

Master Thesis Presentation

Immersive Authoring System with 3D-represented Control Panel on Desk

Yeeun Shin



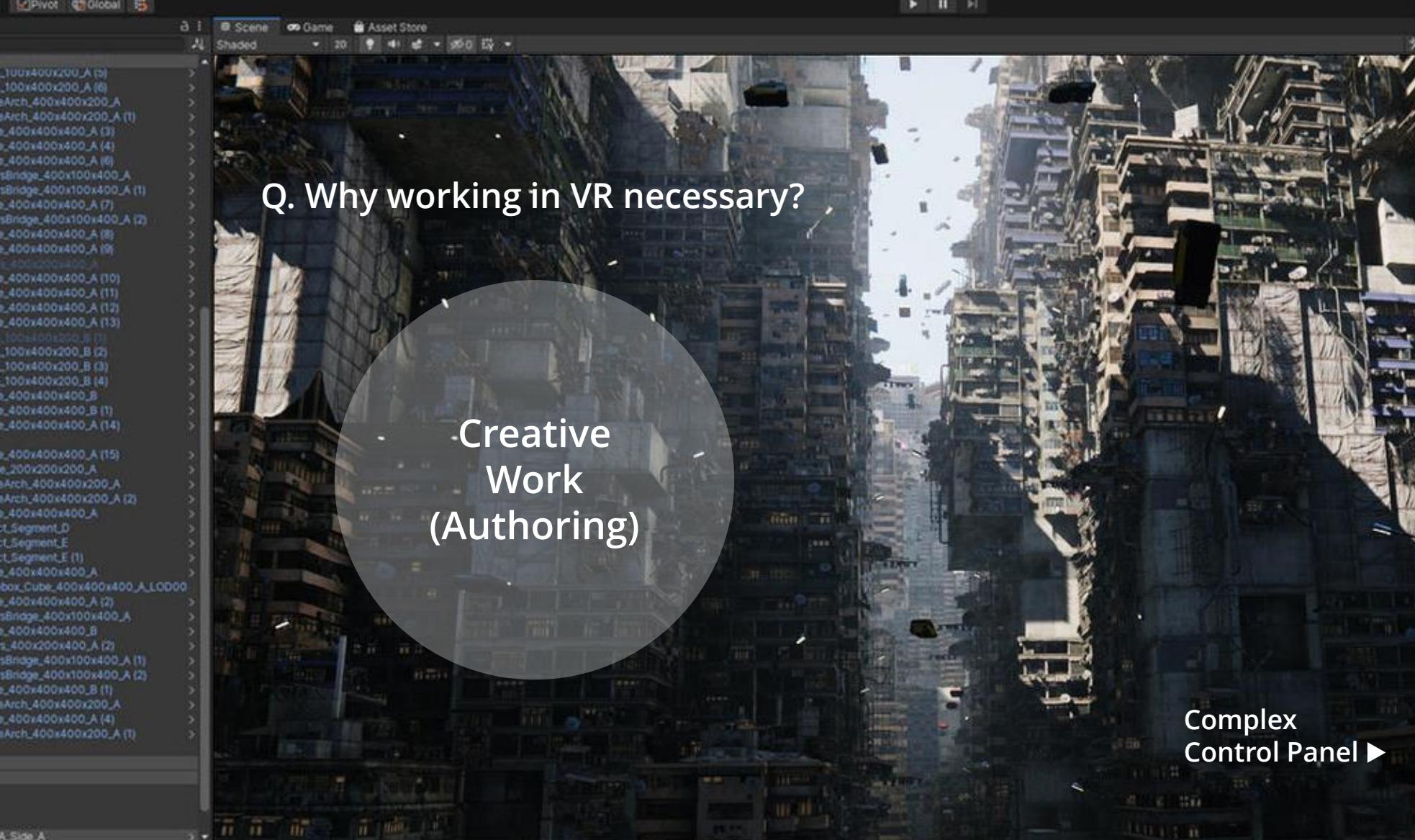
1. Introduction. Background



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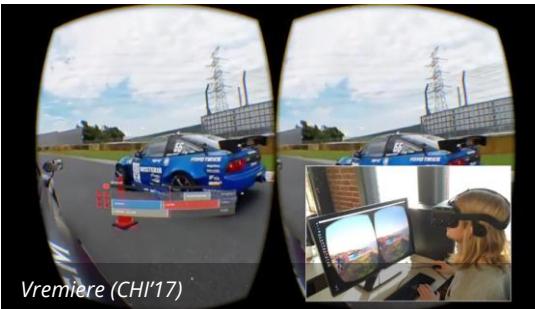
1. Introduction.

Related Works

Immersive Authoring.

Immersive authoring enables users to intuitively view and create 3D content through a "What You See Is What You Get (WYSIWYG)" environment [1]

Virtual Reality (VR)



- (+) Stable operation with controller, mouse
- (-) Decreased portability and hand limitations with additional equipment

Augmented Reality (AR)



- Natural and Expressive Interaction with bare-hands

- Leverage object or environment as passive haptic

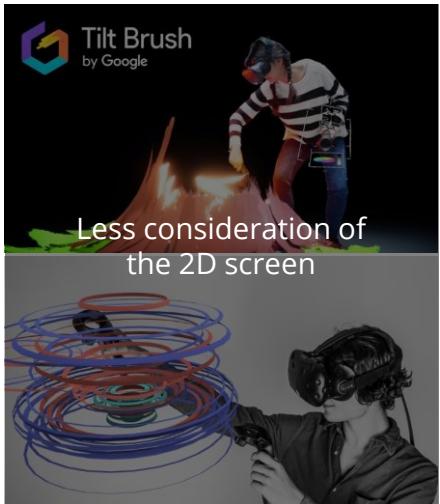
Aim to design an immersive authoring interface utilizing the everyday object desk as a user interface
to capture both **stability** and **natural bare-hand interactions** in manipulation

1. Introduction.

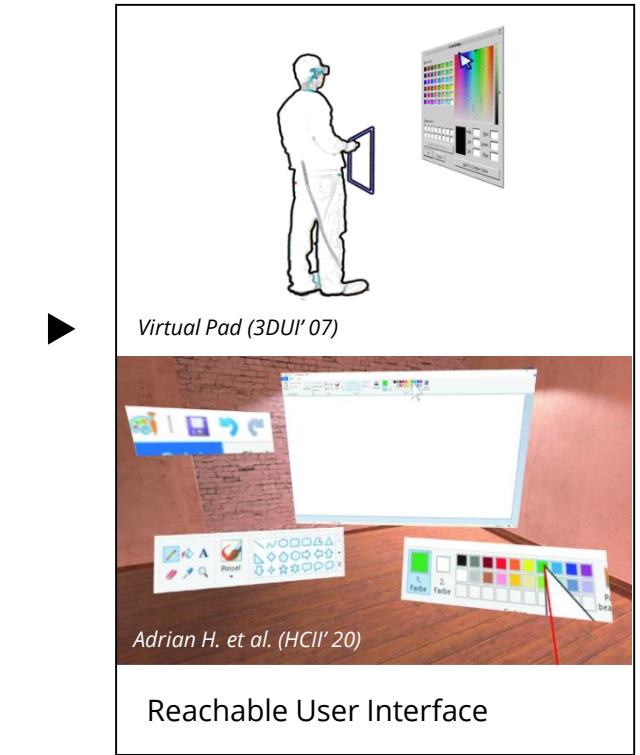
Related Works

Screen interaction in Immersive Authoring.

Screens, even in a 3D environment, remain efficient in conveying information
2D techniques can be effective for tasks involving widget manipulation [2]



Raycasting sensitive to distance and interactable element size.



Reachable User Interface

not covering the design process,
still making the HMD off and on

Our work involves encompassing the entire design process by considering **screen interaction**,
while ensuring users can comfortably **direct** interact with it at a **reachable distance**.

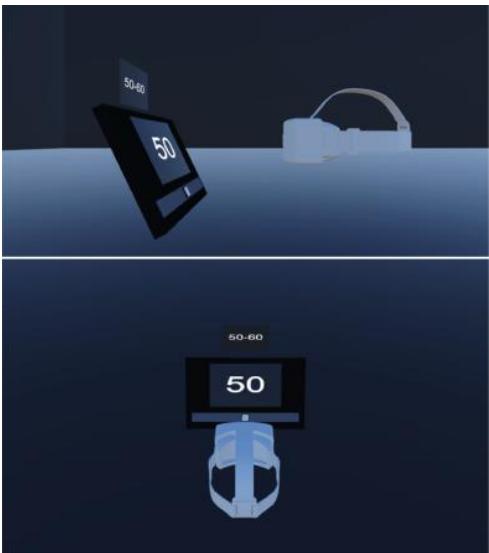
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Related Works

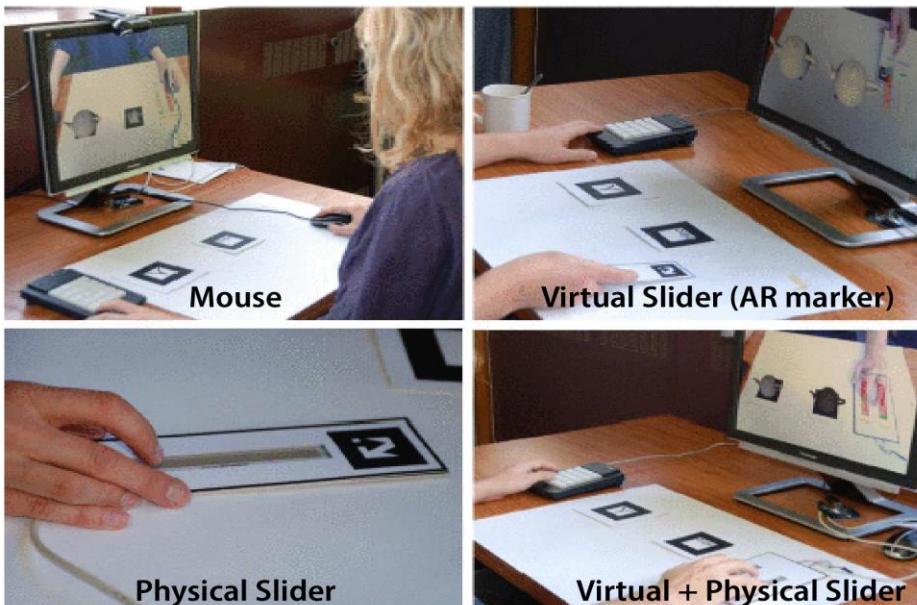
Creativity Support in Immersive Authoring.

