- Industry: The better UI wins.
- Methodology: *design, prototype, study*.
- In my talk, videos = whole research.

**ME, STRUGGLING
(A FEW WEEKS AGO)**



WHERE I LOOK
HOW I MANIPULATE



**3 HOURS AGO
(TODAY)**



GAZE + PINCH

Gaze + Pinch Interaction in Virtual Reality

Ken Pfeuffer¹, Benedikt Mayer^{1,2}, Diako Mardanbegi¹, Hans Gellersen¹

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²University of Munich (LMU), Munich, Germany

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mayer.benedikt@campus.lmu.de



Figure 1: Gaze + Pinch interactions unify a user's eye gaze and hand input: look at the target, and manipulate it (a). Virtual reality users can utilise free hand direct manipulation (b) to virtual objects at a distance in intuitive and fluid ways (c).

ABSTRACT

Virtual reality affords experimentation with human abilities beyond what's possible in the real world, toward novel senses of interaction. In many interactions, the eyes naturally point at objects of interest while the hands skilfully manipulate in 3D space. We explore a particular combination for virtual reality, the *Gaze + Pinch* interaction technique. It integrates eye gaze to select targets, and indirect freehand gestures to manipulate them. This keeps the gesture use

1 INTRODUCTION

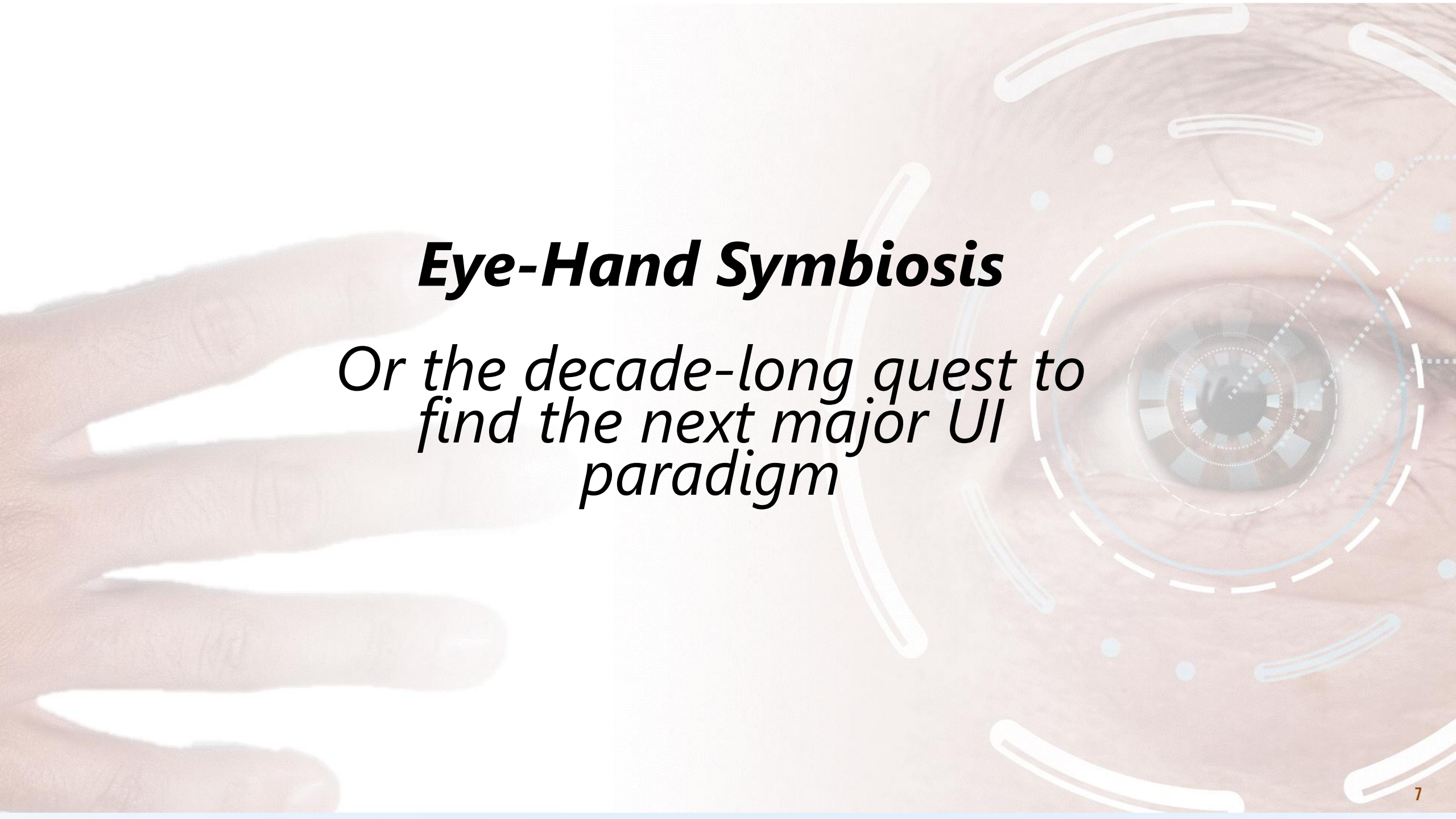
Current advances in virtual reality (VR) technology afford new explorations of experimental user interfaces in the pursuit to “*identify natural forms of interaction and extend them in ways not possible in the real world*” [23]. A natural form of interaction is the use of free virtual hands, enabling direct control of objects based on analogies from the real world [12, 18, 33]. Using the eyes for control, however, is not possible in the real world, although considered as efficient,



Pfeuffer et al., ACM SUI 2017

Apple Vision Pro, 2024

<https://developer.apple.com/design/human-interface-guidelines/gestures#visionOS>



Eye-Hand Symbiosis

*Or the decade-long quest to
find the next major UI
paradigm*

UI EVOLUTION



**I. HOW DID WE GET
HERE?**



**II. WHERE DOES EYE
INPUT COME FROM?**



III. WHAT'S AHEAD?

USER INTERFACE EVOLUTION

-2 Mil → -2000 → 1950 →



Stone



Axe, Hammer



Keyboard
Christopher
Latham
Sholes (1868)



Mouse
Douglas
Engelbart
(1964)



Stylus
Tom
Dimond
(1957)



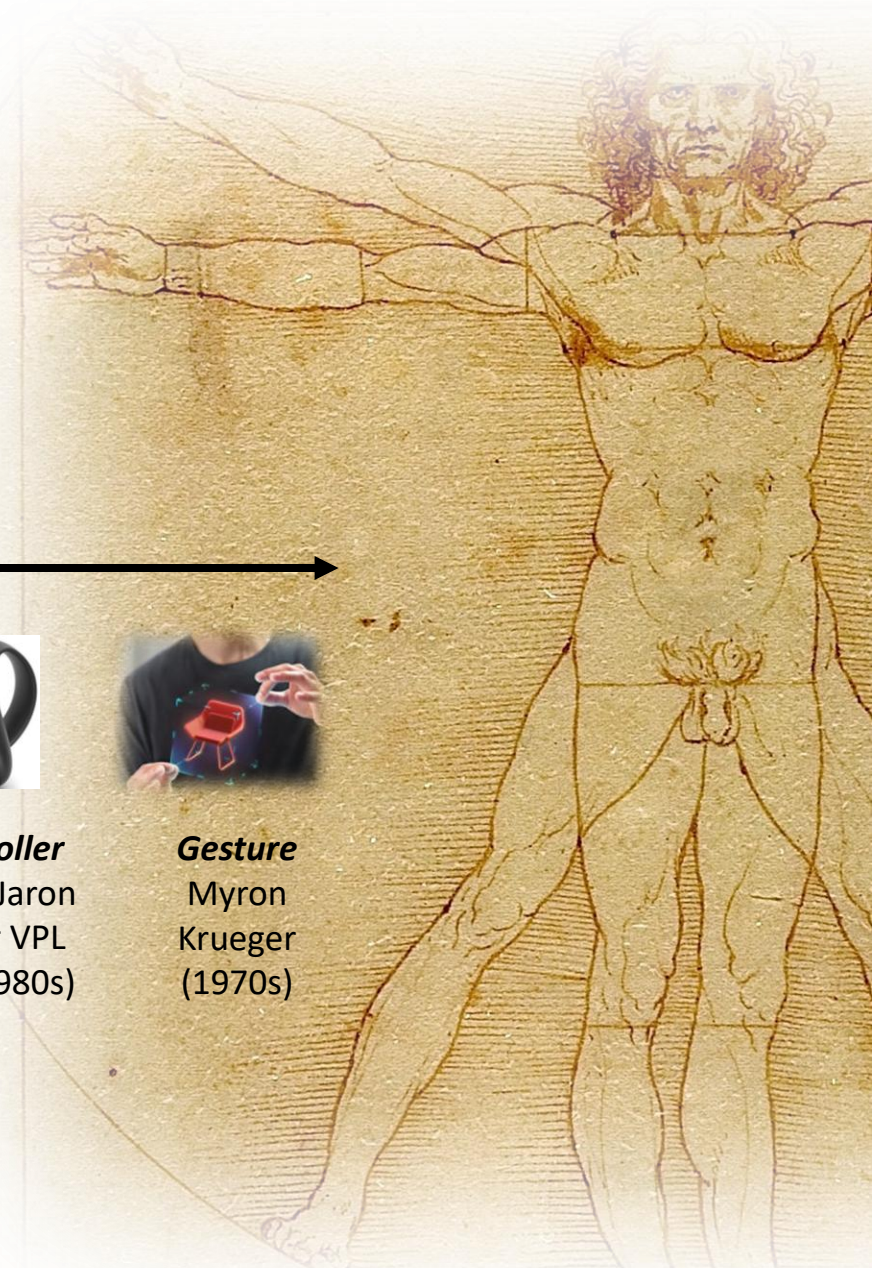
Touchscreen
E.A. Johnson
(1965)



Controller
NASA/Jaron
Lanier VPL
(late 1980s)



Gesture
Myron
Krueger
(1970s)



MOBILE PHONE WARS 2000-10



Steve Jobs, Apple CEO (2007)



Steve Ballmer, Microsoft CEO (2007)



r/OculusQuest • 2 yr. ago

Conscious-Ball8373



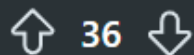
Does anyone else find VR user interfaces almost impossible to use?

Discussion

There seems to be a lack of imagination; VR UIs are just the same buttons and sliders that get used in desktop UIs, just much, much harder to actually use, especially if you're trying to do it with hand tracking.

I'm reminded of the products of the Sirius Cybernetics Corporation; It is very easy to be blinded to their essential uselessness by the sense of achievement you get from getting them to work at all. In other words - and this is the rock solid principle on which the whole of the Corporation's galaxy-wide success is founded - their fundamental design flaws are completely hidden by their superficial design flaws. [Douglas Adams]

ETA: The experience that prompted this post was being sat on a sofa trying to watch an immersive video. The VR player has a slider for the video time scale; trying to do anything useful with this is utterly impossible. If you're very lucky, you'll manage to skip to an entirely random point in the video. But trying to hold the "beam" on the slider at all while pinching is so near impossible as to be not worth mentioning.



