



Personalization as Spatial Logic:
Reimagining XR Interfaces Beyond 2D Screens

THESIS



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01 Abstract

This thesis explores how extended reality (XR) redefines spatial experience by merging physical and virtual worlds. Focusing on the perspective of interface design, by analyzing how to transcend current traditional two-dimensional (2D) user interfaces (UI) to spatial three-dimensional (3D) systems that extend the immersiveness of spatial environments. The project seeks to reimagine XR interfaces as a symbolic system that rhymes with the user's individuality using personalization.

Current XR systems still inherit the traditional flat, screen-based systems that offer condensed information. This limitation would bring misalignment between the dimension of interface and the spatial environment would restrict further immersion and personal expression. Allowing personalization would enhance adaptability and acceptance of virtual space for each user in immersion, identity expression, and belongingness.

By analyzing the historical development of XR to current technology evolutions like Apple Vision Pro and Meta, then define the current gaps and limitations of current user obstacles in user experience and interface design. Grounded in theories of symbolism, design history, as well as human cognition, this thesis investigates how interface design and user experience can evolve beyond flat menus to personalized spatial symbols that cohere an individual's environment. Supporting this hypothesis, this thesis proposes a series of demonstrations of a prototype using 3D modeling, motion graphics, and videos.

This thesis proposes a hypothetical blueprint of personalized 3D interfaces as cognitive and emotional extensions of users between physical to virtual worlds. Suggesting meaningful XR interface design requires beyond 2D interfaces, and bridging informational systems from condensed menu windows to symbolic representation to fully express humans' imagination and presence.

02 Introduction

In encountering the idea of space, humans associate it with the physical world around us. Where it is limitless, and full of possibilities in explorations. When the first human started to manipulate the objective space around us to build and create, the concept of our space was created.

As smart-phones and computer technology evolved to today, each person can easily create virtual spaces which abstractly condense information with limited presentation ways. These are websites, accounts, and even the message chat tabs when sending texts. However the rise of extended reality (XR), expanded our condensed virtual spaces and further potential of merging reality and virtual spaces together. Allowing people to bring visible imagination to our space.

Yet, despite XR's promise, there are still barriers that need to be overcome before achieving the full immersive experience. One of the barriers is the literal transition of two-dimensional (2D) interface to three-dimensional space.

Current XR devices adopted the logic of flat, 2D menus inherited from smartphones and computer's interface design. When dimensions of a tool do not align with current the dimension of space, the limitation to achieve the full potential of experience. Immersion, usability, and personal expression, which all contribute to the quality of meaningfulness of a space are absent to an extent. Leaving no reason to become a trailblazer of their XR space.

Therefore, this thesis intends to explore how XR interfaces can transcend traditional inheritance of 2D interfaces to become logically aligned with XR's 3D spatial experience.

Through researching concepts of symbolism and design of real-life objects, this thesis intends to propose a possibility of a 3D interface that not only functions as an information system but also reflects each user's individuality. Using visualizing methods such as motion graphics, 3D modeling, and symbolic systems to visualize how digital environments can become personalized extensions of one's thoughts and presence.

This thesis intends to map out the blueprint for the bridge between true immersion of human imagination and reality.




Meta Quest 2
128 GB

03 XR Technologies and Interface Approaches

03.1 Components of XR Technologies

It is not surprising that the history of XR technology is closely related to imaginative subjects such as science fiction and advertisements of door-opening products that bring people to another world, such as Morton Heilig's "Sensorama Machine" in the 1960s.[1] Later on, the early development of virtual experience in the 1990s was highly influenced by video games, which included multiplayer concepts, immersive artificial environment creations, and logic behind player interactions.[2] As XR advances and enlarges, in the 2000s, scientists and researchers started to closely analyze the core presence of being in the experience. Where first suggestions of why and how virtual immersive experience allows and extends the presence of a person. In their deconstruction analysis of presence: realism, sense of transference, and psychological factors forms the cornerstone of a person's perception of existence. Extending from this foundation are the further intuitive perception of existence, execution of actions in the moment, and cognitive predictability for upcoming actions.[3]

1 Becker, Savan C., and Michael E. Johnson, "Extended Reality: History, Concepts, and Techniques.", 238.
2 Ibid., 240.
3 Ibid., 242.

Today, after many years of technological and conceptual accumulation, XR is no longer just an ideology for games and science fiction works but a pioneer approach applied to a wider range of fields. Such as the “Digital Twin” system where it uses real-time data and behaviors to calculate and reflect outcomes in a virtual representation.[1] In overviewing the history of XR, the essence stems from the imagination of reality. It is a technology that brings the impossible into existence in different fields that points to the same concept: to experience another world immersively within the real world.

1 Armstrong, Maggie Mae, “Digital Twin.”

03.2 Current XR Contributors

Today, current XR technologies supporters can be generically categorized into two groups by their targeting audience: the mass-audience or niche-audience. Mass audience supporters of XR technology are the larger companies that provide XR devices in large amounts for customers, such as Apple, Meta, and Google.