Supports creativity with spatial multiplexed inputs through 3D representation

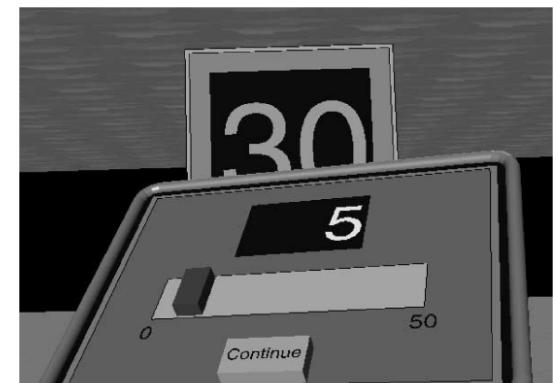
2D Interaction Interface in AR/VR



A comparative evaluation of direct hand and wand interactions on consumer devices (Computers & Graphics 77 '18)



Evaluation of Tangible User Interfaces for Desktop AR (ISUVR' 10)



The effect of 3D widget representation and simulated surface constraints on interaction in virtual environments (IEEE VR' 01)

Aims to support creative authoring through Space-multiplexed input.

Extending prior research comparing 3D represented control with 2D, we explore this impact on creativity supporting aspect.

[4] George W, An empirical evaluation of graspable user interfaces: towards specialized, space-multiplexed input (CHI'97)
[5] Alissa N, Comparing motor-cognitive strategies for spatial problem solving with tangible and multi-touch interfaces (TEI'13)

1. Introduction.

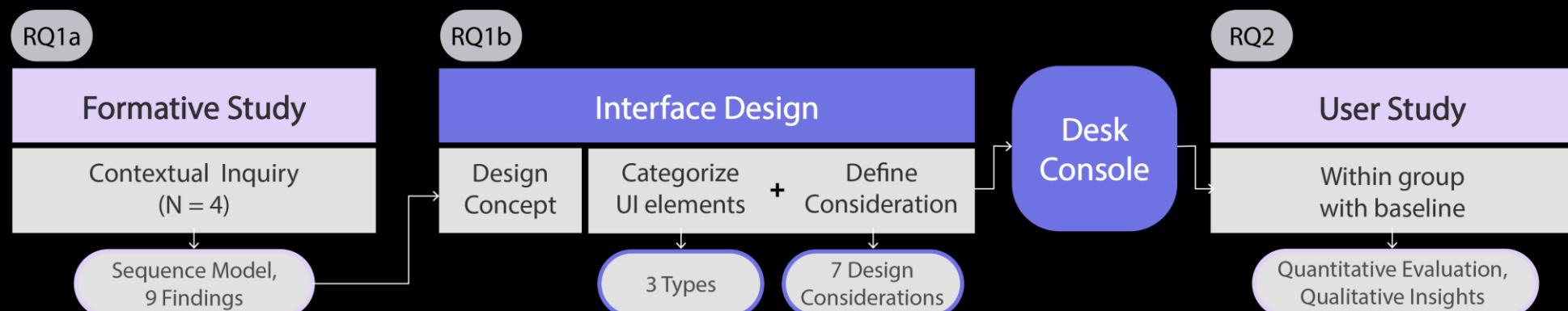
Objectives

How can we design the **immersive authoring interface**
enabling intuitive **screen UI interaction**
to capture both **stability** and **naturality** in operation?

1. Introduction.

Objectives

- RQ1a What are current user experiences of creative work with virtual screens?
- RQ1b How can an immersive authoring interface be designed to enable intuitive and natural interaction, while ensuring the stability of bare-handed operation with a virtual control panel?
- RQ2 How does the designed interface impact users' creative experience, and to what extent does it enhance various aspects of creative work?



2. Formative Study

Contextual Inquiry

Objectives

To clearly understand the user's experience of creative working with virtual screens

- Identify specific work [breakpoints](#) during the process
- Gain insights into the [limitations of the current interface](#)

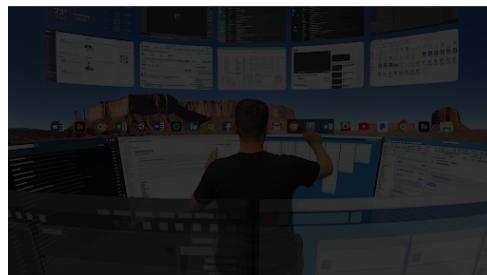
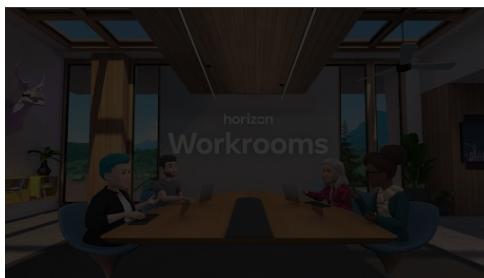
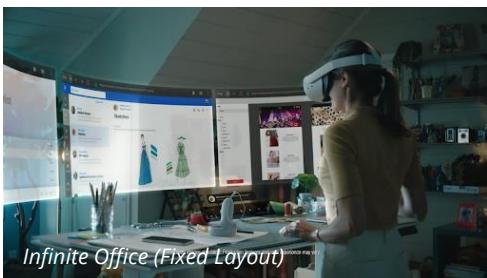
Participants

4 Participants (2F/2M)

- Average age = 23, SD = 0.82
- previous VR experience
- familiar with design task

Setup and Task

Mood-board making in 2 different screen environments using bare-hand Raycasting and mouse, keyboard.



2. Formative Study

Contextual Inquiry

Key Findings

Characteristics of the creative work

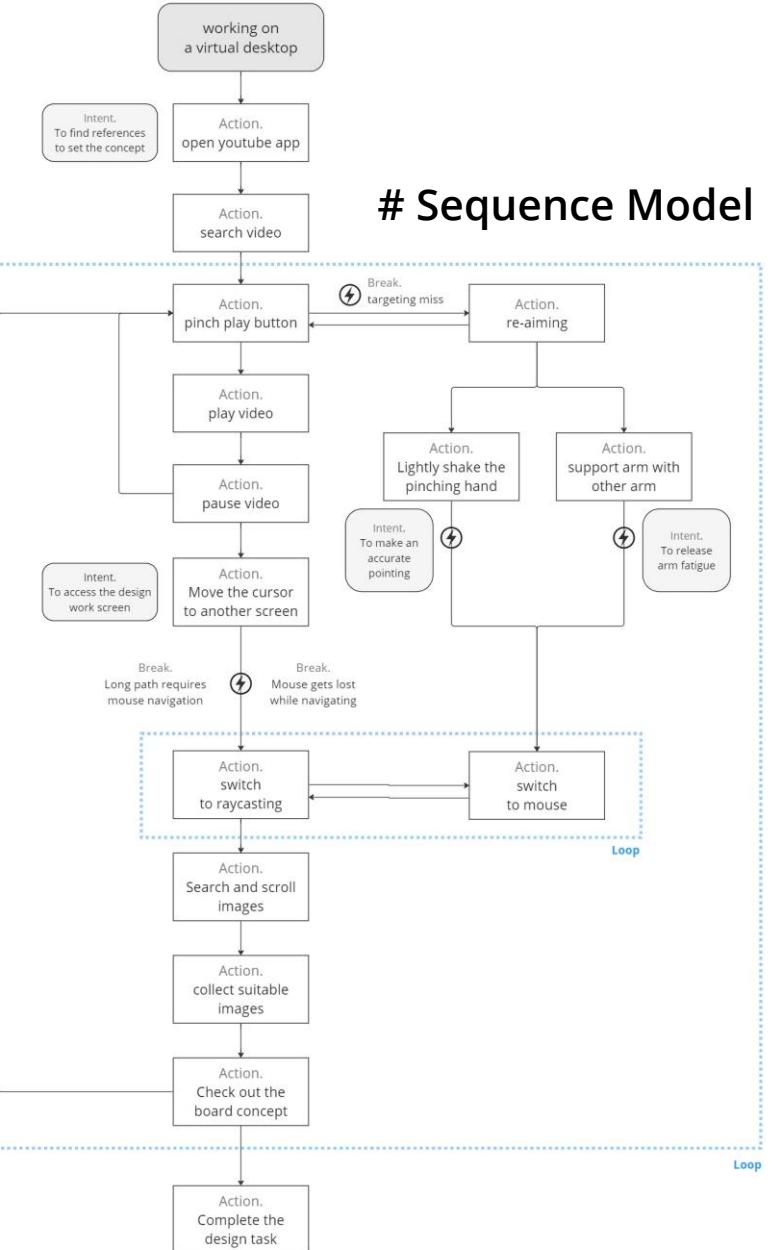
- D1. Utilize multiple screens for ref and task
- D2. Require control panel interaction (densely packed UI elements)
- D3. Require respective access to certain control
- D4. Include various type of controls

Characteristics of VR working

- V1. Typically uses a larger virtual screen than reality for immersion
- V2. Commonly use Raycasting method to interact with distant objects

Common Pain-points of creative work with virtual screens

- 1. Generation of repetitive and lengthy movements of the hands and gazes (D1+D3+V1)
- 2. Physical fatigue due to fine manipulation required for control panels (D2+V2)
- 3. Distracted attention by cognitively awkward indirect manipulation (D4 + V2)



