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An Analysis of Interaction Design Features in Virtual Reality Applications

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ABSTRACT
Virtual reality technology has come a long way but many VR systems still struggle to offer smooth and natural interactions that feel truly immersive. This study explores how key design features like affordance, feedback, and challenge shape the way people experience VR across five popular applications. The findings show that engaging both the mind and body keeps users focused and involved, while realistic touch, pressure, and vibration make the virtual world feel more authentic. At the same time, we learned that giving users a sense of control and making sure their actions feel smooth and responsive are crucial for keeping them comfortable and present. Overall, this research highlights that creating great VR experiences depends on finding the right balance between immersion, ease of use, and realistic feedback. By understanding these elements, designers can make VR more intuitive, enjoyable, and truly engaging for everyone.

Keywords: *Virtual Reality, Immersive interaction Design, Human Computer Interaction*

1 INTRODUCTION

Virtual reality (VR) applications have witnessed substantial growth, offering increasingly immersive experiences across a range of domains, including gaming, education, and professional training. The quality of interactivity constitutes a critical determinant of such experiences, as it directly influences the degree of user engagement and satisfaction. Despite considerable advancements, several persistent challenges continue to impede the optimal design of VR interactions. Specifically, limitations in input modalities constrain naturalistic user behaviour, while latencies between user actions and system responses disrupt the sense of immersion and contribute to motion sickness. Moreover, the prevalent inability of VR systems to replicate tactile sensations such as touch and resistance further undermines the realism of user interactions.

The present study seeks to analyse by specifically measuring key interaction design principles specifically affordance, feedback, and challenge within virtual reality environments. this is because the affordance of immersive virtual reality (VR) holds significant potential in virtual gaming and education, as it can support learning through simulation and visualization (Hyeon Jo, Do-Hyung Park, 2023). According to Norman (1999), the concept of affordance plays a crucial role in guiding how humans perceive and interact with objects. He emphasized that the design of an object inherently suggests its potential uses, meaning that well-designed affordances can intuitively signal to users how an object should be used, thereby shaping the nature and effectiveness of the interaction. Feedback

technology works by using vibrations, touch, and pressure to recreate realistic sensory experiences for users. It helps make virtual interactions feel more lifelike, allowing users to sense and respond to their digital environment in a more natural and immersive way (rocketweb, 2024). The challenges related to engagement in virtual reality applications can lead to motion sickness, ocular fatigue, confusion, and anxiety, particularly when utilizing inferior hardware and software (Roopali Joshi, 2023). Through an empirical evaluation of user engagement and response times, this research aims to identify design strategies that enhance interactivity and mitigate existing limitations. A comprehensive understanding of these elements is essential for the development of more intuitive and immersive Virtual Reality (VR) systems, thereby advancing user experience and fostering the broader adoption of virtual reality technologies across diverse practical applications.

1.1 Research Objectives

This study objective is to identify interactions between elements such as affordance, feedback, and challenge in Virtual Reality Applications.

1.2 Problem Statement

Despite significant advancements in Virtual Reality (VR) technology, current VR systems continue to face critical challenges that hinder the quality of user interaction. First, input limitations restrict the naturalness and intuitiveness of user actions within virtual environments, making it difficult to achieve seamless and immersive experiences (Nurul Aiman, 2024).

Second, delays between a user's action and the system's response disrupt the sense of presence and immersion, and can contribute to motion or cybersickness, negatively impacting user comfort and engagement (Interaction Design Foundation, 2024)

Third, most VR systems lack the capability to effectively simulate tactile sensations such as touch and resistance, resulting in interactions that feel less realistic and diminish the overall user experience (Dangxiao Wang et al. 2019).

2 LITERATURE REVIEW

The literature review provides a comprehensive understanding of the topic by examining key aspects of interaction design in virtual reality, including affordance, feedback, and challenge. It aims to explore how these elements contribute to the development of VR applications, enabling developers, designers, and researchers to evaluate and optimize their systems more effectively.

2.1 Interaction Design

Virtual reality (VR) interaction design focuses on creating user interfaces and experiences that make users feel truly present and engaged within a virtual environment. Key aspects of VR interaction design include understanding user needs, designing effective 3D spaces, developing intuitive user interfaces, and providing clear feedback to users.