36



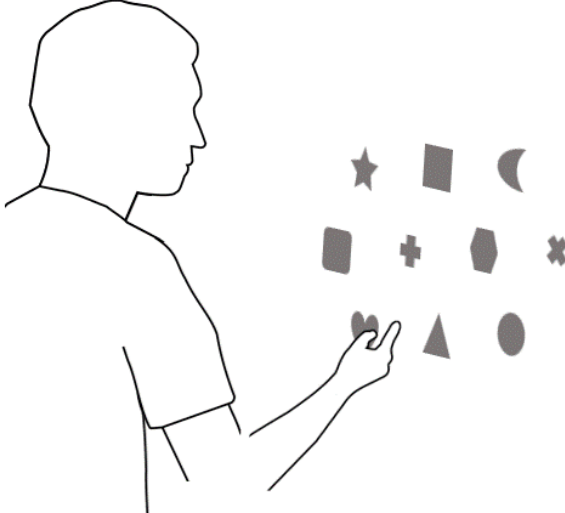
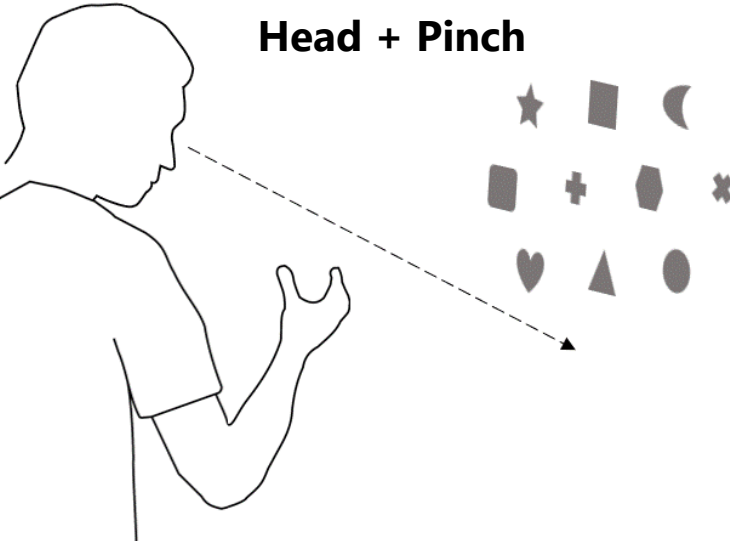
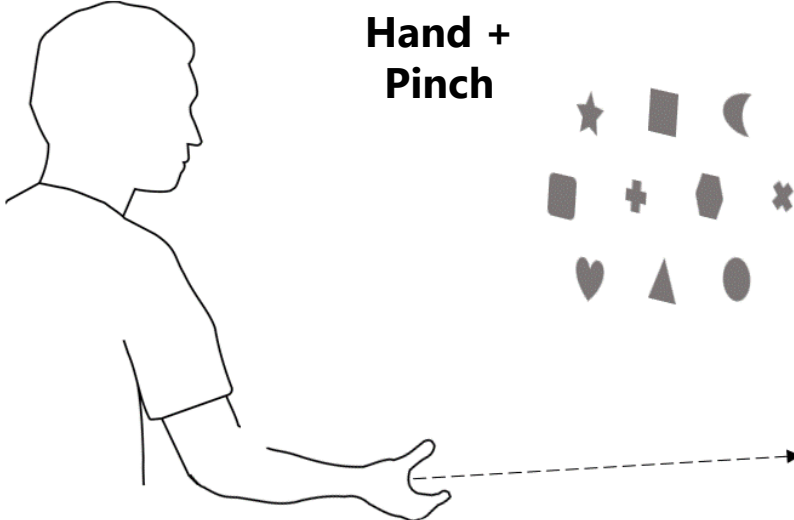
38



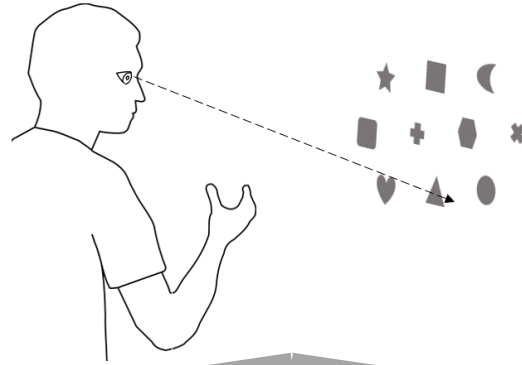
Share

Join the conversation

VR/AR/XR: UI BEFORE 2024

	Microsoft HoloLens 1 (2016)	HoloLens 2 (2019), Meta Quest 2 (2020), Quest 3 (2023), Magic Leap
Near space	Direct touch  A line drawing of a person's head and shoulder in profile, facing right. Their right hand is reaching out and touching a cluster of various geometric shapes (star, square, circle, heart, triangle, etc.) that are floating in the air just in front of their hand.	
Far space	Head + Pinch  A line drawing of a person's head and shoulder in profile, facing right. Their right hand is in a pinching gesture. A dashed arrow points from the person's head towards a cluster of geometric shapes floating in the air at a distance.	Hand + Pinch  A line drawing of a person's head and shoulder in profile, facing right. Their right hand is in a pinching gesture. A dashed arrow points from the person's hand towards a cluster of geometric shapes floating in the air at a distance.

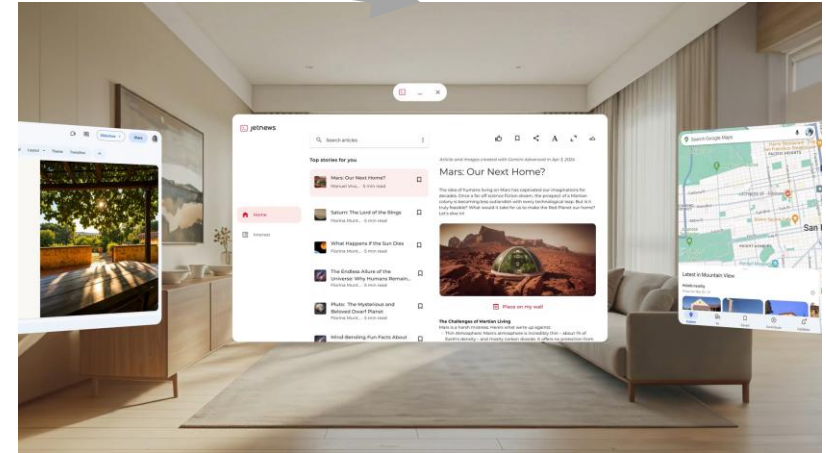
2024: PARADIGM SHIFT TO EYES & HANDS



Released 2/2024:
Apple Vision Pro



Announced 9/2024:
Meta Orion

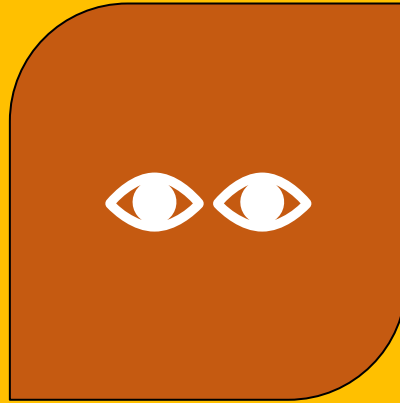


Announced 12/2024:
Android XR

UI EVOLUTION



**I. HOW DID WE GET
HERE?**



**II. WHERE DOES EYE
INPUT COME FROM?**



III. WHAT'S AHEAD?

Gaze computer control (MIT, 1981)

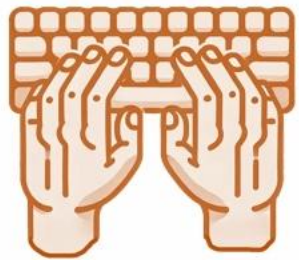


“in the midst of impressions and events, the mode par excellence of directing attention is vision, specifically, where you are looking”

LONG TRADITION IN HCI RESEARCH



1950 —————→ 2010



Keyboard



Mouse



Stylus



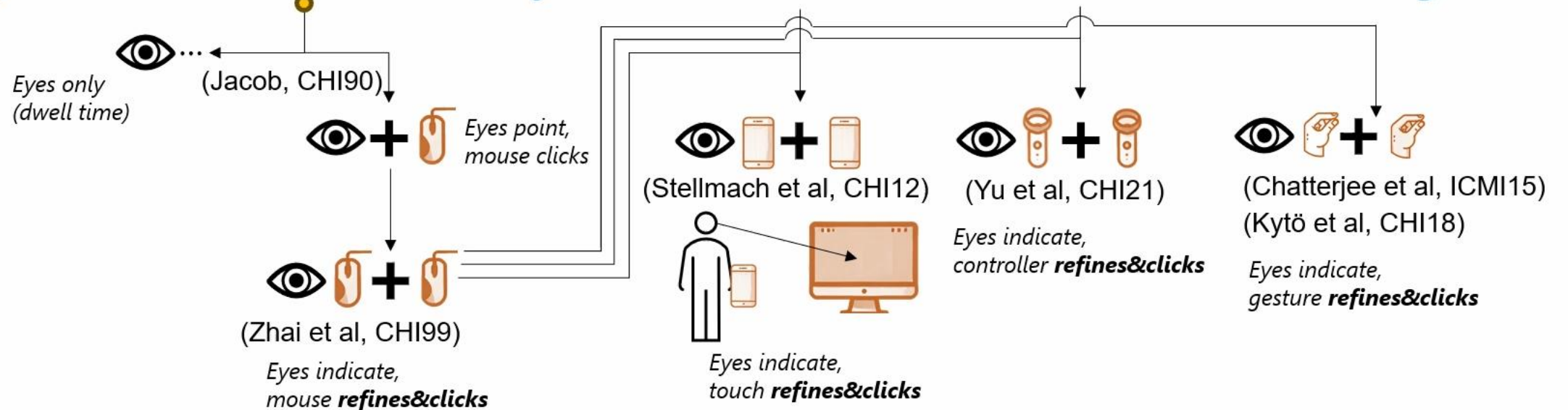
Touchscreen



Controller



Hand tracking



LONG TIME NO SEA...