Desk Console

Immersive Authoring System with
3D-represented Control Panel on Desk



3. Desk Console System

Desk Console



Desk Console

Desk Console Design Process

1. Define
Interaction Design
Consideration

2. Categorize
UI Elements of
Creative Tools

3. Design
interaction
for each UI type

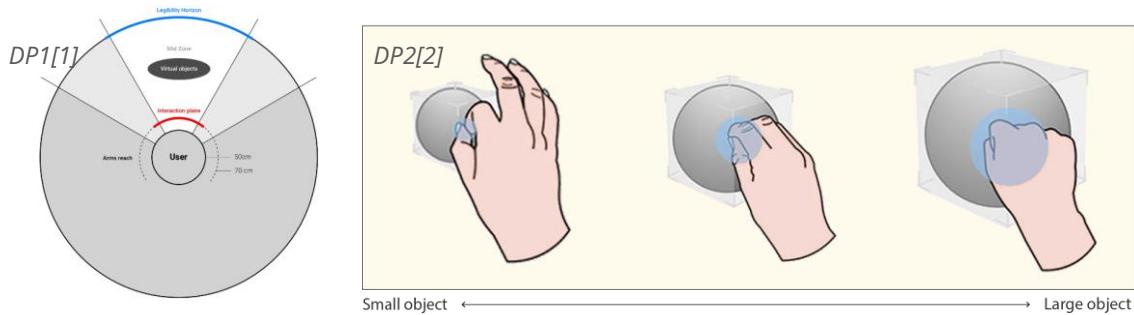
4. Apply to
example panel



Interaction Design

AR/VR Interaction Design Principle

*Referring to AR/VR Design Guidelines and Heuristic from
(Ultraleap, Microsoft, Adobe, Meta, etc)*



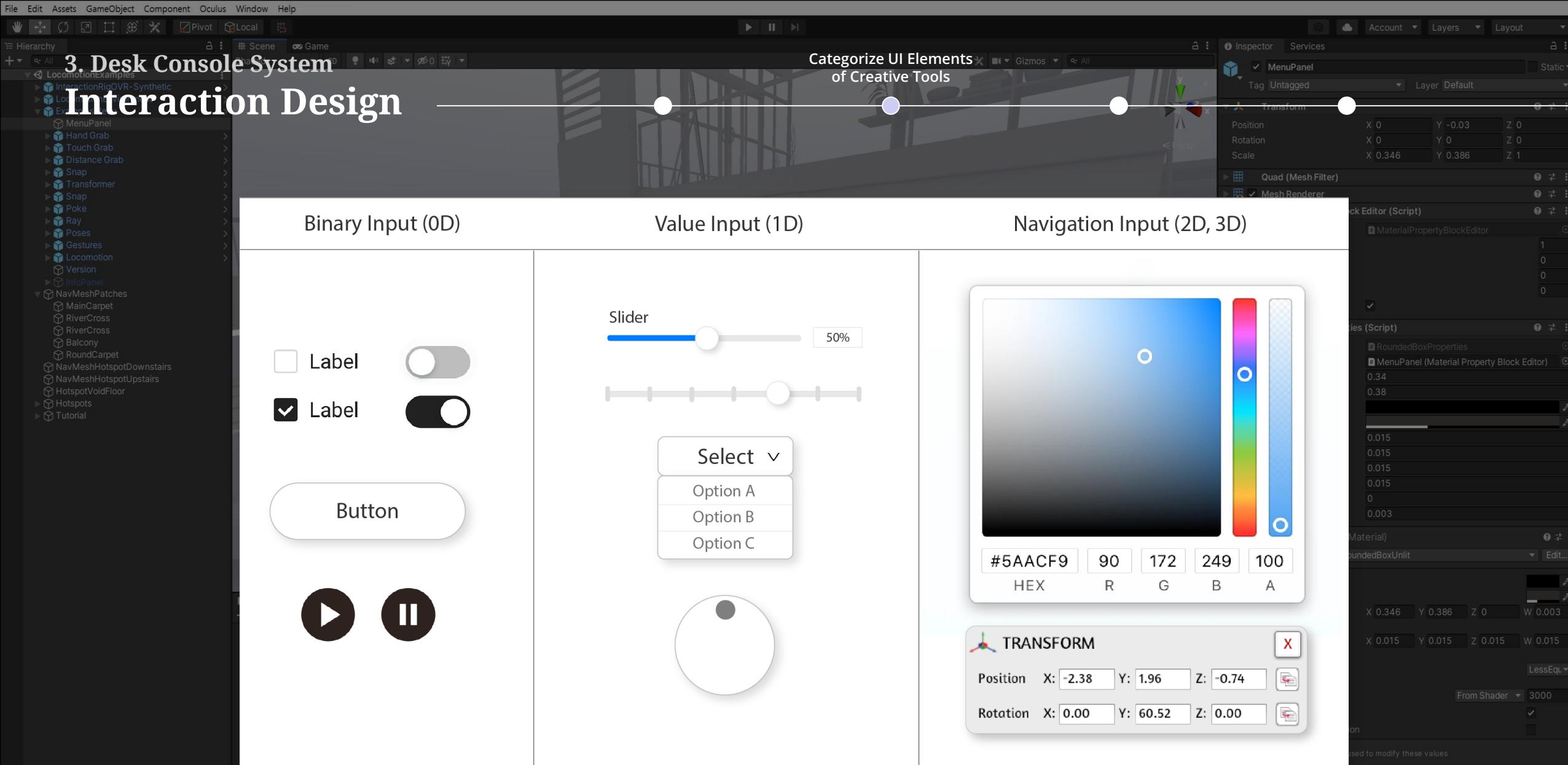
- DP 1. Consider spatial zoning when placing content Placement
- DP 2. Design direct manipulation with instinctual gestures Manipulation
- DP 3. Adopt Familiar user interface(UI) Patterns Form
- DP 4. Provide sufficient audio and visual cues for interaction Cue

Creative Console Consideration

Referring to existing physical creative console devices



- CC 1. Maintain simplicity for blind operation Manipulation
- CC 2. Design for one-handed operation Manipulation
- CC 3. Design simple form with clear affordances Form



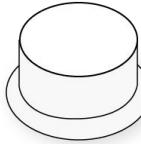
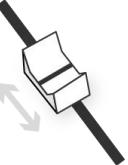
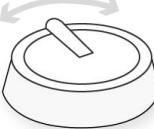
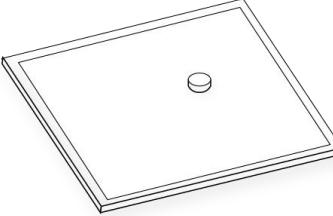
[3] Card, S. K., Mackinlay, J. D., & Robertson, G. G. (1991). A morphological analysis of the design space of input devices. *ACM Transactions on Information Systems (TOIS)*

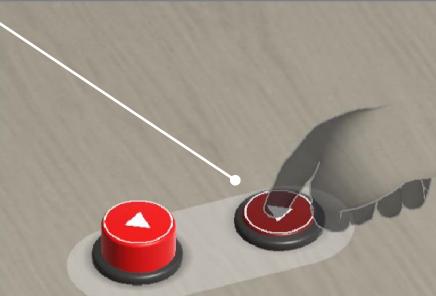
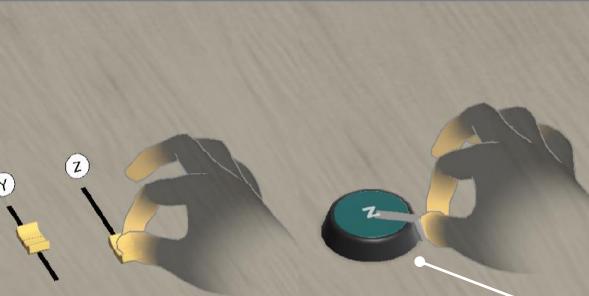
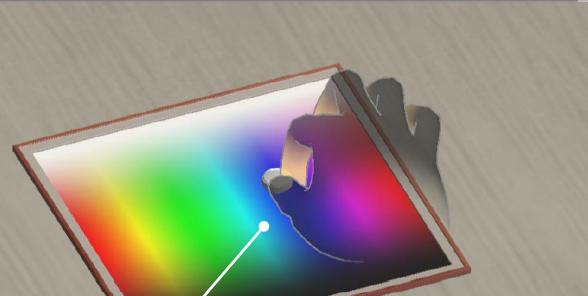
[4] George W, An empirical evaluation of graspable user interfaces: towards specialized, space-multiplexed input (CHI'97)

3. Desk Console System

Interaction Design

Design interaction
for each UI type

Binary Input (0D)	Value Input (1D)	Navigation Input (2D, 3D)
Button	Linear Slider Rotary Knob	Frame with Pin (Color Picker)
<p>Form PD3+CC3</p> <p>Familiar UI patterns with real-world object shapes for easy function inference.</p> 	 	

<p>Manipulation</p> <p>PD2 + CC1 + CC2</p> <p>Single-handed controls without constant eye contact.</p> <p>Seamless and immersive experience through instinctual and real-world interactions.</p>			
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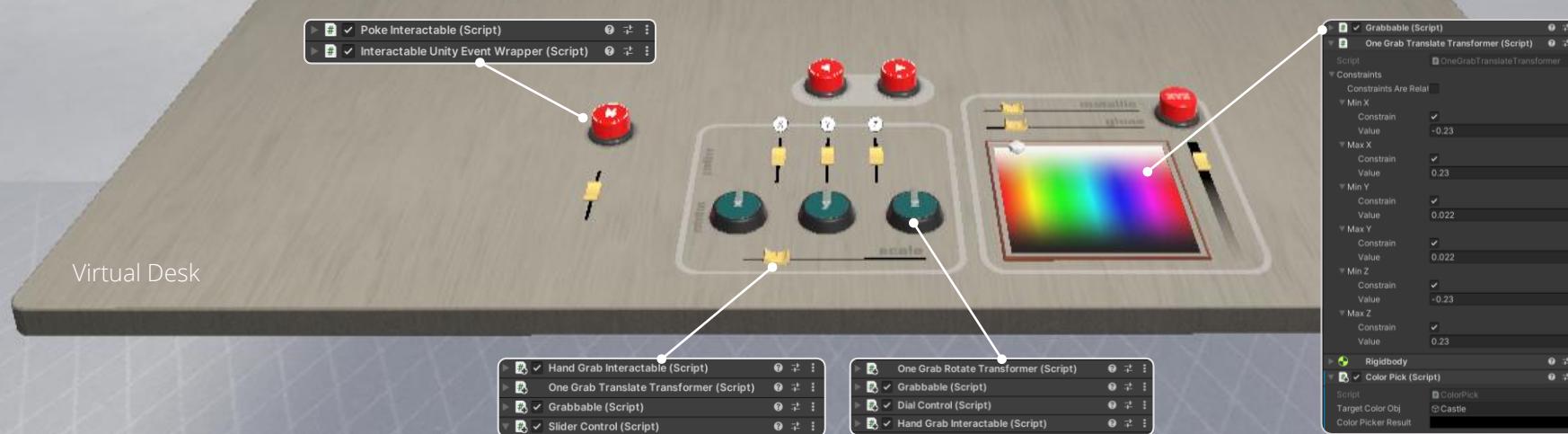
[5] Mark B, Human Input to Computer Systems: Theories, Techniques and Technology

Cue Sound cue: sounds mimic real-world counterparts
PD4 Visual cue: fingertip color change for confident interaction.