Virtual reality (VR) interaction with design is the craft of creating intuitive, interactive, and responsive ways for users to interact with digital worlds and objects within a simulated three-dimensional space. It is an interdisciplinary field that marries user experience (UX) design, human-computer interaction, and 3D graphics to deliver immersive experiences in which users are not just observers but participants. In educational contexts, interactivity design in immersive VR is shown to vary widely, with learning tasks ranging from passive observation to highly interactive, personalized engagements. These variations reflect different priorities such as accessibility, engagement, and interactivity, which influence the design of learning experiences and the effectiveness of VR as a pedagogical tool (Makransky et al., 2022). Creating good 3D spaces and movement in VR is key to

making users feel like they're there. Well-made 3D worlds can take users to new places, while easy-to-use movement makes the experience feel real.

2.1.1 Affordance

Affordance describes an object or space in terms of the actions made possible for humans in the meeting of a design (or non-design) of anything. Affordance is a key concept across all scales of design, as it allows us to not only understand a site, structure, or object in terms of its physical, aesthetic, and material, properties but how these relate to the abilities of humans or animals and their opportunities for actions (Hyeon Jo, Do-Hyung Park, 2023). Hartson (2003) proposed a framework for understanding affordances in interaction design by classifying them into four distinct categories: cognitive, sensory, functional, and physical. Each type represents a different aspect of how users perceive and engage with interactive systems, contributing to a more comprehensive approach to user-cantered design.

2.1.2 Feedback

Feedback is a technology that uses vibration, touch, or other physical movements to simulate sensory experiences for users. In the context of Virtual Reality (VR), haptic feedback allows users to feel physical sensations such as touch, pressure, or vibration when interacting with objects in a virtual environment. This technology goes beyond just sight and sounds it also emphasizes the sense of touch, significantly enhancing the level of immersion (Joyleap, 2024).

4.1. Challenge

Virtual Reality (VR) integrates flat digital graphics with the illusion of three-dimensional space to create immersive environments. However, this approach often conflicts with the natural way our eyes and brain work together to perceive depth and spatial relationships (Hanqing Xie, 2023).