State in 2013

- *“Eyetrackers are too inaccurate”*
- *“Using your eyes for control is unnatural”*
- *“You get eye fatigue”*

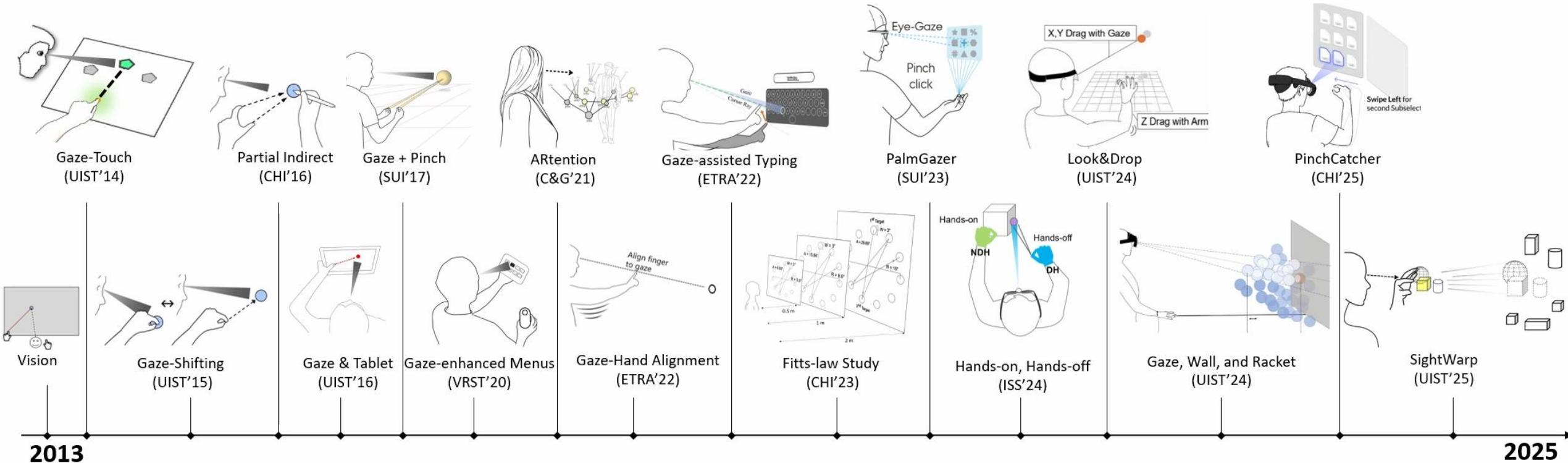
THE QUEST TO FIND THE NEXT BIG UI PARADIGM

Human-computer interaction where user's eye and hand information form a symbiotic relationship.

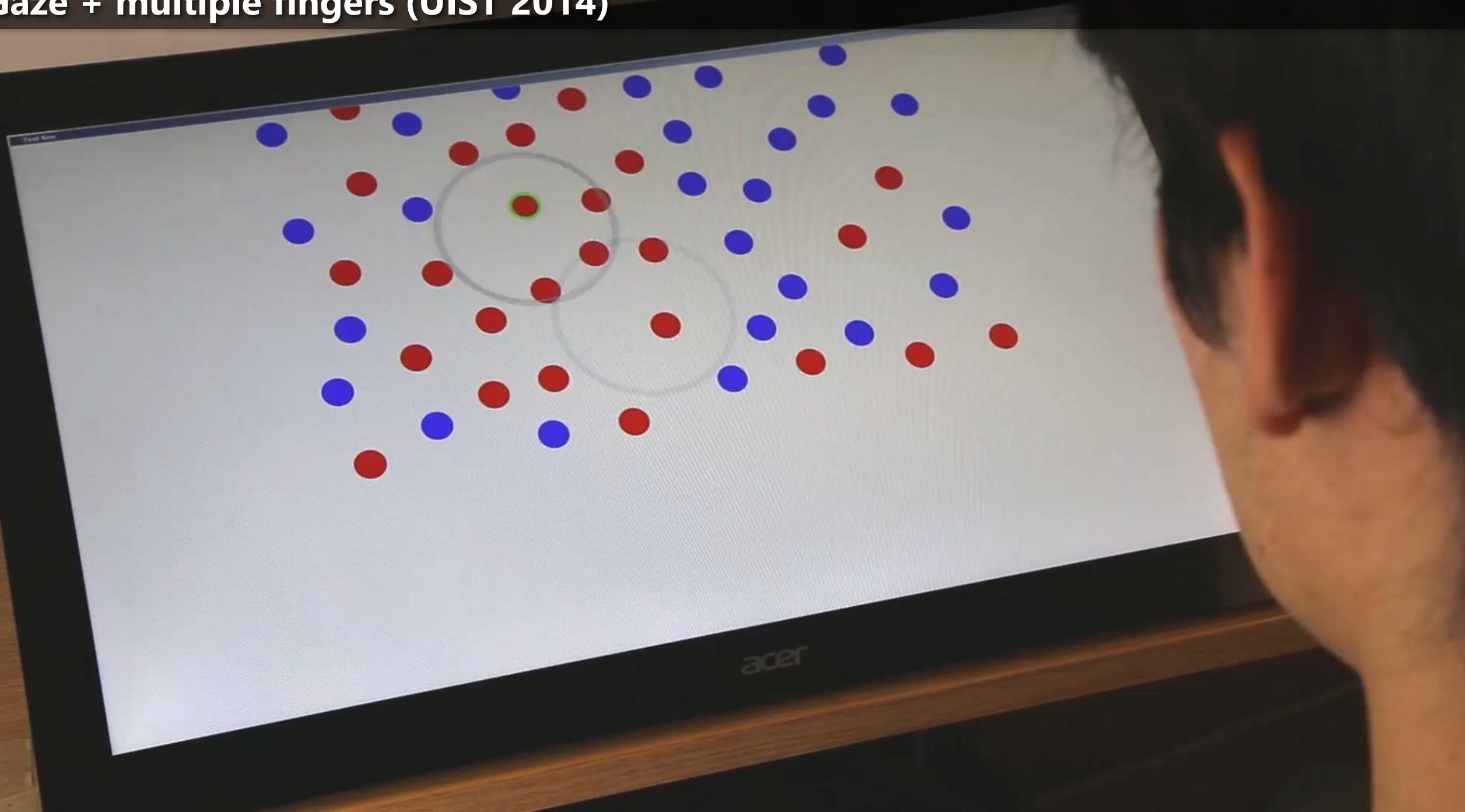
- I have 3-4 years for my PhD
- Desert = problem & opportunity
- What comes after the mouse and multi-touch
- From high-level paradigm to low-level UI features

THE *EYE-HAND SYMBIOSIS* PROJECT JOURNEY

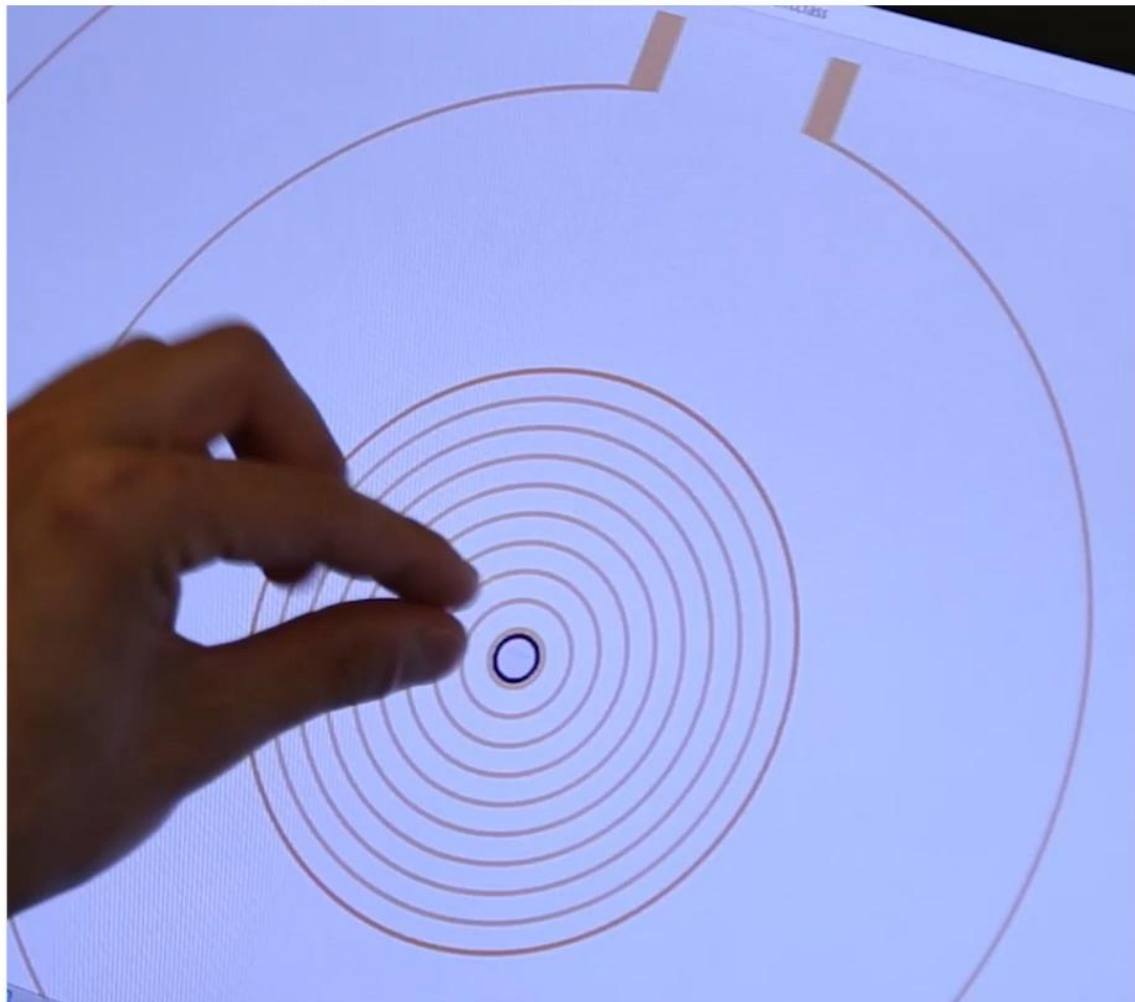
Human-computer interaction where user's eye and hand information form a symbiotic relationship.