3. Desk Console System Interaction Design



3. Desk Console System Implementation



4. Evaluation

User Study - configuration

Objectives

To Investigate Desk Console's impact on user experience and creative process compared to existing methods

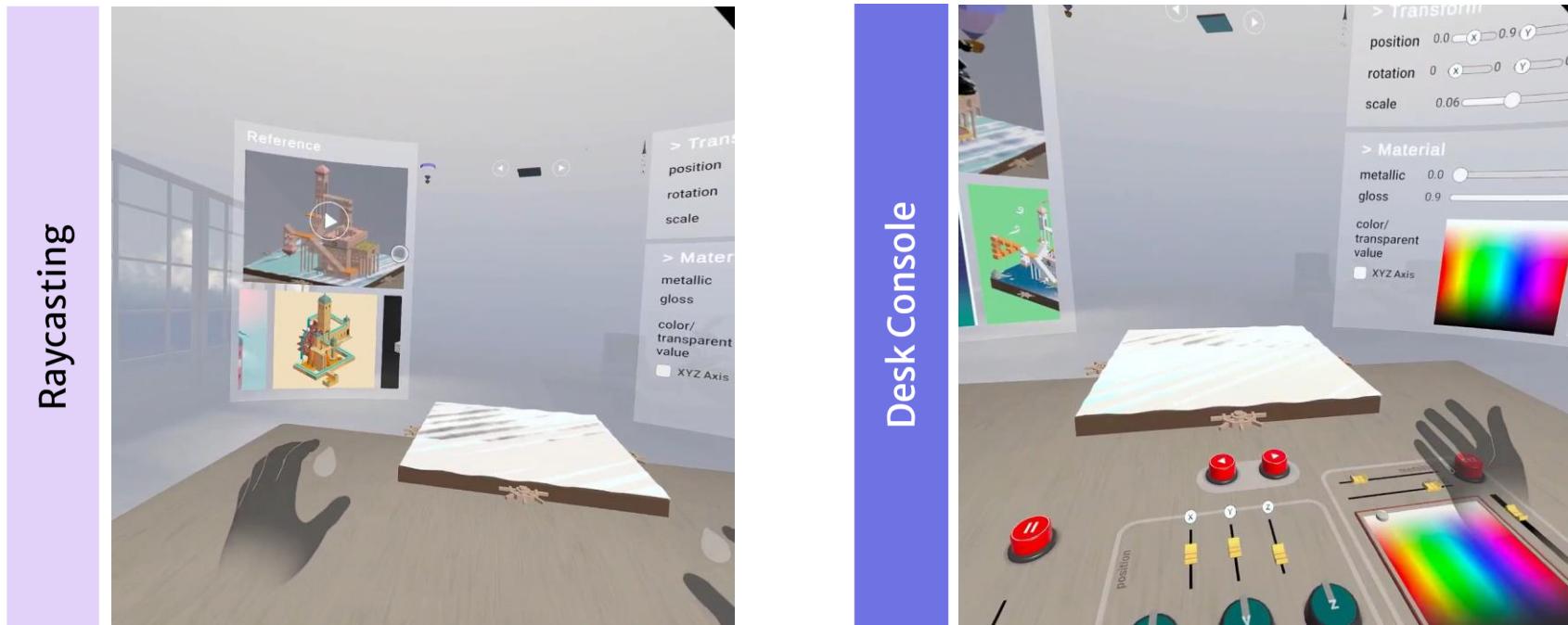
Participants

14 Participants (7F/7M)
• Average age = 25.4, SD = 2.8
• previous VR and 3D design exp

Measure

- Workload (NASA-TLX)
- Creative Support (CSI)
- User Behavior (Log Data)

Baseline Design



4. Evaluation

User Study - configuration

Task Design

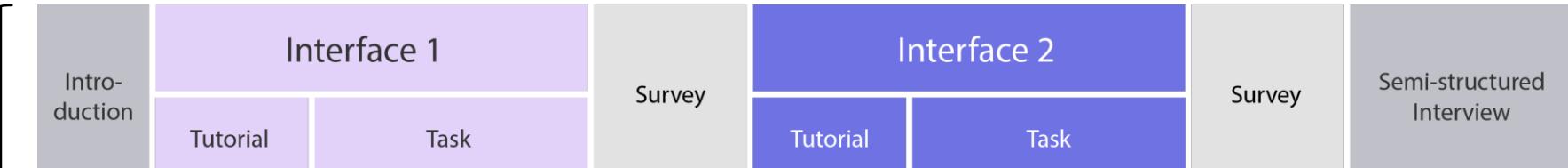
Open-ended task
to explore the impact
on creative work

Task Goal:
Create scene content
by adjusting given assets
based on a specific concept