3 RESEARCH DESIGN

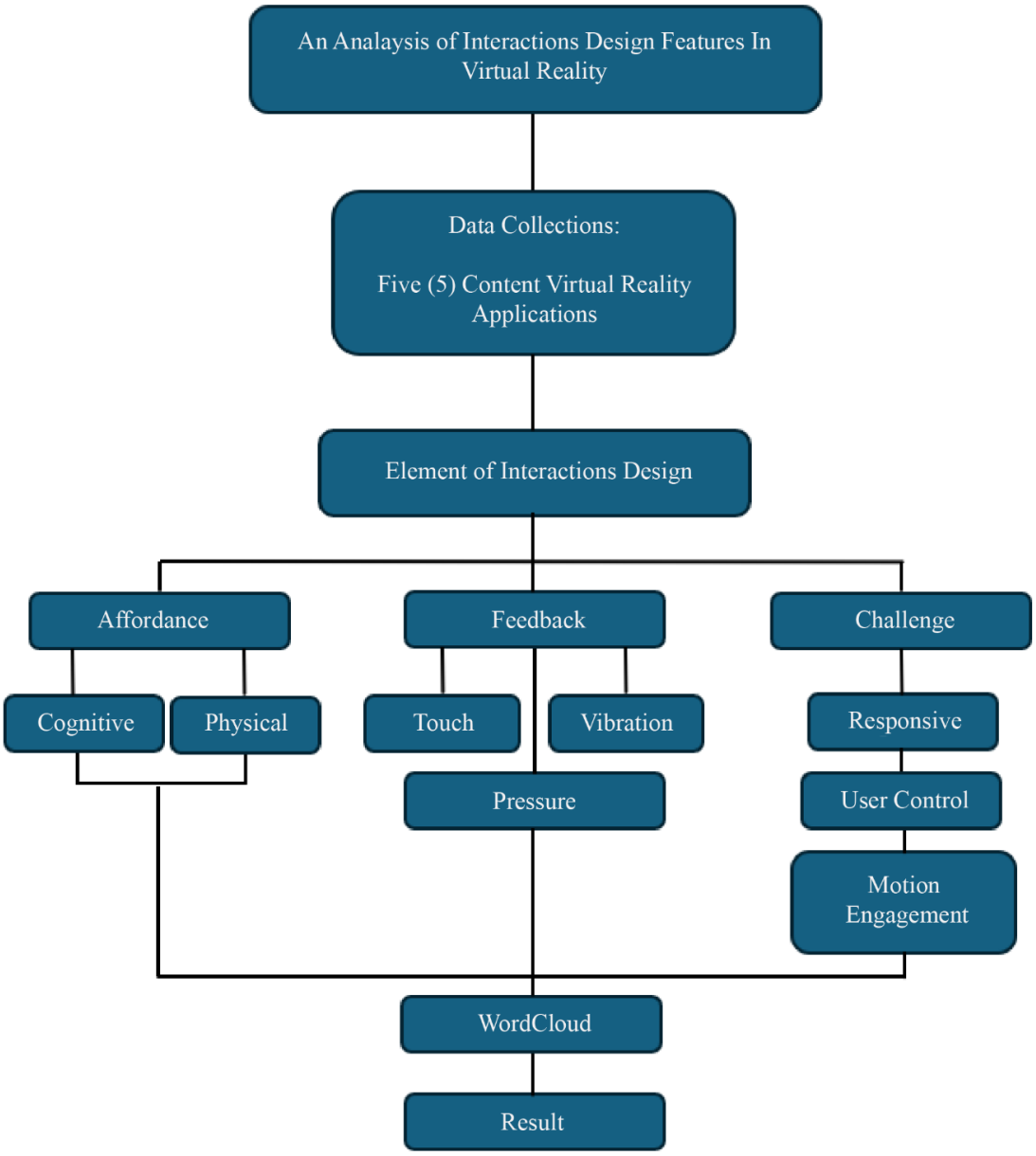
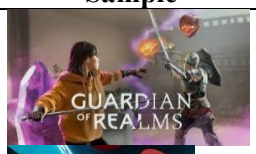
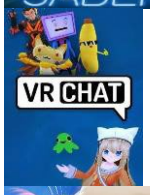
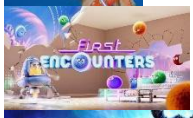
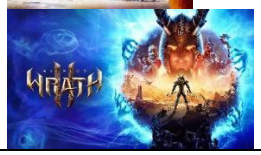


Figure 1 Framework of study

4 SAMPLES

Table 1 Selection Sample of Virtual Reality Applications

	Sample	Title	Developer	Release Years
Sample 1		Guardian of Realms	Sinn Studio Inc.	September 17, 2024
Sample 2		BEAT SABER	Beat Games	May 22, 2019
Sample 3		VR CHAT	VR Chat Inc.	February 17, 2017
Sample 4		First Encounter	Meta	September 27, 2023
Sample 5		Asgard's Wrath 2	Sanzaru Games	December 15, 2023

5 DATA ANALYSIS

The data were analysed thematically to identify the interaction design in virtual reality such as affordance, feedback, and challenge in all 5 five selected sample in Virtual reality applications.

Table 2 Analysis of Interaction in Virtual Reality Applications

	Analysis	Sample 1 Guardian of Realms
Affordance	Cognitive	In Guardian of Realms, users are constantly thinking on their feet as they solve puzzles, make quick decisions, and stay alert to changes in the environment. The game keeps the brain active by challenging memory, attention, and strategic thinking throughout the experience.
	Physical	In term of physical Guardian of Realms involves a fair amount of physical interaction, encouraging user to move their hands and arms to cast spells, interact with objects, or defend against enemies. The game promotes full-body movement, making the experience feel more immersive and physically engaging.
Feedback	Touching	In term of touching players can interact with the virtual world through hand gestures and object manipulation, giving a sense of "touch" even without physical contact. Picking up items or activating the crystal creates a tactile-like experience that adds to the feeling of presence in the game.
	Pressure	*Guardian of Realms* responds to how players apply force through their hand movements, such as pressing harder to activate a powerful ability or gently interacting with objects to avoid attack from Non-Player Characters. This sensitivity to pressure adds depth and realism to the way user engage with the virtual world.