For Meta, since their beginning of the Quest series, they aimed to fulfill the need of companies and individuals for fully virtual training and remote working purposes. Years later, when Apple launched its Apple Vision Pro, its mission and vision differed from Meta's full virtual reality (VR) approach, but towards an augmented reality (AR) direction. Apple Vision Pro aims to "blend digital content and physical world seamlessly," as Apple described on its product page. By this description, Apple Vision Pro is designed as an extension of a new perspective to digital content, where the main focus is still centered around the iOS digital system. Therefore, they aim to target the mass audience who are already used to iOS system devices, such as iPhone, iPad, or Mac series.

On the other hand, Google and Microsoft have explored many different routes but were each excited temporarily as experimental products rather than revenue- driven mature products.

Google and Microsoft were both trailblazers in the area of VR/AR projects, starting in 2012 with Google Glass, and by 2015, Microsoft's mind-blowing HoloLens series. Both companies went through many trial-and-error exploration projects. What differentiates them from Apple and Meta is that ultimately, they both drifted from hardware development to software solutions as of today. HoloLens 2 has been discontinued, and Microsoft has not announced a new project ever since. After the permanent archiving of Google Cardboard, the company turned to partnerships with Samsung XR for hardware; in return, Google developed Android XR as the supporting software.[1] [2]

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1 Warren,"Microsoft Is Discontinuing Its HoloLens Headsets,".
2 Bhutani, "The Life and Death of Google's VR/AR Projects,".

Additionally, what distinguishes the niche audience is the specific XR technologies, which are tailored to enterprise features for business and professional settings; thus, their devices include functions not in the interest of the general audience. Enterprise devices are used across training, healthcare, remote work, and engineering. Such companies include but are not limited to: Pico 4 Ultra—for large-scale development, HTC Vive Focus 3—for all-day training, Varjo—technical professional training and military simulations, Osso—for proficiency training for nurses, etc.[1]

While these enterprise XR devices boast powerful performance and exceptional ability to simulate immersive environments, they sacrificed scalability and practical flexibility from the beginning to achieve their focus on specific niches. As a result, enterprise devices naturally struggle to adapt the concept of personalization and user's individuality. Therefore, this thesis's perspective will focus on the general-audience customer XR devices rather than enterprise ones.

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1 Hilgeman, "Consumer vs Enterprise vr Headsets: Key Differences?".

03.3 Interfaces Approaches and Problems

Before diving into the interface problems of current XR devices, it is essential to observe what are the current interface approaches across all general-audience XR devices, which are focused around Apple Vision Pro and Oculus series. Regardless of how different each company views XR's capabilities in immersiveness, the concept of 2D flat panels is still the default approach of information displays.

Apple, known for its minimalist design of product including interface of all operation systems, has undoubtedly continued to follow the governing principles of their design principles. Rounded corners and glassmorphism user interface (UI) visuals are the cornerstone of all informational panels in Apple Vision Pro *(Figure 1)*.