Screens and panels
designed based on
interviews with
professional 3D artists

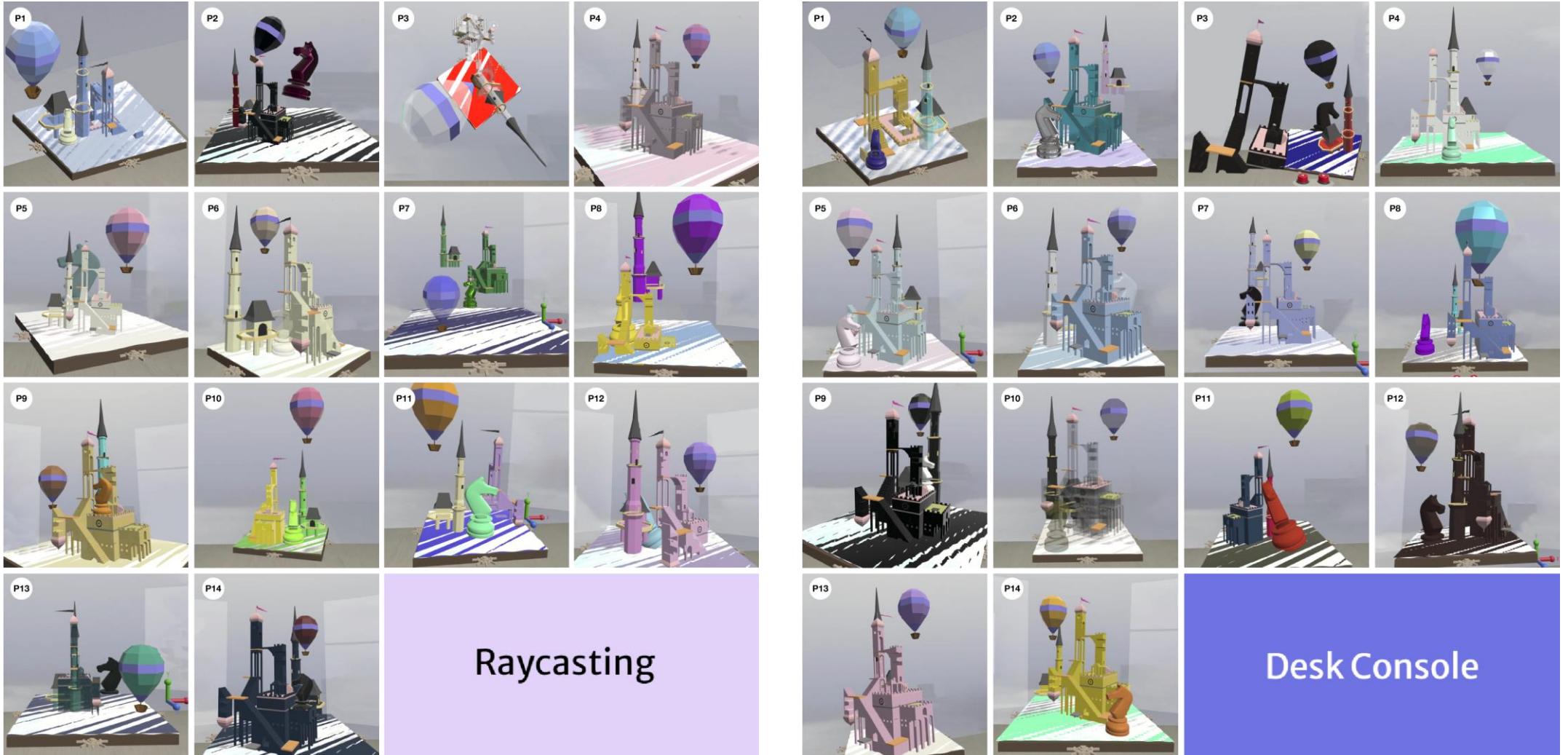
Procedure



* Within-group study - order of interfaces continuously changed

4. Evaluation

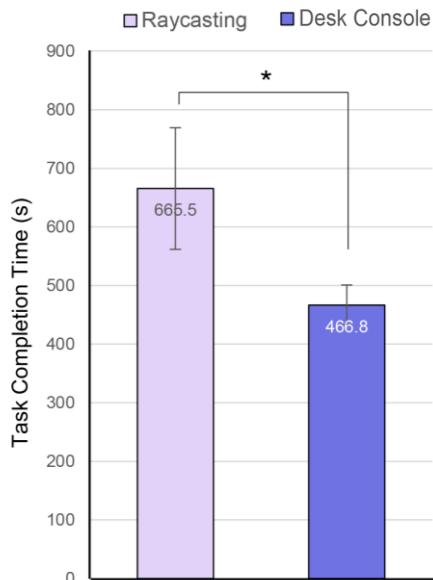
User Study



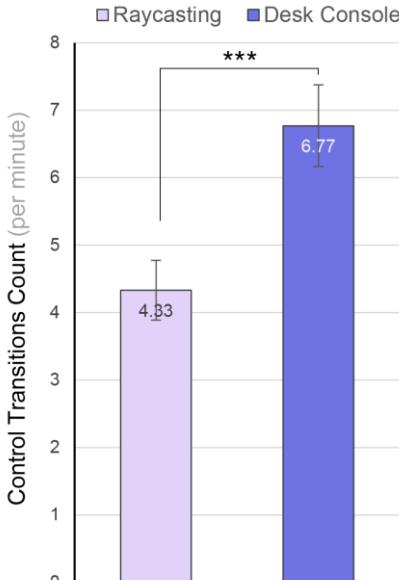
4. Evaluation

Result - Performance Indicators

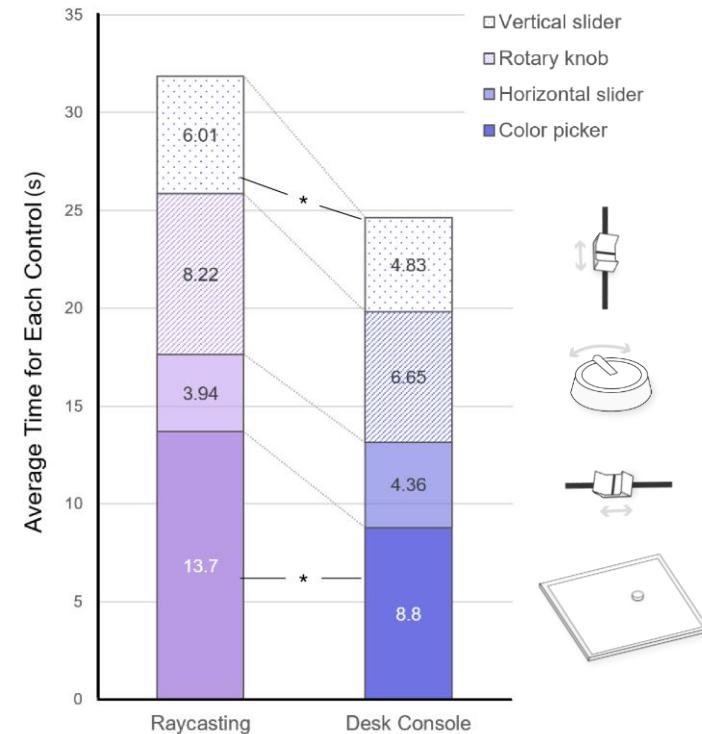
Task Completion Time
(Wilcoxon Signed Ranks Test, p= .027*)



Control Transition per Min
(Variety of controls used)
(Paired Samples T-Test, p= .000***)



Average Time for each Control
(approximate performance of each control)
(Wilcoxon Signed Ranks Test)

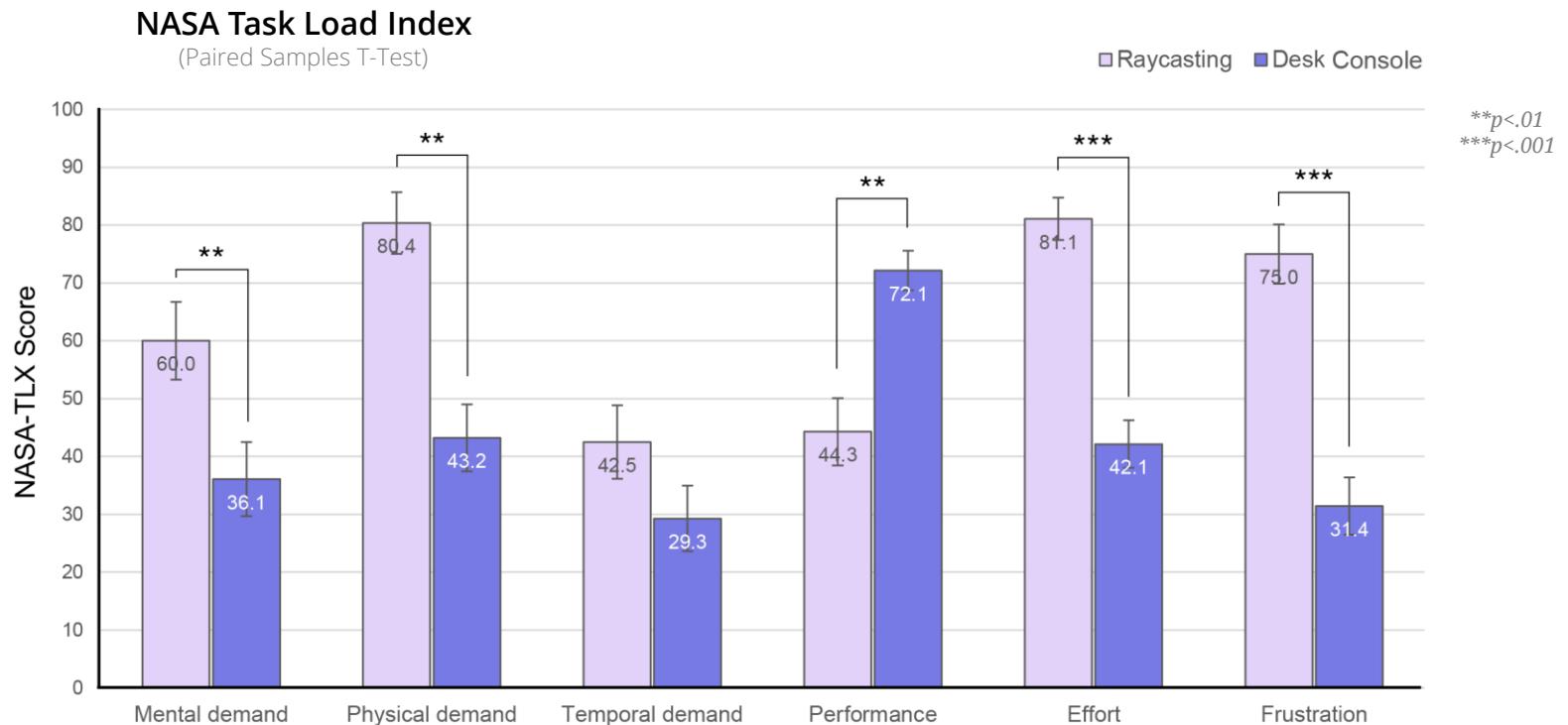


Users were able to explore more various controls within the same amount of time using Desk Console.
The vertical slider and color picker were adjusted significantly faster on the Desk Console.

"Using this (Desk Console) felt more comfortable, so I tried different controls earlier and experimented with various options, whereas in Raycasting, I focused on performing one task well rather than exploring multiple options. " (P9)

4. Evaluation

Result - Workload



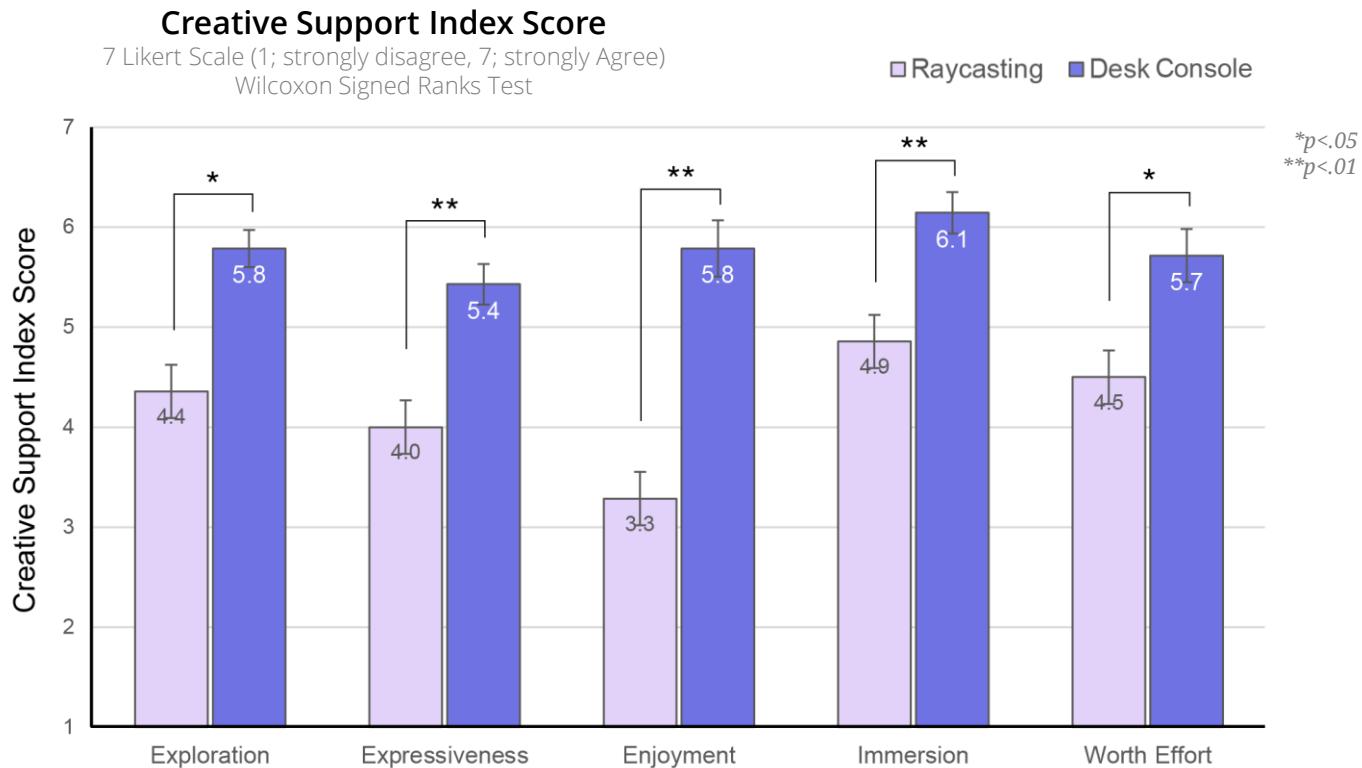
As the interaction in work becomes more realistic, users can focus more on the task, reducing mental demand.
Providing suitable tactile feedback can affect not only physical comfort but also cognitive processes.