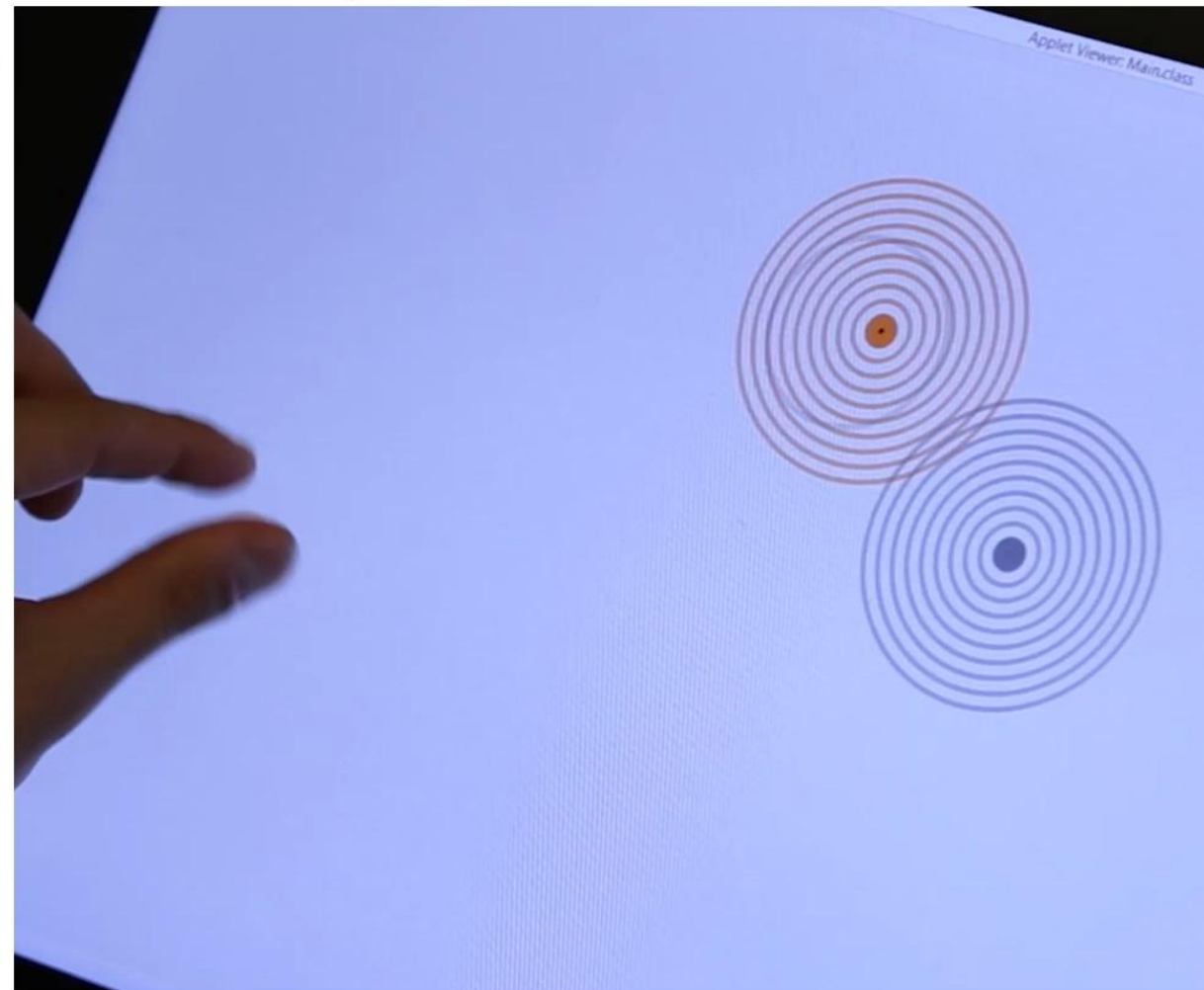
Gaze + multiple fingers (UIST 2014)



Direct gesture based pinch-to-zoom



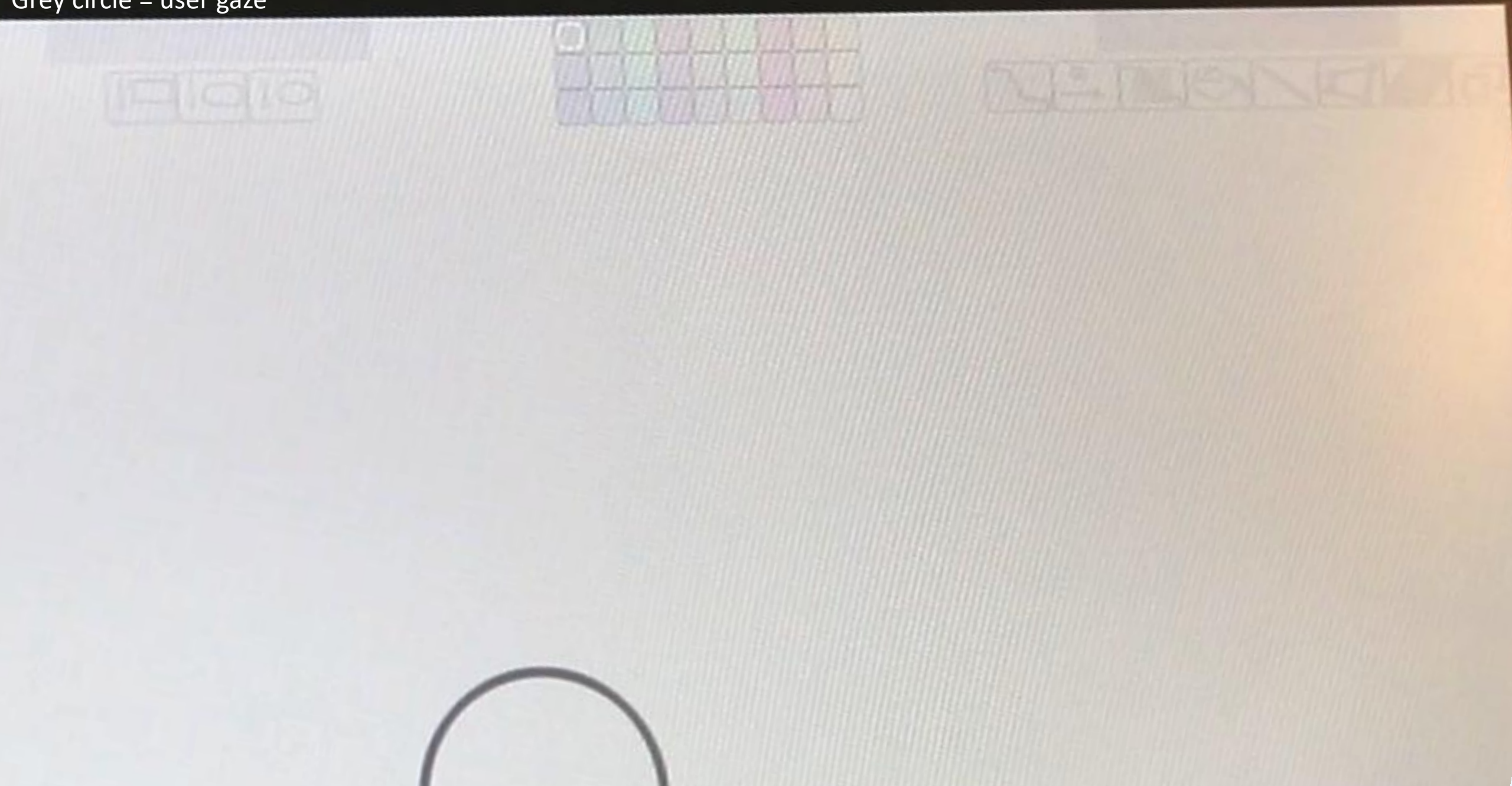
Eye gaze based pinch-to-zoom



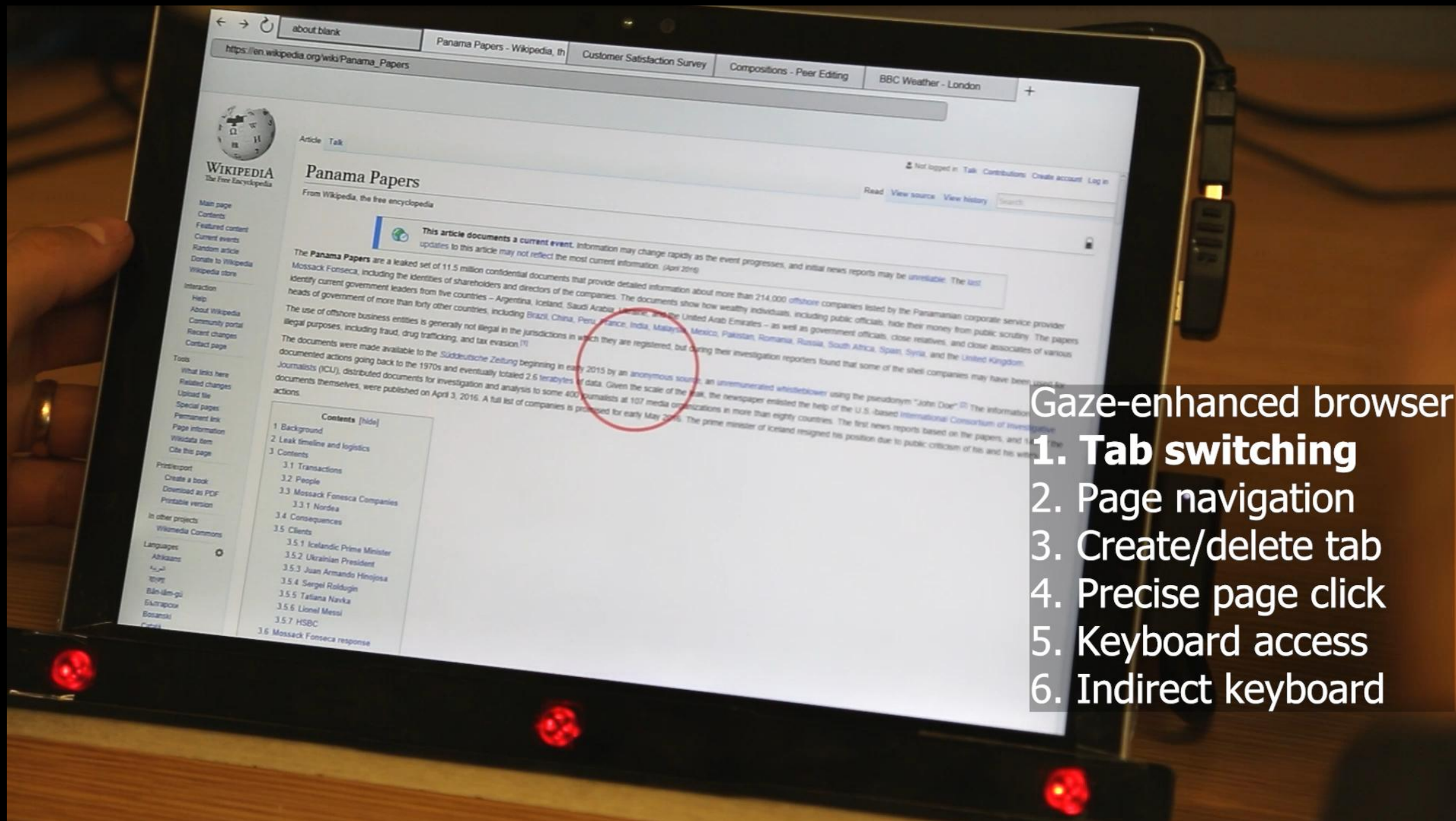
Grey circle indicates gaze point of the user
(for demonstration, not shown in actual use)

Pen + gaze + menus (UIST 2015)