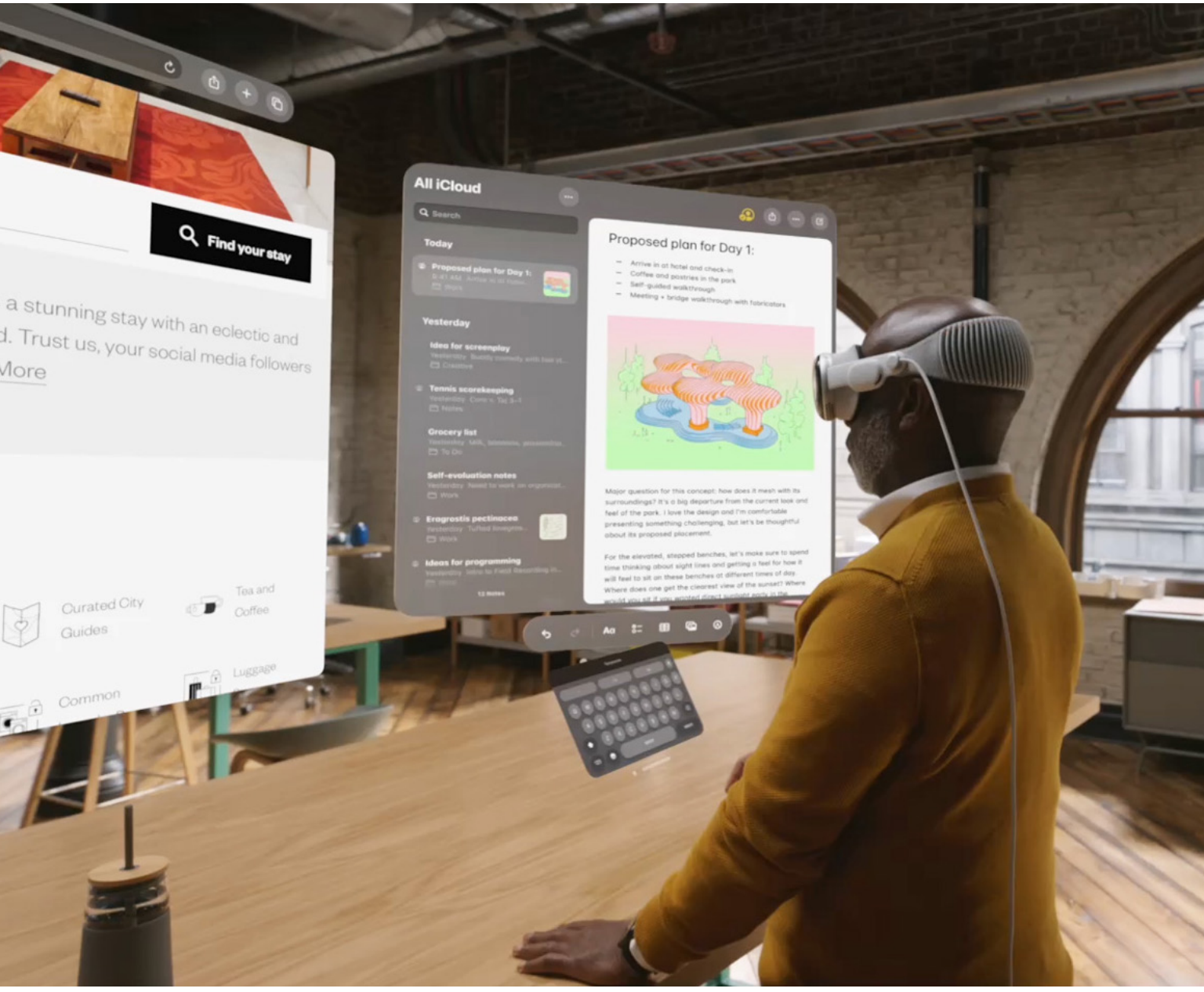

Find your stay
a stunning stay with an eclectic and
d. Trust us, your social media followers
More
Curated City Guides
Tea and Coffee
Common
Luggage
All iCloud
Search
Today
Proposed plan for Day 1:
Yesterday
Idea for screenplay
Tennis scorekeeping
Grocery list
Self-evaluation notes
Eragrostis pectinacea
Ideas for programming
Proposed plan for Day 1:
Arrive in at hotel and check-in
Coffee and pastries in the park
Self-guided walkthrough
Meeting + bridge walkthrough with fabricators

Figure 1



Users are able to drag and drop any application or website menus the way they want to orient. On top of that, XR interactions are rooted upon hand gestures and voice for inputs.

By this, we can see that Vision Pro is a demonstration by Apple of how they treated XR as an evolution of current computers rather than a new vision of era. Which is the underlying reason why they prioritized the path to AR instead of VR as it coexisted between digital menus and physical environments. It is built to emphasize, and integrate with the real world, rather than extracting people from the real world.

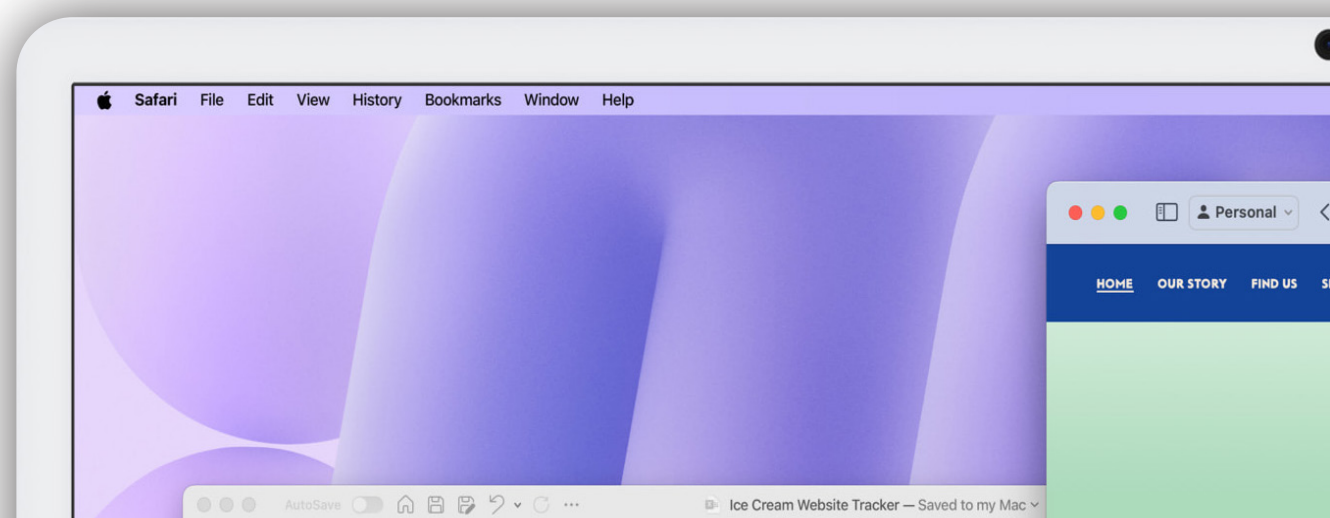
On the other hand, Meta, is at the different end of the spectrum. Their philosophy is prioritizing virtual immersion over real world grounding experience, in other words their approach is to VR instead of AR. Meta values the immersiveness in different fictional settings, such as different VR games. In the first steps of Meta Quest 3 user experience, users are being brought into a mini game that makes users shatter their real environment, visually there will be holes and cracks around you and what's behind is the fully virtual world which you can peek to see (Figure 2).