"When working on a desk, it's almost instinctively connected to physically moving objects, so it feels comfortable to do it like I usually would." (P14),

"With second one(Desk Console), it's like just pressing buttons right away, so the thought process itself feels a bit shorter.
Since I immediately get feedback right in my fingers, it feels like I was able to do things rightaway without hesitation." (P9)

4. Evaluation

Result – Impact on Creative Workflow



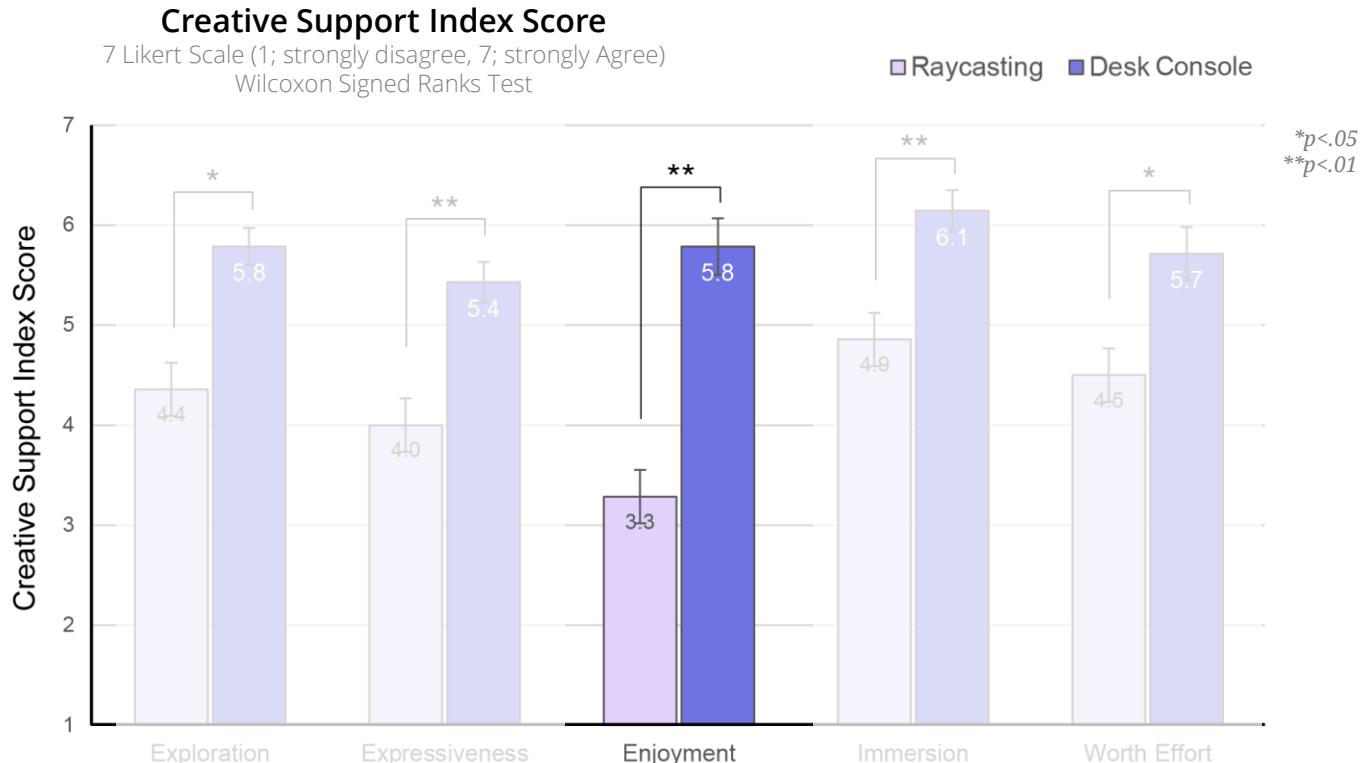
Facilitating users' exploration is enhanced by controllability with easily reversible previous states.
Effective expression is facilitated by passive haptic providing a sense of scale and enhancing spatial awareness.

"It was easier to go back to that state compared to raycasting, so I would discover something good while exploring..." (P12)

"When I used it (on the desk), there was a sense of scale that allowed me to control more accurately and precisely because I could see the difference of double the size between this and that." (P10)

4. Evaluation

Result – Impact on Creative Workflow



And “it was Fun to Use!”
participants frequently referenced the Desk Console in terms of real-world objects

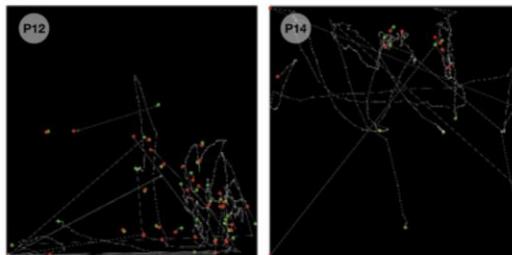
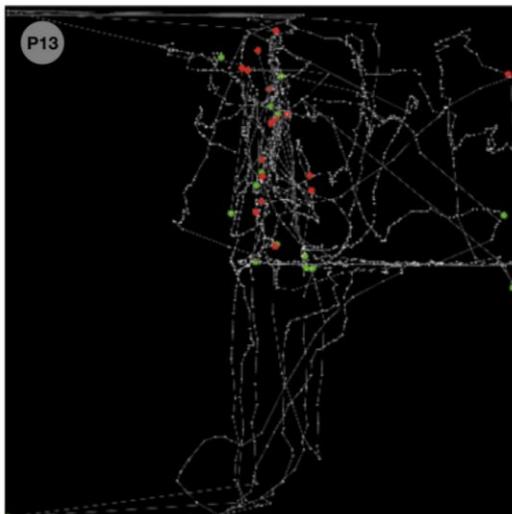
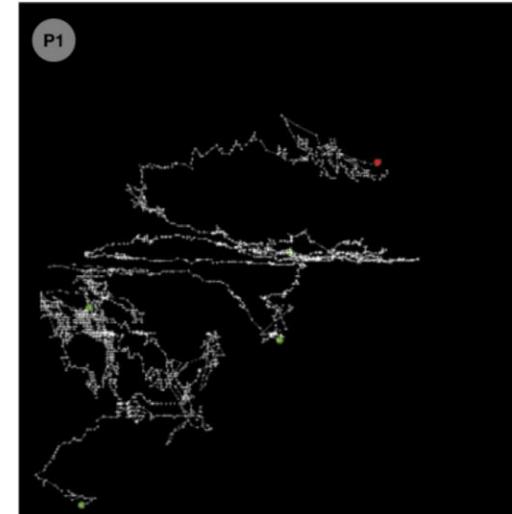
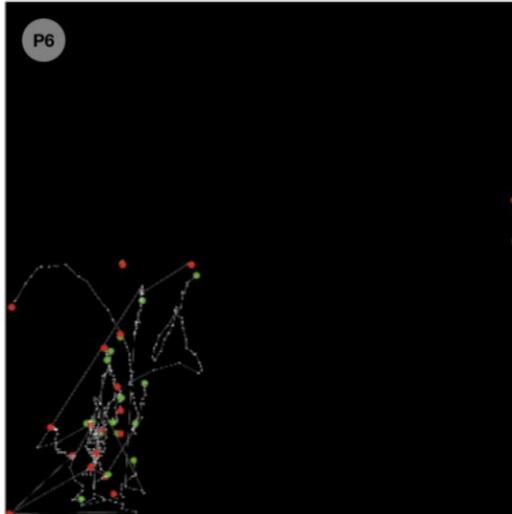
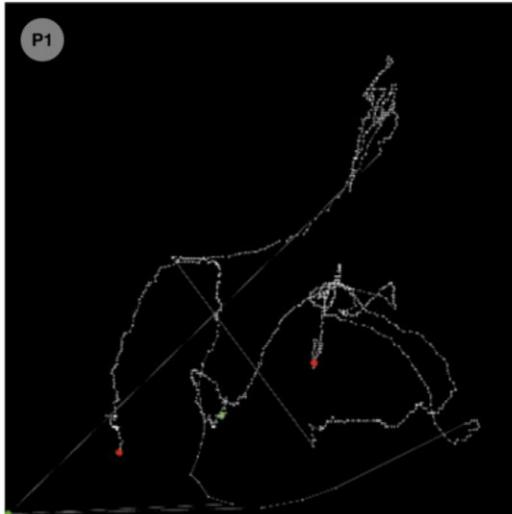
mouse, keyboard (P5, P9, P14) / airplane or helicopter cockpit (P13) / game console pad (P3) / augmented reality (P9)

The alignment with familiar objects and associated tactile experience enhanced the overall fun factor

4. Evaluation

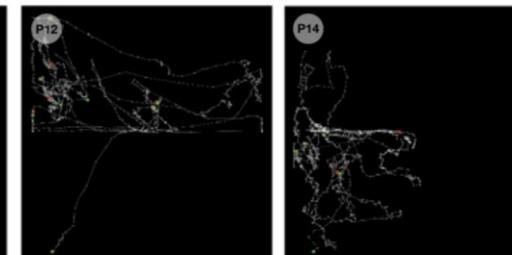
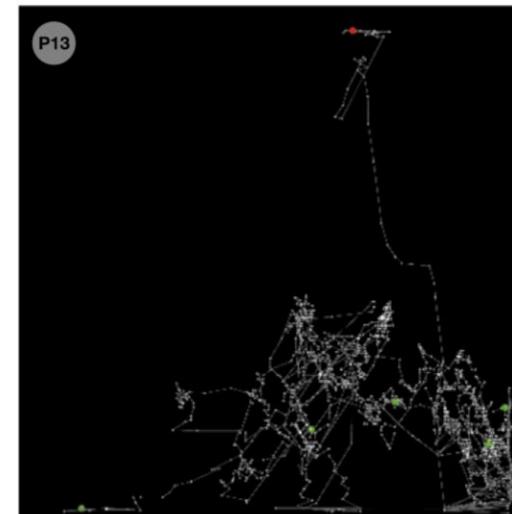
Result – Impact on Creative Workflow

■ START POINT ■ END POINT



Raycasting

Many Points (Frequent operation adjustments)