Grey circle = user gaze

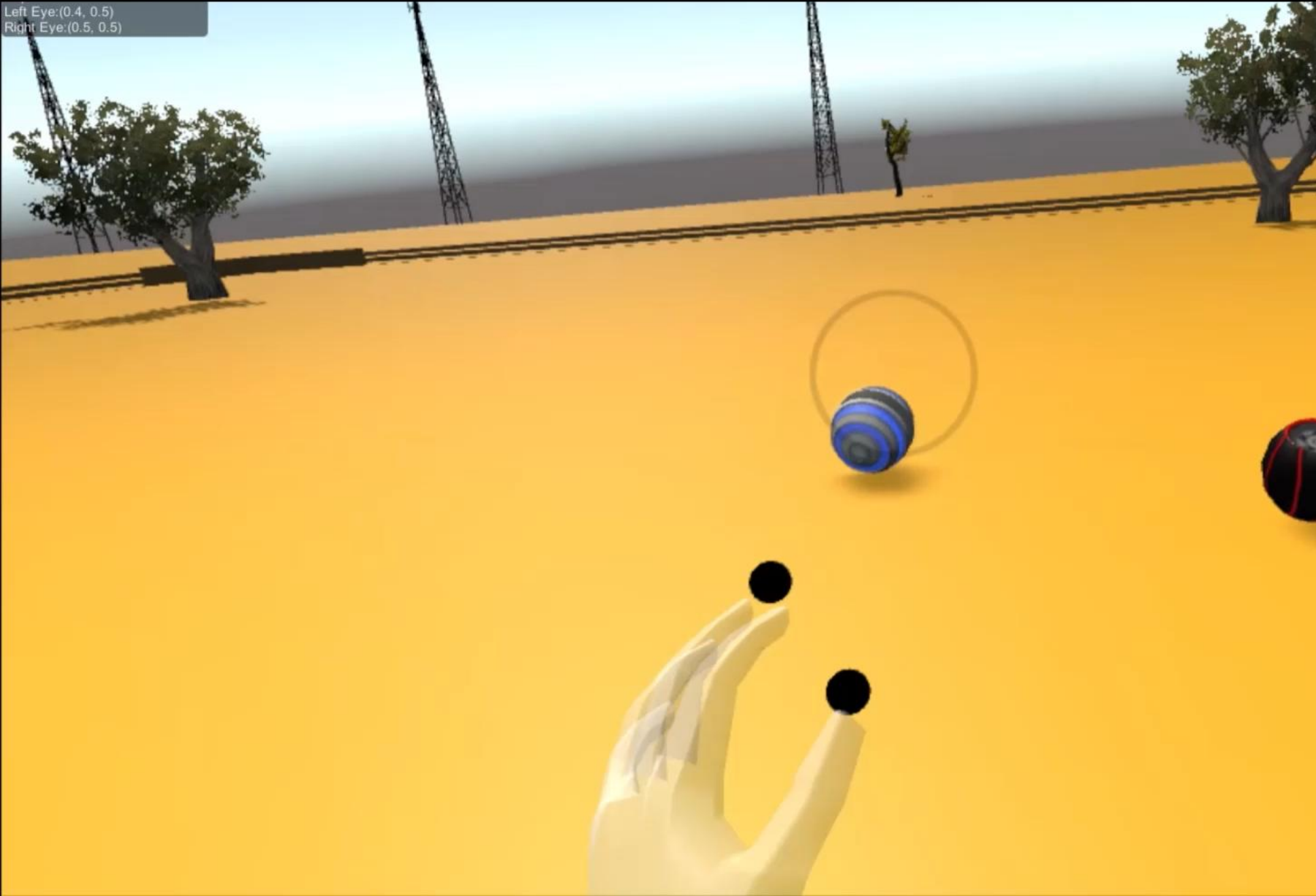


Gaze+touch browser UI (UIST 2016)



GAZE + PINCH IN VR (SUI 2017)

Left Eye: (0.4, 0.5)
Right Eye: (0.5, 0.5)

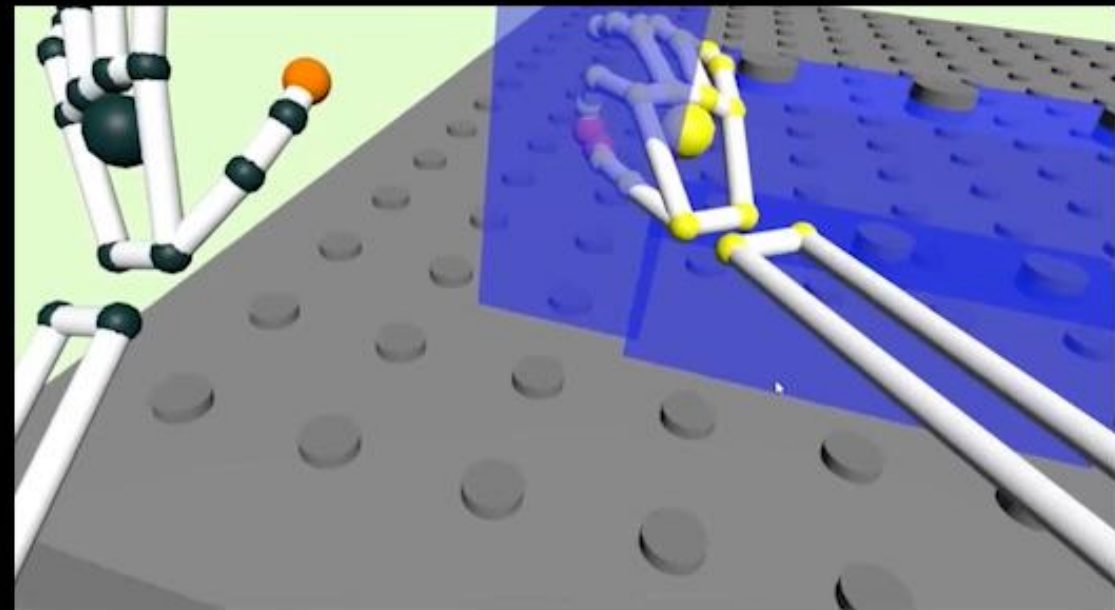


GAZE + PINCH IN VR (SUI 2017)

Pinch gesture: take object from menu
Eyegaze + pinch: place object



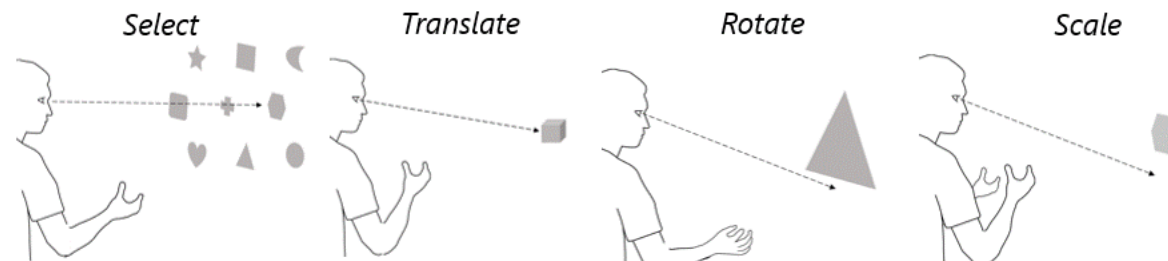
Pinch gesture: place object
Eyegaze + Pinch: get object from menu



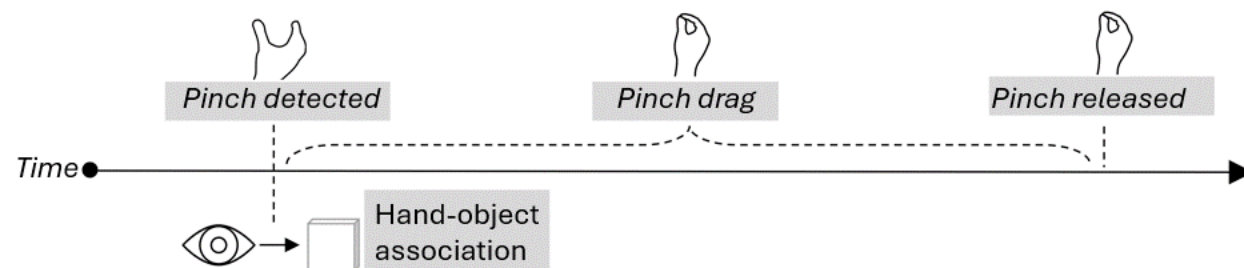
2024

GAZE + PINCH: ONE TECHNIQUE TO RULE ALL XR

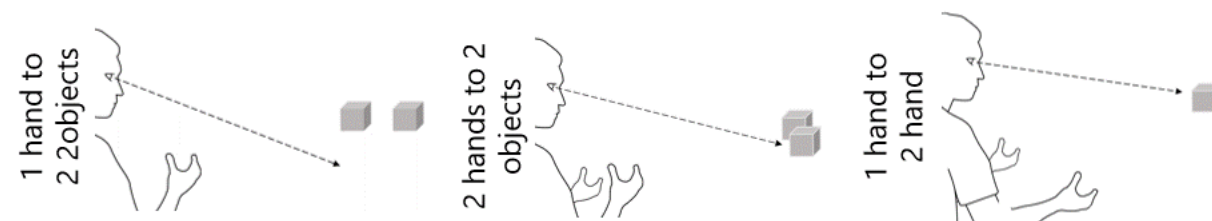
1) A clear *division of labor*: the eyes indicate selection of a target, hands do the work.



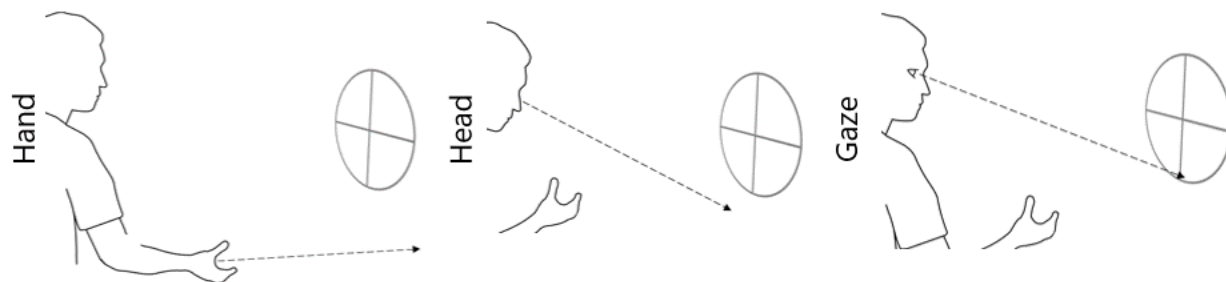
2) *Minimalistic timing*: One moment matters for the eyes—the moment thumb and index finger contact. Then, the hands take over, relieving the eyes from the motor control tasks.



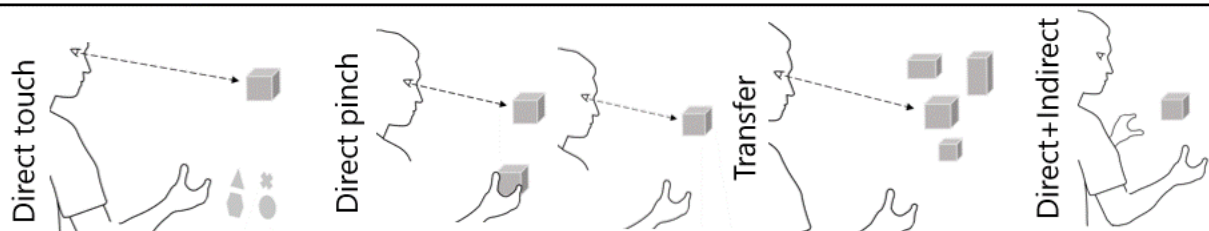
3) Support *flexible gesturing*, by transitions from 1 vs. 2-hands to 1 vs. multi-object control.



4) *Eyes are infallible*, they operate almost instantly at constant accuracy. With good tracking, you can't miss or overshoot like with hand or head rays— you look at an object or not.



5) Gaze + Pinch is *multimodal by design*. It's indirect gestures complement direct gestures. Understand what works best for each, to get the best of both worlds.