Based on this vision, Meta designed their XR experience in centering on social, and gaming that fully establishes the digital experiences. As for the interface approach for Meta's user system, similar to Apple, they also inherit 2D UI visual and floating panels and menus for user navigation. Interactions relies on gesture controls and hand piece controls which act like a mouse for pointing and clicking.



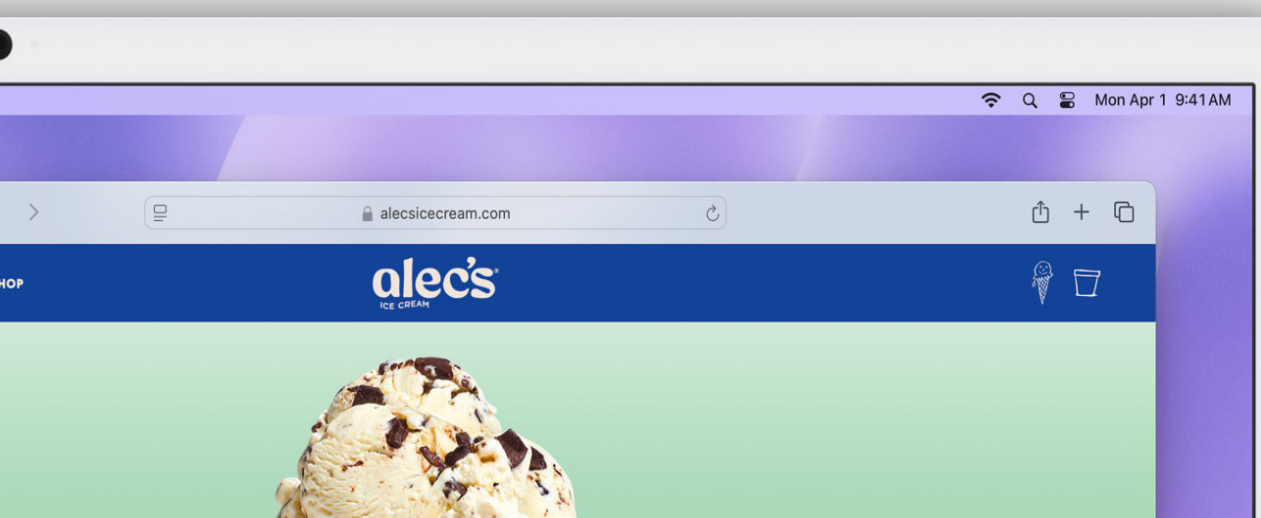
Figure 2

Despite the different visions for the future of XR, Apple and Meta both rely on interface designs inherited from traditional screens. Their control menus and icons exist on 2D planes within the 3D environment. This approach doesn't allow for a deep engagement with their 3D space, thus limiting how users perceive to understand the virtual world. Virtual space is a space for imagination, but human imagination is also an extension of thought based on the existence of real world objects. The key difference is how the real world has sets of laws and principles that govern every aspect of the environment, such as the law of gravity and physics. A space without an underlying logic naturally creates a sense of repulsion.



However, these 2D interfaces float like layers, as if they are independent of the surrounding environment rather than being a part of it. Creating disconnection, and a sense of dimensional misalignment between space and tools.