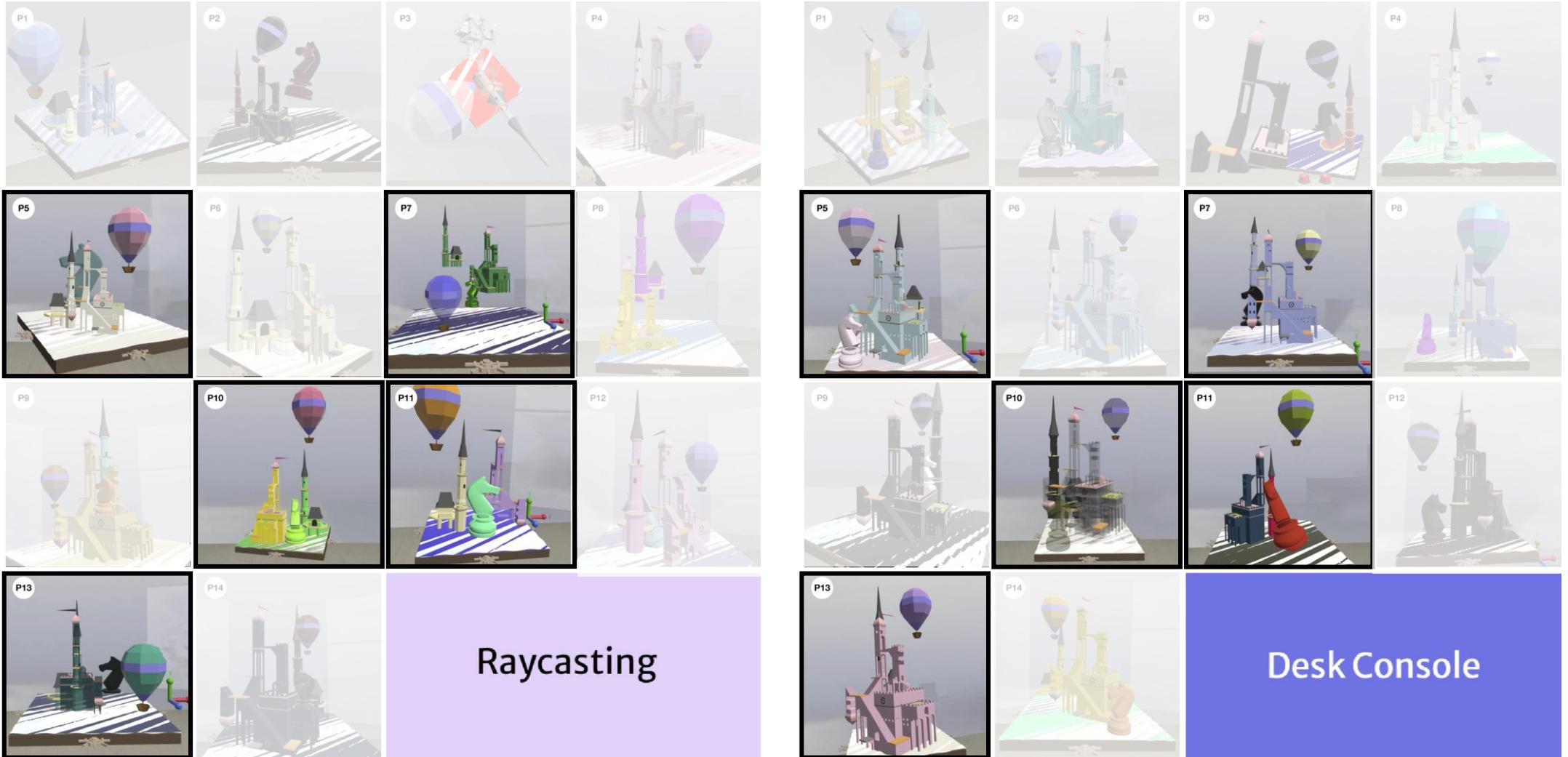


Desk
Console

Condensed path (more detailed color exploration)

4. Evaluation

Result – Impact on Creative Workflow

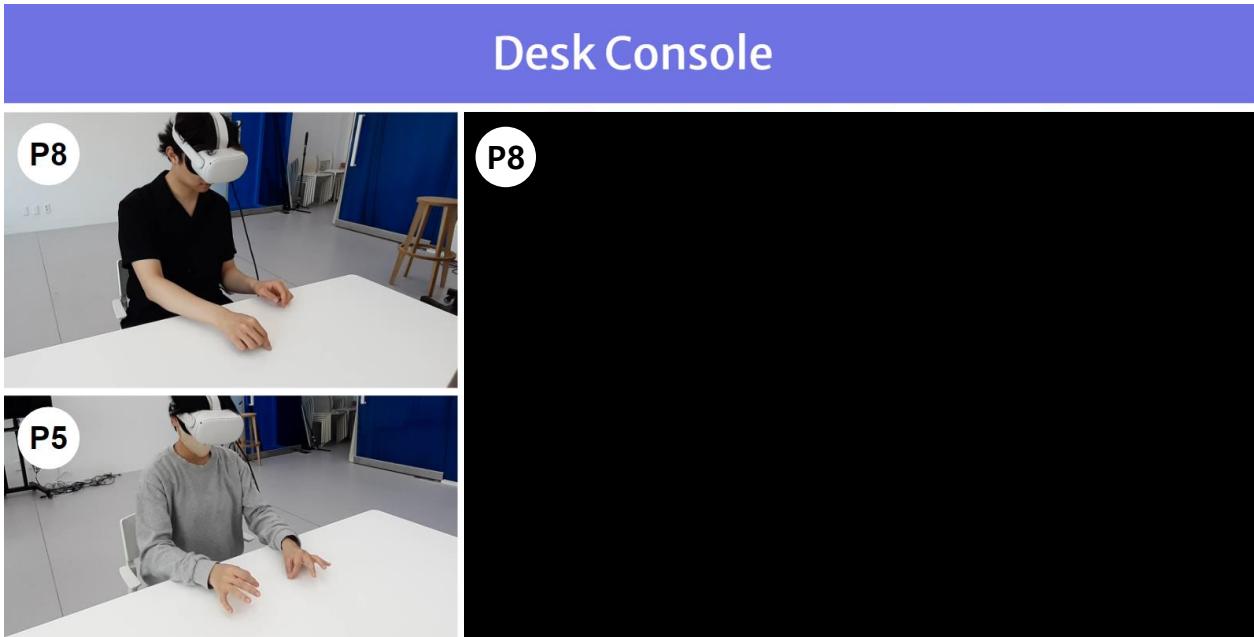


More similar tones (Easy to express the same mood)

4. Evaluation

Result – Qualitative Observations

Potential for Bimanual Manipulation



"Having something like buttons in a cognitive sense makes it much more convenient, I would say. And since I'm not yet very familiar with it, I couldn't use both hands, but I think I could. Because using both hands reduces the burden significantly."
(P11)

4. Evaluation

Result – Qualitative Observations

Gaze Dispersion Extent

Raycasting



Desk Console



"I have a feeling that moving up and down made the eyes much less distracted.
I feel that this (Desk Console) is firmly fixed in my hand, so I think I did it with a similar feeling,
just as I didn't look at the control and focus on the work when I was working in Photoshop with the mouse." (P6)

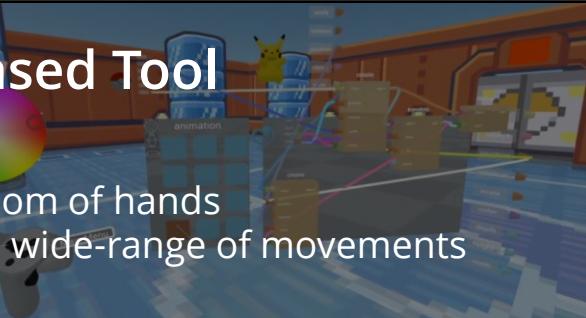
5. Discussion

Discussion - Implications of Desk Console System

Desk Console contributes to the future way of working by introducing novel ways to interact with control panels in AR/VR.

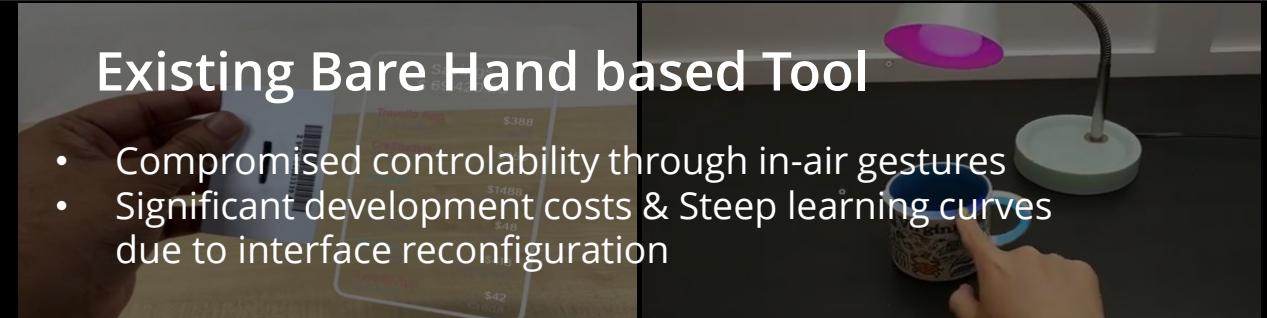
Existing Controller based Tool

- Limited portability and freedom of hands
- Physically demanding due to wide-range of movements



Existing Bare Hand based Tool

- Compromised controlability through in-air gestures
- Significant development costs & Steep learning curves due to interface reconfiguration



Addressed these challenges by ...

- Integrate Desks as interfaces
- Based on familiar GUIs experience

The impact was ...

- stable & natural bare-handed operation in a comfortable posture
seamless and user-friendly authoring interface,
ensuring easy adoption and use.

Desk Console system's combination of natural and stable interaction / user-friendly interfaces unlocks new possibilities for creative work: enhancing immersive and enjoyable authoring experience, promoting productivity and facilitating the expression of creativity.