Ken Pfeuffer's Research Comes to Life in Apple's Vision Pro Headset

Ken Pfeuffer, a young pioneering computer scientist, has embarked on a remarkable research journey that reached new heights during Apple's presentation of the Vision Pro headset*, as it turns out that the device utilizes a technology similar to the “gaze+pinch” interaction principle that he published back in 2017. Ken is now an Assistant Professor at the Department of Computer Science at Aarhus University.

I didn't know that a user interface so close to my ideas had been integrated into Vision Pro before the product was announced by Apple. There had been some rumors on



Jacob Gorm Hansen • 2.

Founder at Jamscape

1 Woche • 🌐

+ Folgen

While they are trying to put a positive spin on on it, it looks a colossal failure that [Aarhus University](#) forgot to patent this tech <https://lnkd.in/e8nQmepU> and let the tech giants use it for free and without attribution. I have to admit to making a similar mistake myself not patenting Live Virtual Machine Migration back in my day, but that was over 20 years ago, and Danish universities really ought to have learned by now.

visionOS

visionOS supports two categories of gestures: indirect and direct.

People use an *indirect* gesture by looking at an object to target it, and then manipulating that object from a distance — indirectly — with their hands. For example, a person can look at a button to focus it and select it by quickly tapping their finger and thumb together. Indirect gestures are comfortable to perform at any distance, and let people quickly change focus between different objects and select items with minimal movement.

<https://developer.apple.com/design/human-interface-guidelines/gestures#visionOS>



Ken Pfeuffer  @KenPfeuffer · Jun 6, 2023



It's pretty insane that apple's new device's UI with eye and hand is in principle the Gaze + pinch technique we invented in our paper at SUI 2017! Little do they know... it is just the beginning of the computer interface revolution :-)



Tim Cook   @tim_cook · Jun 5, 2023

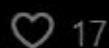
Welcome to the era of spatial computing with Apple Vision Pro. You've never seen anything like this before!



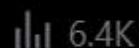
2



5



17



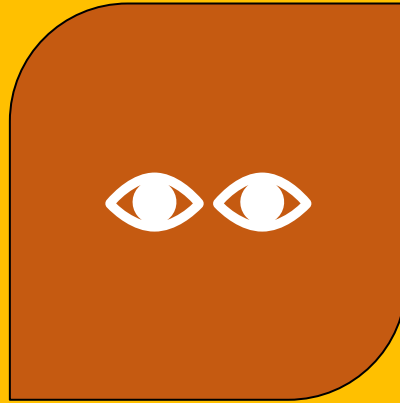
6.4K



UI EVOLUTION



I. HOW DID WE GET
HERE?

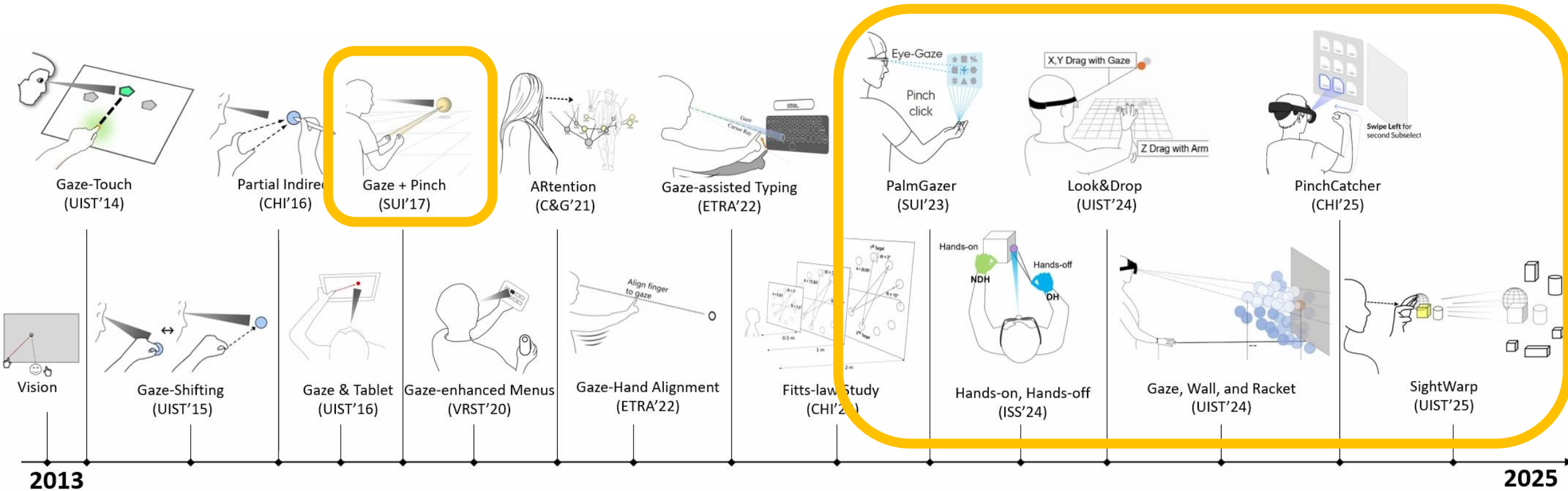


II. WHERE DOES EYE
INPUT COME FROM?



III. WHAT'S AHEAD?

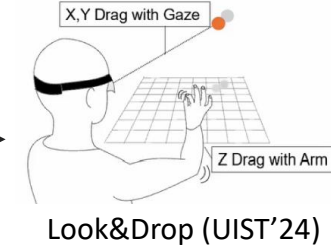
EYE-HAND SYMBIOSIS- ADV. GAZE + PINCH



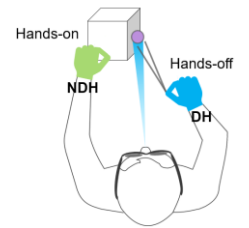
ADVANCING GAZE + PINCH

Amazing for selection & sliders, but...

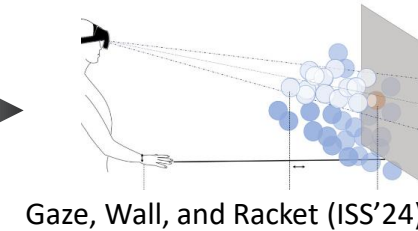
- Drag & Drop → fatigue



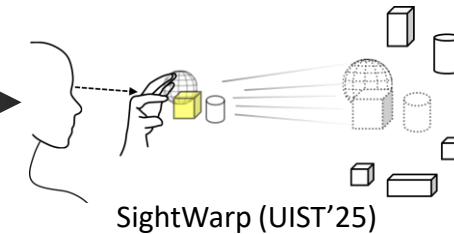
- Bimanual Gestures (direct and indirect) → complex



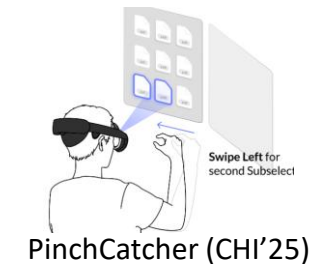
- Gaze is “2D” ray → limits 3D point specification



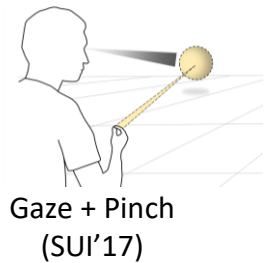
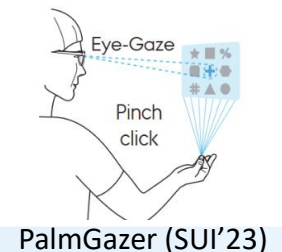
- Clutching for 6DOF Object Manipulation → difficult with gaze



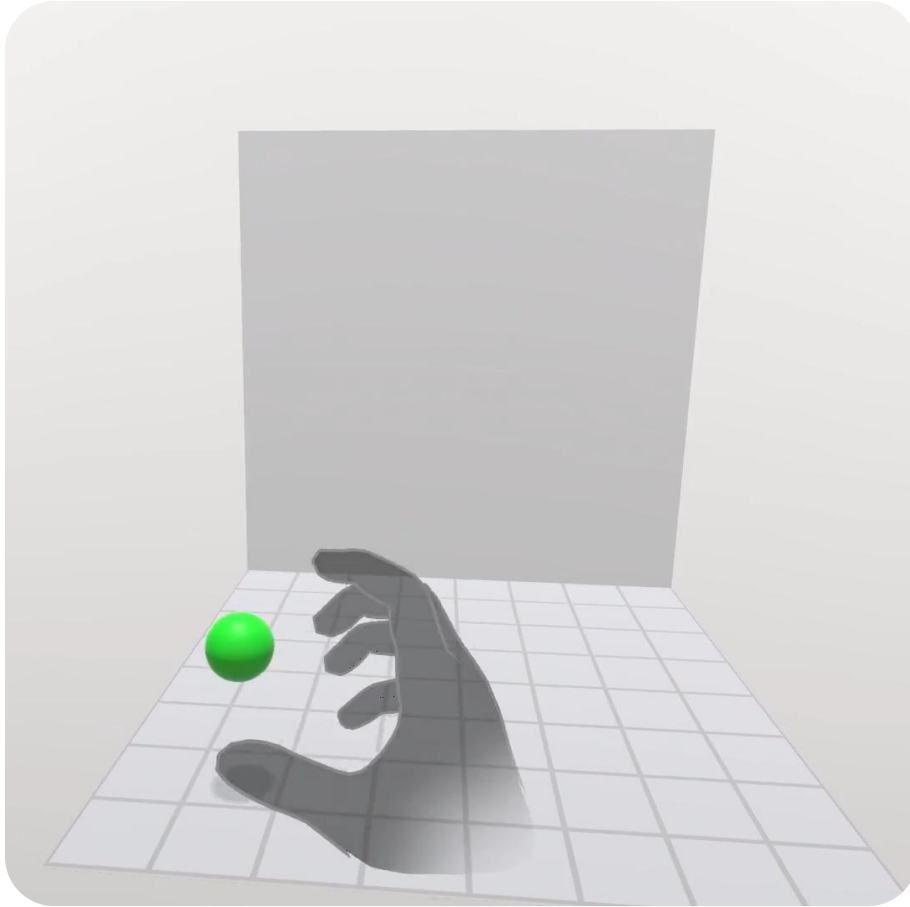
- Single-state Pinch Gestures → limits multi-target interaction