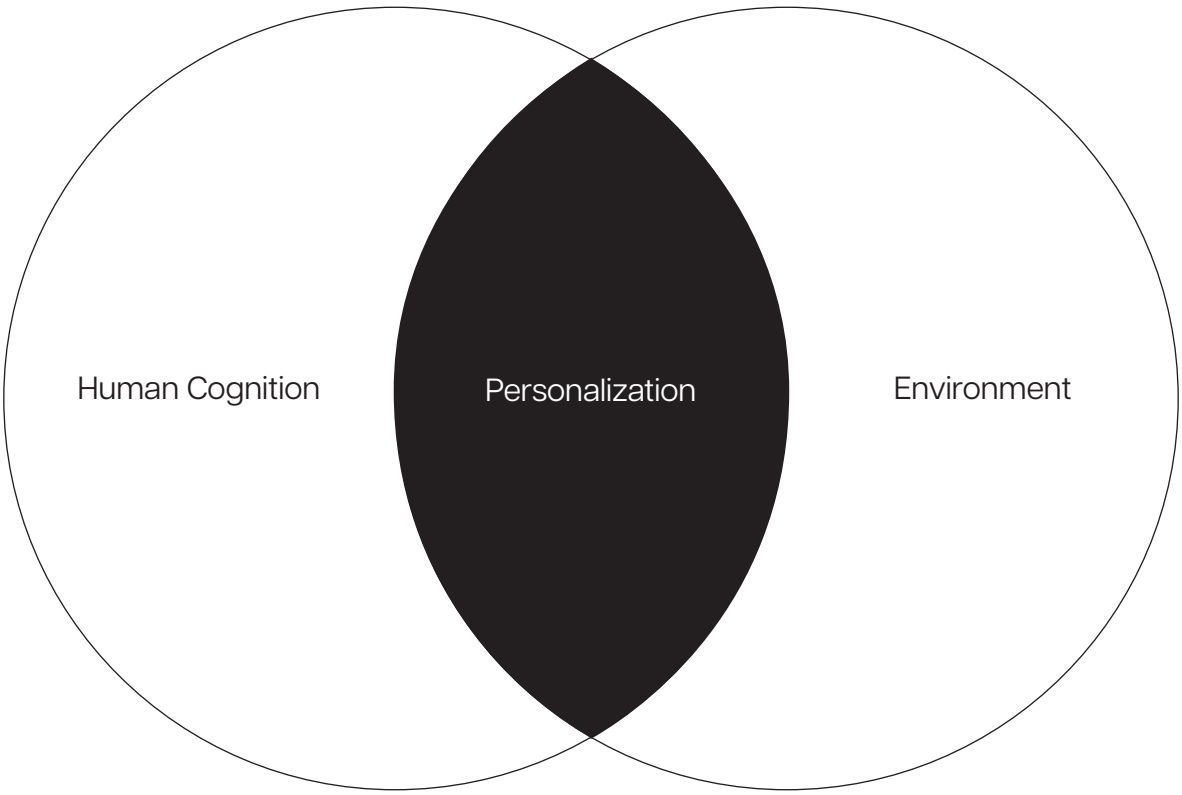
Therefore, while XR environments may offer visual immersion, they remain disconnected in terms of human cognition. This limits the instinctive, personalized creative expression based on established laws and principles. Because these rules don't exist from the start, they will lead to a sensory discomfort and a gradual loss of interest and emptiness towards the virtual world.



04 The Logic of Personalization

04.1 Hypothesis of Solution: Personalization as Spatial Logic

What is personalization? Why can personalization improve the immersion and disconnection of dimensions? The reason lies in humanity's understanding of the world over the development of our civilization. Therefore, personalization is not simply a visual change, but rather an alignment with each user's own habits and interactions with their environment.



In human perception, space is an environment formed by behavior, memory, and meaning. In reality, the placement of everyday items is influenced not only by aesthetics but also by physical movements, personal habits, and functional priorities. For example, keys are placed by the door, frequently used items on the desktop, and important documents locked in chambers. In other words, humans organize their cognition through spatial rules, rather than an abstract hierarchical system of tabs and panels.

Therefore, the “personalization” discussed in this thesis is not about changing interface skins, adjusting colors, or dragging panels. Rather, it allows users to create an environment that conforms to their own spatial logic and arrange elements according to their own habits. This spatial personalization can further create immersiveness by embedding interface elements into the 3D environment in current XR environments. This is because it allows elements to participate in spatial laws rather than being floating as layers, thus users are able to develop a sense of owning the space within the virtual environment.

04.2 Historical Roots of Symbols and Personalization

When did humanity begin to adapt to the rule of the world and demonstrate creativity? Perhaps we need to trace back to the earliest records of human interaction and adaptation to the environment–the Mesopotamian clay plates.

In the early period of civilization, systems are yet nearly polished, but people were already attempting to create and survive with their environment. They used what they could to record their era, language, laws, and even ways to cure disease and wounds with medicine. For example, the “therapeutic” clay plate series that recorded information about methods of disease and drug intervention at that time. They also dissected animals and recorded their understanding of organs and what they are.[1] This reveals that since ancient times.

1 Karim, Saad, and Osama Amin, “Stroke in Ancient Mesopotamia,” 2018.

Humans have organized their memories and information about their environment through external objects. The Mesopotamia clay plates are the earliest records of human exploring and establishing connections with their environment. They recorded rules and systems by carving the plates by observing the world around them.