5. Discussion

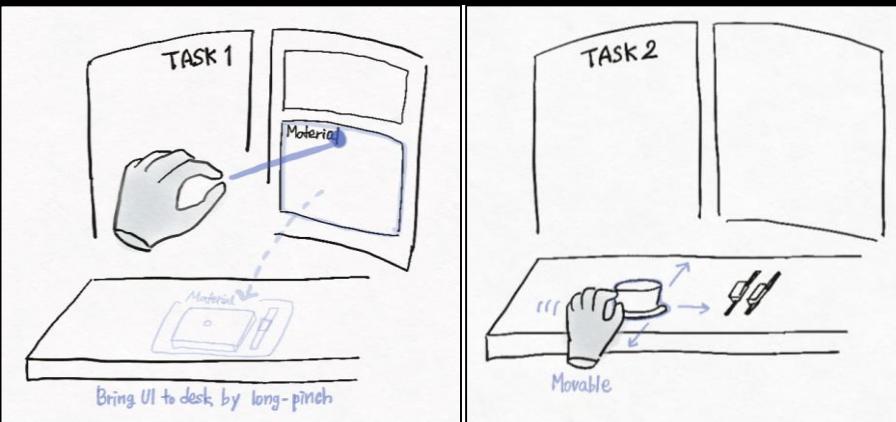
Discussion - Interface Scalability

The potential extensions of the Desk Console beyond the controlled evaluation conditions, aiming to enhance its support for users' real-world tasks.

Limitation:

Real work often involve [complex control panels](#) with numerous UI elements, making it inefficient to display them all on the desk.

Customization according to Workflow



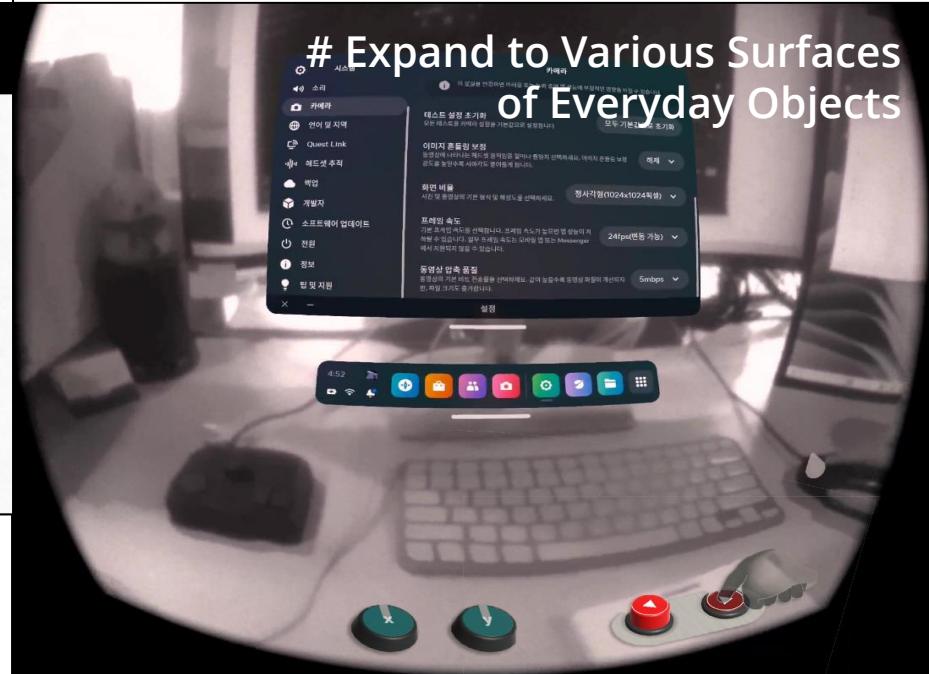
Next Step:

Flexible Approach; Automated Desk Console Generator ; allowing users to detach and place only the necessary elements from the screen UI onto the desk according to own workflow.

Limitation:

It is practiced on a limited surface, desk.

Expand to Various Surfaces of Everyday Objects



Next Step:
More complicated surface-based opportunistic TUIs

5. Discussion

Discussion – Limitations and Future Work

Future Work. Limitations.

1.

Lack of long-term observations of interface usage

Actual tasks require longer durations, and extended use may impact Interface utilization

Long-term use observations inform more concrete considerations and insights for applying Desk Console in real-world work scenarios.

2.

Room for expanding the range of demonstrated gestures

"I felt somewhat constrained in expressing my ideas because all the diverse UI elements are controlled using the same interaction. But, it (Desk Console) was nice that the movements were more diverse. (P1)"

Interfaces Improvement by exploring and incorporating natural gesture designs without compromising learnability and operational clarity.

3.

Addressing Limitations of Constraints Based on Body Size

Interface adjustments and Observed variations in hand tracking accuracy due to different sitting heights and hand sizes.

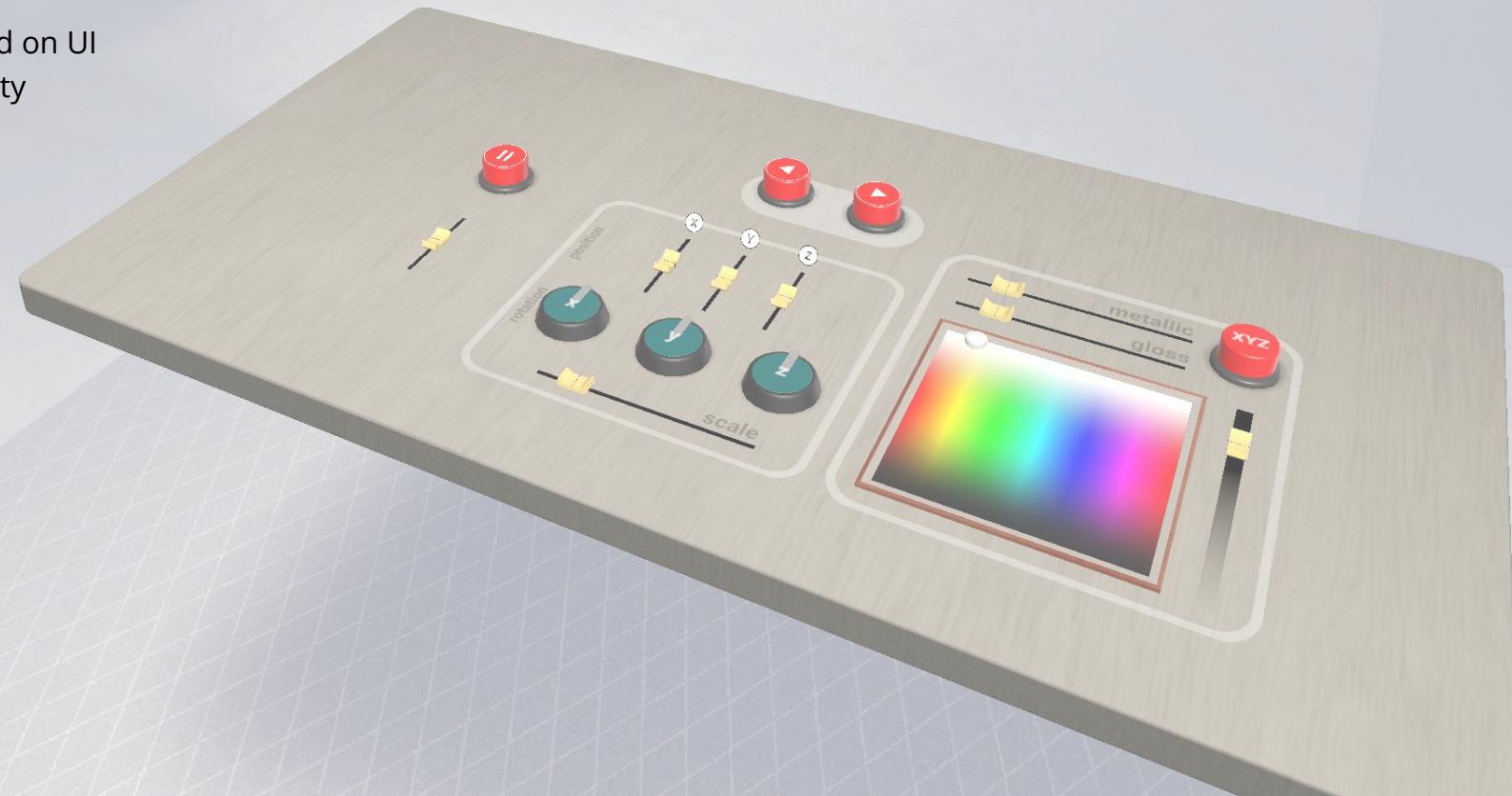
Integrate desk tracking. **Improving the accuracy of computer vision-based approaches** through assistive technologies such as eye tracking.

6. Conclusion

Conclusion

We present Desk Console, an immersive authoring system that represents 2D screen-based control panels as virtual 3D objects on a desk, offering a stable and intuitive operation.

- Proposed a system enhancing control panel interaction with stability and expressiveness.
- Developed authoring system based on UI category for flexibility and scalability
- Figured out the interface's impact on creative work



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Appendix

Quantitative Data Results

Table 5.2: Quantitative Data Results

Category	Mean (SE)		Type of Test Used	p-value (* $p < .05$, ** $p < .01$, *** $p < .001$)
	Raycasting	Desk Console		
Task Completion Time (s)	665.5 (103.6)	466.8 (34.0)	Wilcoxon Signed Ranks Test	.027*
Average time per each control (s)	Vertical Slider	6.01 (0.59)	Wilcoxon Signed Ranks Test	.041*
	Rotary Knob	8.22 (3.62)		.507
	Horizontal Slider	3.94 (3.62)		.730
	Color Picker	13.73 (1.36)		.001**
Control Transitions Count	4.33 (0.44)	6.77 (0.61)	Paired Samples T-Test	.000***
NASA Task Load Index (NASA-TLX)	Mental Demand	60.0 (6.7)	Paired Samples T-Test	.001**
	Physical Demand	80.4 (5.3)		.001**
	Temporal Demand	42.5 (6.3)		.083
	Performance	44.3 (5.8)		.001**
	Effort	81.1 (3.7)		.000***
	Frustration	75.0 (5.1)		.000***
Creative Support Index (CSI)	Exploration	4.4 (0.5)	Wilcoxon Signed Rank Test	.011*
	Expressiveness	4.0 (0.5)		.006**
	Enjoyment	3.3 (0.5)		.003**
	Immersion	4.9 (0.4)		.004**
	Worth Effort	4.5 (0.4)		.01*

Appendix

Movement traces in the Color Picker