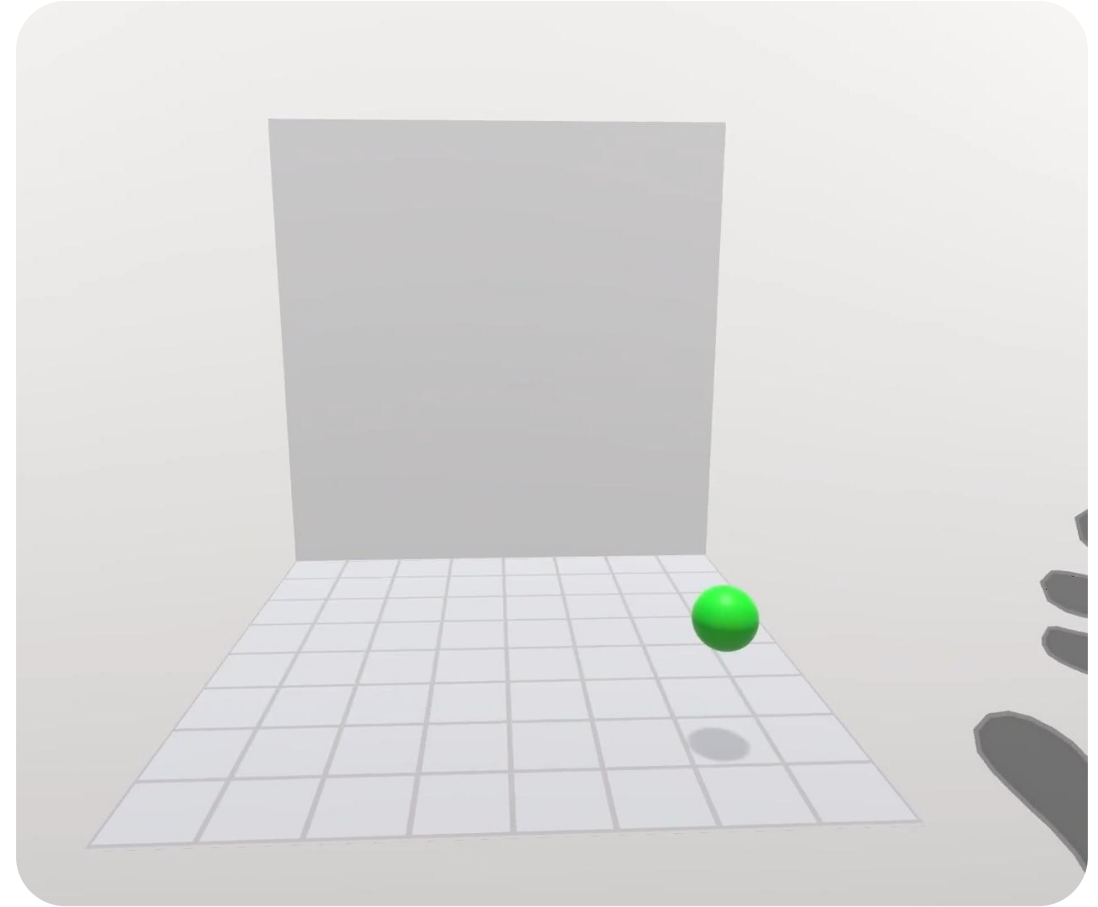
- Mobility: On-the-Go interaction



LOOK & DROP (UIST'24)

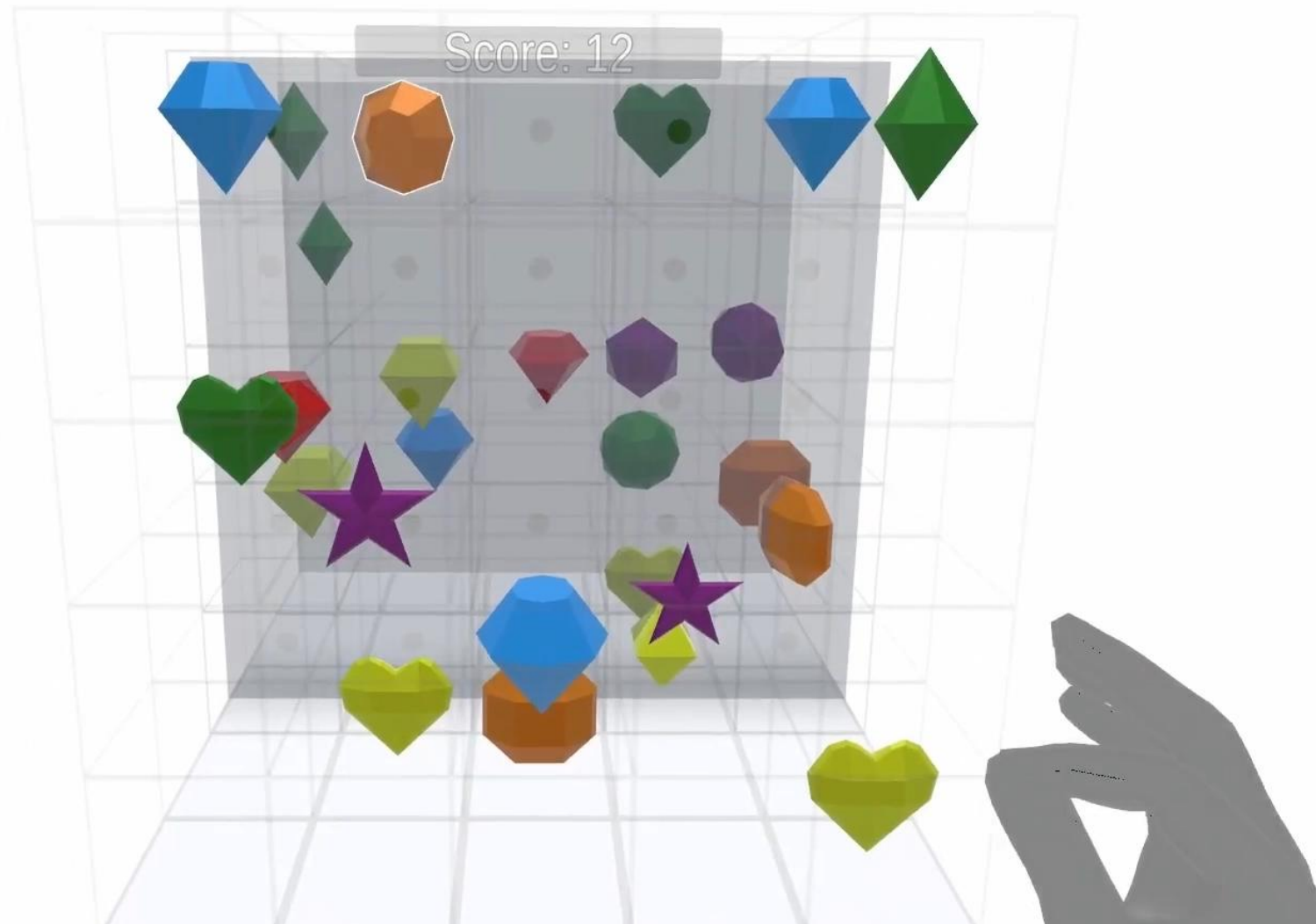


Gaze+Pinch



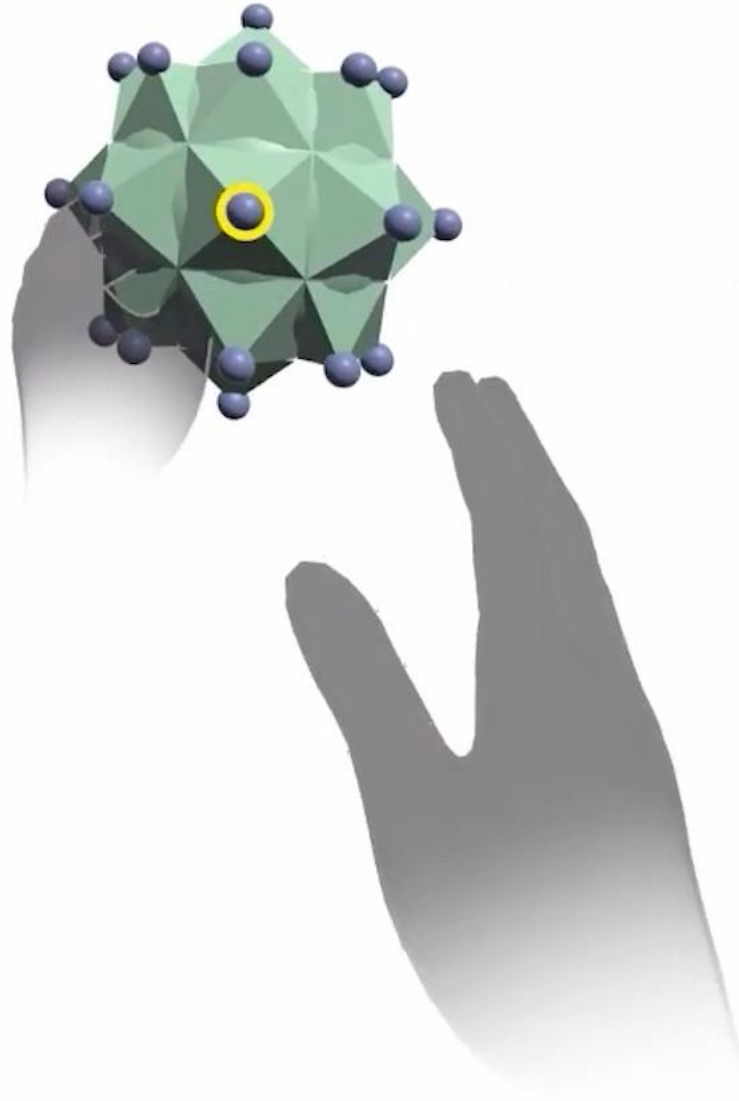
Look&Drop (new)

LOOK&DROP PRO-GAMER IN „3D BEJEWELLED“



TWO HANDS + GAZE [UIST'24]

Direct
gesture



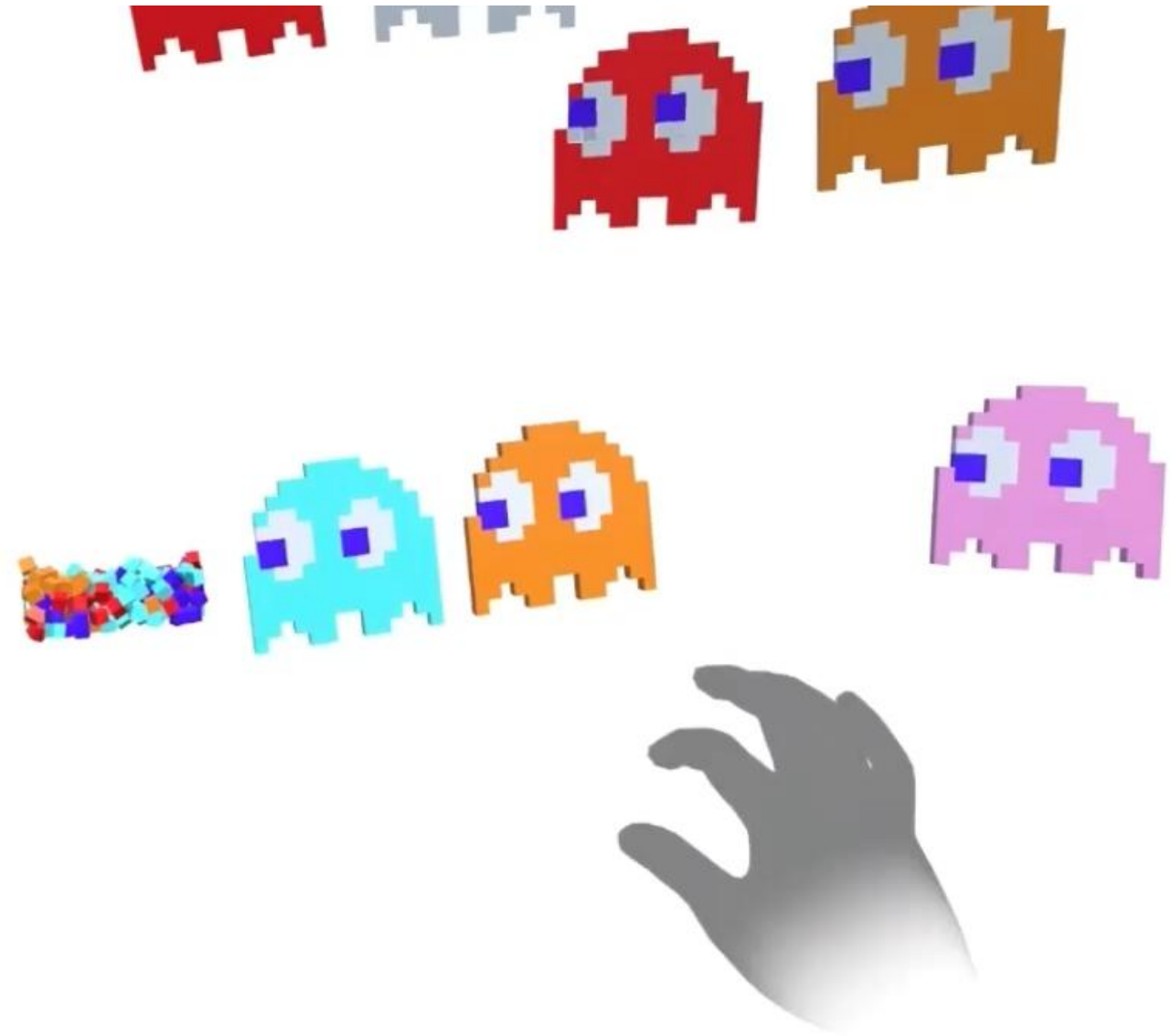
AT A GLANCE TO YOUR FINGERTIPS (UIST'25)