In addition, space is not merely a container for survival, but a symbolic system that carries meaning. Any structure, state, distance, and layout within a space can guide human actions and emotions. Space itself is a language, and all physical objects it encompasses can be seen as "symbols," conveying information and meaning like writing words. Spatial symbols can be broadly categorized into three types: cognition, transformation, and evaluation. Cognitive symbols transmit knowledge, such as scientific icons and information representations. Transformation symbols guide behaviors, such as various road signs, mazes and tool designs. Evaluation symbols convey emotions and meaning such as medals, certificates and ceremonial gestures.[1]

1 Tchertov, Leonid, and L Tchertov, "Feeling, Skill and Knowledge: Semiotics of the Subject in Environment, " 2025.

Humans are naturally inclined to extract contents, such as meaning and emotion, from their surroundings. Therefore, space is another symbolic system's parallel to language, both emotional and rational. For example, a cup, rationally speaking, is a tool for holding liquids, but it also can be a carefully chosen birthday gift from a friend. Similarly, in virtual environments of XR, things within that environment should possess a similar direction. The XR interface is not merely a presentation of information, it should also support behavioral and emotional experiences.

04.3 Everyday Things and Interface for Individuals

In the well-known book of The Design of Everyday Things, human-centered design emphasized that design of a system should begin with an understanding of real human behavior. As the author points out, people are often unaware of the actual difficulties they face. Therefore, meaningful design must stem from observing how individuals naturally interact with their environment rather than relying on preconceived preferences or purely visual customization.[1]

In daily life, this interaction governs at the spatial level, such as the placement of objects depends on body actions, memories and emotional associations. These spatial arrangements form a cognitive framework, shaping how people think, remember and act.

1 Noman, Donald A, The Design of Everyday Things, 8.

Furthermore, people perceive meaning through storytelling. Norman explains that humans are natural storytellers. We interpret objects and events as part of a larger causal sequence. Or in other words, humans naturally seek the cause of an object or event.[1] This narrative nature means that the environment is not merely a backdrop for action, but a stage for meaning. Therefore, in XR, interface components should not be floating panels or isolated menus. They must participate in the user's spatial world and narrative experience, functioning as objects in continuity for symbolic values.

1 Noman, Donald A, The Design of Everyday Things, 57.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05 Methodology: Design of Personlization System

05.1 Blueprinting Personalization

To transform personalization from visual aesthetic customization to a deeper spatial logic, this thesis proposes a set of design principles for defining how digital objects exist in XR. Rather than viewing the interface as a decorative element that can be placed randomly, these principles consider interface as an object that interacts with space. Interface behavior is primarily influenced by four key behavioral principles: spatial laws, semantic laws, behavioral laws, and cognitive laws. Under these laws, interfaces will be influenced by gravity, inertia, distance and situated scenes.

These principles are not created to define specific functions, but to establish an interaction framework that adapts to the user's habits. This is an interactive framework built on understanding of dynamic adjustments of psychological states. It transforms the interface from a layer attached to the field of vision into an object that can situate in space.

Spatial laws simply means that in a XR environment, the interface should possess position, weight, and resistance. Introducing gravity, friction, inertia and collision means that users need to physically approach the interface. By this means reaching out, grabbing, or moving their body to interact with the interface, much like picking up objects in the real world.

This not only reduces the conflict between visual input and body movement but also allows the virtual space to gain a memorable path and a position that can be returned to. This provides a foundation for reducing motion sickness and creating a sense of space.

Semantic laws emphasize that an interface is not merely an information carrier, but a spatial symbol with readability. In the real world, the shape, material and position of an object naturally suggest its purpose. Such as a doorknob means to push or pull, and a chair means to sit. This same logic should extend to XR, interface objects should not appear as abstract geometric shapes, but possess semantic features that can be understood.

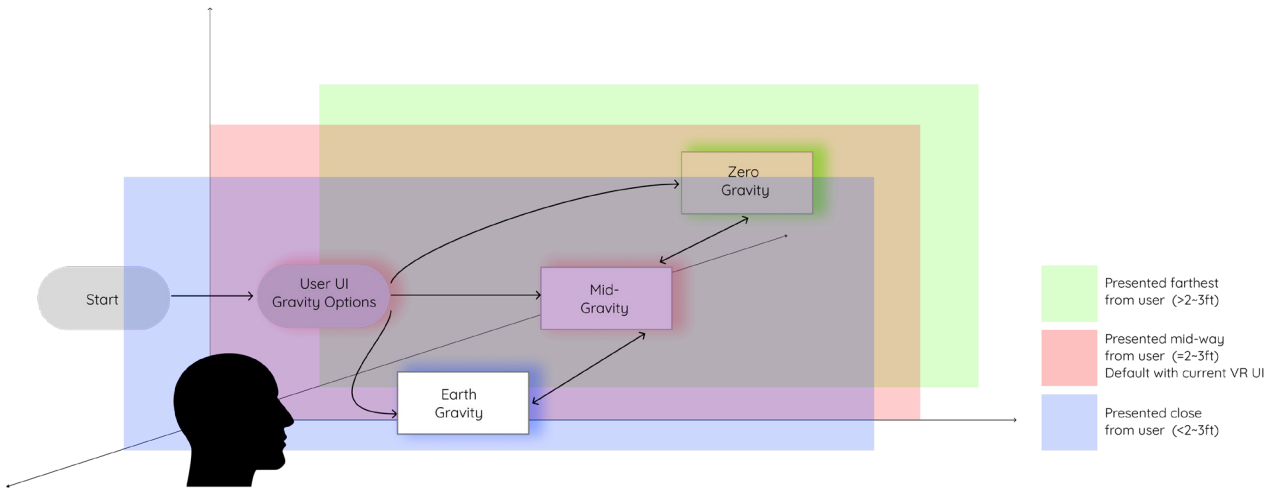
For example, tool-type objects can have gripping or hanging points, a database can exist as a storage shelf or bookshelf with folders. This approach doesn't require realism, but emphasizes the consistency between the object's actual appearance and position with its functions. Transforming interface from an icon system into a spatial narrative.

Behavioral laws focus on how the interface responds to the user's action patterns. In real life, people don't first open a menu, then open a file, find location, and select an item, instead act through paths and sequences. Such as putting away keys at home, entering a room and turning on lights, sitting down and starting the computer. If XR interfaces can automatically adjust based on behavioral patterns, interaction will transform from operational command into action processes.

For example, during long reading sessions, the interface will automatically align with the nearest desktop and reduce motion effects. When entering creative mode, toolbars will surround the user allowing for quicker access. In other words, behavioral laws make the interface an extension of user behavior.

Finally, cognitive laws are about how the interface matches the user's cognitive state. Instead of a constant presentation the interface will record information in the user's memory patterns.

Human's understanding of space relies on long-term visual recognition. In the real world we remember where things are, not how deep they bury in the panel options. In an XR environment, an object's position, size and structure should not rest when the scene refreshes, thus creating spatial memory of the virtual world. In this way, the XR space is not merely an information display device but a cognitive environment that grows with the user.



05.2 Design Demonstration

As the prototype, this paper demonstrates a gravitational interface system as an anchor point, where it extends to three different user states. In creating the prototype, I abandoned the traditional 2D interface approach and further made the interface integrated to the 3D environment by giving it volume, thickness and positions. In this system, users have three saleable modes: Earth gravity, moderate gravity, and zero gravity.

Earth's gravity mode is used for scenarios requiring high concentration, such as studying, reading, or working. In this mode, all interface content highly simulates Earth's gravity and seeks a flat surface to cling to as the ground. Users can place important content on the nearest surface, while less important content can be freely placed around them. These interfaces do not follow the user when they leave but remain in place.
In this mode, all interfaces and content highly mimic real-world logic. Users can understand the most basic operating methods with almost no learning curve. This mode is suitable for the elderly, those with severe 3D motion sickness, and users who need to work in XR environments for extended periods.

Moderate gravity mode is used for daily browsing or short-term operation. Unlike Earth's gravity, which fixes the interface to a surface, the zero-gravity mode rotates entirely around the user's orbit and moves with the user but with a slight delay.

I've created a designated interface habitat for the medium gravity mode, allowing users to define the space where the interface can reside. Similar to defining a virtual workspace as the interface maintains its relative position within this area. In terms of interaction, dragging in medium gravity mode has a slight inertia, and friction. It's suitable for situations where you need to switch between multiple tasks without moving your body, such as reading documents while replying to messages. This mode keeps the interface synchronized with the user without interrupting daily activities, offering a lighter working experience.

The zero-gravity mode is mainly for imagination, immersive experiences, and entertainment relaxation. In this mode, I've weakened the spatial support, allowing the interface to detach from the surface and float around the user. The interface automatically moves closer based on the user's gaze or hand gestures, and operations can be completed without moving the body.

Unlike the previous two modes, the zero-gravity mode interface can automatically combine, expand, or disappear, with fast feedback and smooth animations. For example, users can simply raise their hand to recall tools or trigger selections through gaze. This mode doesn't need to consider desktop or plane, making it closer to current mainstream XR interface systems.

Zero-gravity mode is suitable for scenarios requiring efficiency or immersion, such as gaming experiences. These three modes are not three different systems, but the same spatial logic in different states. Users can quickly switch according to their state, rather than passively adapting to the system.

Furthermore, beyond the gravity logic, the interface's position itself is a form of personalization. In the prototype, users can arrange applications according to their habits.