ENABLING DIRECT
MANIPULATION OF DISTANT
OBJECTS THROUGH
SIGHTWARP



AT A GLANCE TO YOUR FINGERTIPS (UIST'25)

ENABLING DIRECT
MANIPULATION OF DISTANT
OBJECTS THROUGH
SIGHTWARP



PALMGAZER (SUI 2023)

AND MORE...

At a Glance to Your Fingertips: Enabling Direct Manipulation of Distant Objects Through SIGHTWARP

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Thorbjørn Mikkelsen^{*} Aarhus University, Denmark
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Zehai Liu^{*} Aarhus University, Denmark
202303481@post.au.dk

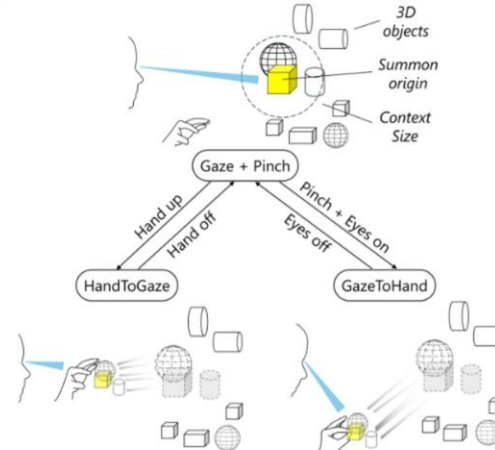
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Ken Pfeuffer^{*} Aarhus University, Denmark
ken@cs.au.dk



ISMAR 2025 (GEMINI Workshop)

Eyes on Target, Pen on Table: Precise VR Interaction with Gaze and Pen

Zhikun Wu^{*} KTH Royal Institute of Technology, Sweden

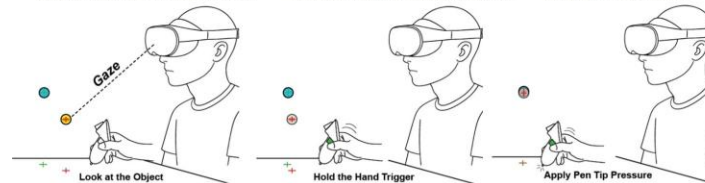
Uta Wagner[†] University of Konstanz, Germany

Mario Romero[‡] Linköping University, Sweden

Alessandro Iop[§] KTH Royal Institute of Technology, Sweden

Andrii Matvienko[§] KTH Royal Institute of Technology, Sweden

Ken Pfeuffer[§] Aarhus University, Denmark



SpatialPad: Using Gaze and Indirect Air-Tap for XR Interaction

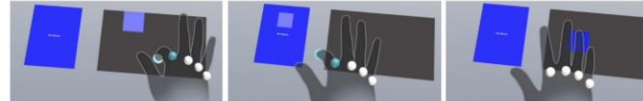
Juan Sánchez Esquivel^{*} Aarhus University

Lauren Zerbin[†] Aarhus University

Qiushi Zhou[‡] Aarhus University

Ken Pfeuffer[§] Aarhus University

Hans Gellersen[§] Lancaster University



Gaze+Mouth: Gaze-Directed Tongue Input with Intraoral Device for Selection in XR

Thorbjørn Mikkelsen^{*} Aarhus University

Yijing Jiang[†] Aarhus University

Baris F. Coskun[‡] Aarhus University

Michael Wessely[§] Aarhus University

Ken Pfeuffer[§] Aarhus University



DOF-Separation for 3D Manipulation in XR: Understanding Finger-Wrist Separation to Simultaneously Translate and Rotate Objects

Thorbjørn Mikkelsen^{*} Aarhus University

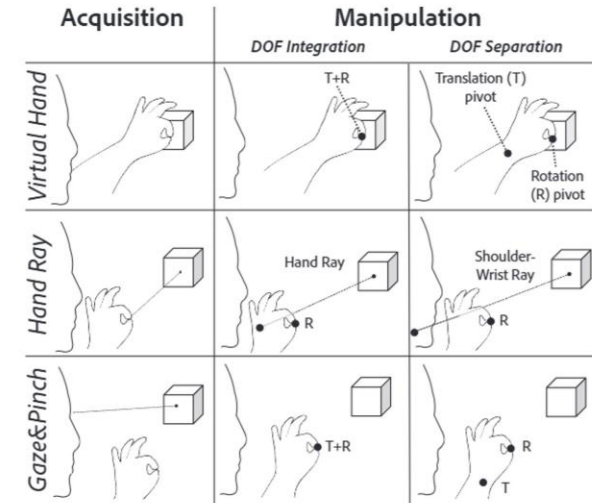
Qiushi Zhou[†] Aarhus University

Mathias N. Lystbæk[‡] Aarhus University

Ken Pfeuffer[§] Aarhus University

Yang Liu[§] Aarhus University

Hans Gellersen[§] Lancaster University



A Study of Multimodal Pen + Gaze Interaction Techniques for Shape Point Translation in Extended Reality

Uta Wagner^{*} University of Konstanz, Germany

Jinwook Kim[†] KAIST, Korea

Zhikun Wu[‡] KTH Royal Institute of Technology, Sweden

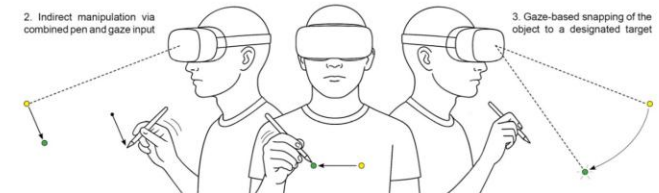
Qiushi Zhou[§] Aarhus University, Denmark

Mario Romero[§] Linköping University, Sweden

Alessandro Iop[§] KTH Royal Institute of Technology, Sweden

Tiare Feuchtnner^{**} University of Konstanz, Germany.

Ken Pfeuffer^{††} Aarhus University, Denmark



HeadDepth: Gaze Raycasting with Head Pitch for Depth Control

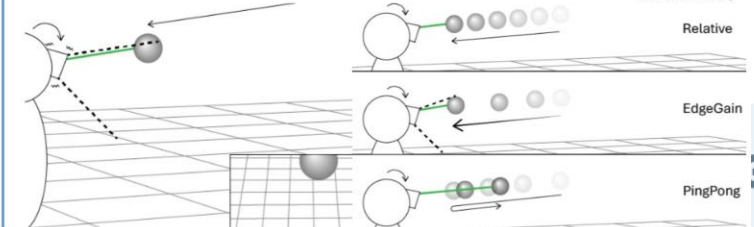
Haopeng Wang^{*} Lancaster University

Florian Weidner[†] University of Glasgow

Yasmeen Abdrabou[‡] Lancaster University

Ken Pfeuffer[§] Aarhus University

Hans Gellersen[§] Lancaster University

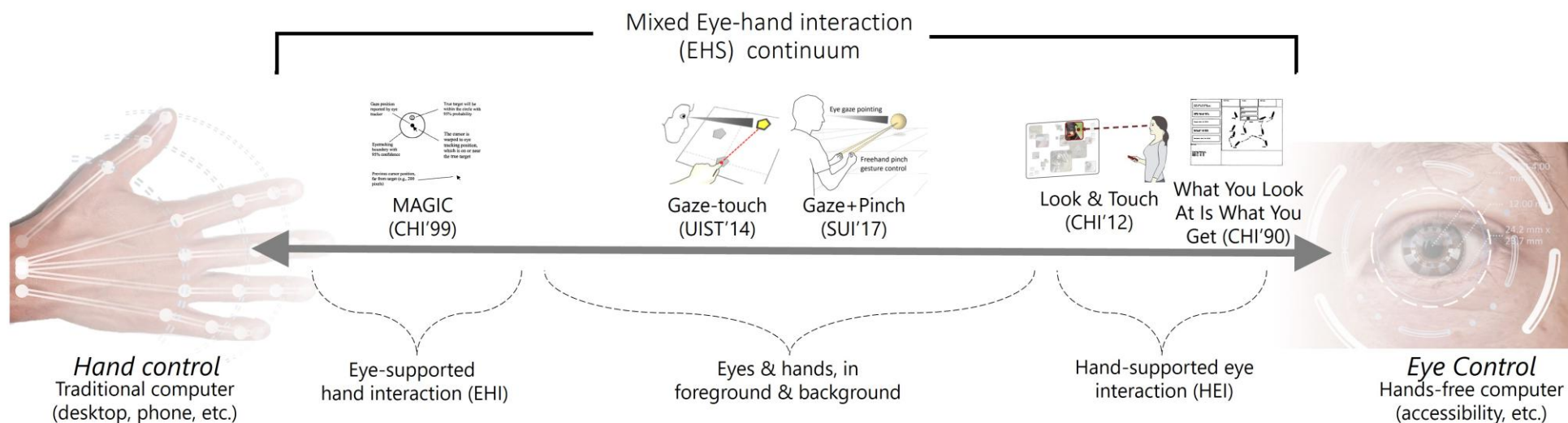


Future directions

1950-2020: Eyes XOR hands

2020+: Eyes AND hands symbiosis

- a. XR: Experiences by gaze + pinch, people adapt
- b. Cross devices: Expand to phone, tablet
- c. Any eyes + hands mixes on a continuum



HANDS → EYES AND HANDS

- 10 year journey
- The hook is in
- Future is bright
 - Cross devices
 - Any eye+hand mixing