When working, documents, calculators, and other materials are placed in the core area. Entertainment apps, such as TikTok, Twitch, and YouTube, are placed further away for avoiding distractions. These actions of habits are recorded and saved as well. Some users will arrange these interfaces in creative ways, such as using app icons to form a heart, or arranging each interface according to color.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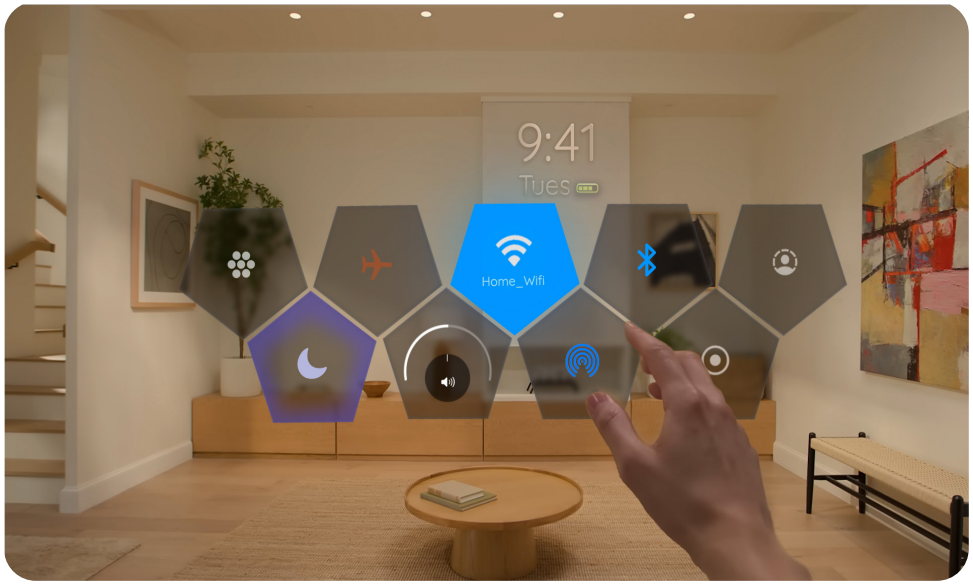
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06 Discussions and Questions

06.1 Limitations of Personalization: Technology

Personalized interfaces offer an idealized vision of the future, but we cannot ignore existing problems. One of the biggest issues is technology. Current XR technology cannot fully simulate the laws of physics, and even if it could, it would be limited. This is also due to device size limitations that prevent the installation of larger processors.

Therefore, while the idea of a physical interface is exploratory, its feasibility depends on future hardware evolutions. Another related issue is that the potential for massive power consumption in the Earth's gravity mode could overwhelm the device. As the battery drains, the device's performance will also decline. Devices with insufficient battery life will struggle to support extended periods of immersive use.

Another problem is that not all users appreciate interfaces seamlessly integrated into 3D environments. Some users prefer the current minimalist, flat interface designs. Furthermore, spatial memory varies greatly from person to person; some people with poor spatial awareness dislike searching for objects in space.

Also, when presented with a vast array of customizable and personalized options, users may feel overwhelmed. Too much freedom can feel like a burden for some. Finally, for those who choose personalization, the adaptive AI capable of recording these choices will take time to develop. There may even be situations where the current memory capacity of AI cannot cover too much 3D environmental data.

06.2 Limitations of Personalization: Contents

Beyond hardware issues, personalized interfaces will also face challenges in terms of content. For example, how to establish boundaries between the interface and its environment? What level of personalization is permissible, and what constitutes excessive personalization? Can personalized interfaces be understood and used in multicultural contexts? And how can we ensure that user data is not compromised in systems that deeply collect user cognition?

Because cognitive data is a fundamental reflection of a person, it cannot be faked, and malicious use of cognitive data could cause irreversible damage. Even on a moral level, should we truly allow the environment to become an extension of a person's thoughts, and what consequences would this lead to?

As a result, while personalized interfaces represent a pioneering design with enormous potential, we must acknowledge that they also carry risks that are currently difficult to assess. Perhaps only when future technology reaches this stage will we fully understand the feasibility of current designs.

07 Conclusion

XR technology has made significant progress, but its interface design remains largely outdated. Most XR devices we use today are flat screens that artificially place us in a 3D world, especially with flat 2D interfaces. While they function, they feel unnatural and fail to fully utilize the full potential of the spatial environment. This gap is what prompted this project.

In this thesis, I explore how space, symbols, and personal meaning shape how we interact with the physical and digital worlds. Research shows that personalization is not merely an afterthought or simple customization. In spatial media like XR, personalization becomes part of the environmental logic itself. It influences how we navigate, remember, and feel comfortable within a space.

The prototype I created is a practical example of this idea. By altering the behavior of space using different physical modes—such as Earth's gravity, moderate gravity, and zero gravity—the interface begins to come alive. It reacts to your state and adapts to your habits. It's no longer just a set of floating panels, but something you can gradually become familiar with and connect with.

Of course, limitations remain. This design model is not perfect. People think and remember differently. Not everyone wants to completely customize all content. Furthermore, many issues regarding culture and privacy require further research. However, these limitations do not negate the concept of personalization, but rather point to directions for future development.

Ultimately, this article argues that XR's potential can only be fully realized when its interface ceases to mimic a two-dimensional screen and truly integrates into the real world. XR will only become a space you inhabit when the environment is meaningful and aligns with your personal needs. Personalized space design is not merely an interface design direction—it's a way to make the virtual world more intuitive, expressive, and human-centered.

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- *Figure 1.* Interface layout of Apple Vision Pro screen panels. Screenshot from Apple Vision Pro-– Product Page, Apple Inc.,2024.

- *Figure 2.* Screenshot from Meta Quest promotional video demonstrating immersive passthrough transition into virtual space. Image from Meta, Quest Gaming. Screenshot by author.