Challenge	Vibration	In *Guardian of Realms*, vibration feedback adds an extra layer of immersion. Users feel subtle pulses when casting spells, taking damage, or interacting with magical objects, helping to make each action more impactful and reinforcing the sense of presence in the game.
	Responsive	Guardian of Realms reacts quickly and smoothly to User actions, whether it's casting a spell, dodging an enemy, or interacting with the environment. This responsiveness makes the experience feel fluid and intuitive, helping players stay immersed and in control.
	User Control	In Guardian of Realms, players feel in charge of every move they make. Whether they're attack or defend enemy attack, the controls respond smoothly and naturally, making it easy to feel connected to the game world.
	Motion Engagement	The game gets players up and moving as they use their bodies to dodge attacks, reach for objects, or perform magic gestures. It is not just about sitting and watching; it is about being active and physically part of the adventure.

Table 3 Analysis of Interaction in Virtual Reality Applications

	Analysis	**Sample 2** **Beat Saber**
Affordance	Cognitive	In *Beat Saber*, User need to stay sharp and focused as they quickly recognize patterns, react to fast-moving blocks, and make split-second decisions. It challenges attention, timing, and coordination, keeping the brain fully engaged throughout the gameplay.
	Physical	Beat Saber is a full body experience. User constantly swinging your arms to slash blocks and moving your body to dodge obstacles. It gets your heart rate up and feels more like a workout than just a game.
	Touching	In Beat Saber user don't physically touch the blocks but it still feels like you're interacting with them. When you swing your sabre and hit a block there's a satisfying sense of impact. The motion and sound together create the feeling that your actions have real presence in the game even though everything is virtual.
Feedback	Pressure	Beat Saber doesn’t involve actual physical pressure like pushing or squeezing but the game creates a strong sense of urgency through its fast pace and precision. Users feel the pressure to keep up with the rhythm react quickly and not miss any blocks. It adds excitement and keeps user fully engaged from start to finish.
	Vibration	The game uses vibration well to make everything feel more real. When users hit a block or miss a beat the controller gives a little buzz that matches your action. It’s a subtle but powerful way to make user movements feel connected to what’s happening in the game helping users stay focused and more engaged.
Challenge	Responsive	Beat Saber reacts instantly to user movements. When swing your arms or change direction the game keeps up with users smoothly and without delay. This quick response makes everything feel natural and satisfying like the game is really listening to what users doing. It helps users stay in the flow and feel fully connected to the experience.
	User Control	In Beat Saber user are in full control of the actions. Users decide how to swing when to move and how to match the rhythm. The game responds to user timing and style so it feels like users can leading the experience not just following along. That sense of freedom makes it more fun and personal every time user play.
	Motion Engagement	Beat Saber keeps users moving from start to finish. User constantly swinging the arms dodging obstacles and shifting user body with the rhythm. The movements feel fun and natural, so it doesn’t feel like exercise even though it really gets user active. It keeps user physically and mentally engaged the whole time.

Table 4 Analysis of Interaction in Virtual Reality Applications

	Analysis	Sample 3 VR Chat
Affordance	Cognitive	In VRChat User mind is always active because user constantly thinking about how to interact with others how to express yourself and how to move in different social settings. User might be solving problems during a game chatting in real-time or exploring new virtual worlds all of which keep user brain engaged and alert. It feels like real-life social interaction but in a creative and unpredictable virtual space.
	Physical	In VRChat user move hands head and sometimes your whole body to express yourself and interact with the environment. Whether you're waving dancing or just turning to face someone it involves natural physical movement. It's not as intense as a fitness game but it still keeps user physically involved especially during activities like mini-games or virtual hangouts.
	Touching	In VRChat user don't physically touch other people or objects but it still gives the feeling of presence and interaction. When user reach out to give a high five pick something up or gesture during a conversation it feels like your virtual hands are really connecting with the world around user. That sense of touch is created through movement visuals and how others respond to your actions.
Feedback	Pressure	VRChat doesn't involve physical pressure like squeezing or pushing but user might still feel a kind of social pressure. Whether it's trying to express user self clearly or keeping up with group conversations the pressure comes from wanting to interact smoothly with others. This kind of pressure makes the experience more immersive and can even help build confidence over time.
	Vibration	In VRChat vibration is used more subtly compared to action games. User might feel a light buzz when you interact with objects or when something happens around user like a virtual handshake or a sudden event. It's not the focus but the gentle haptic feedback helps make the virtual world feel a bit more real and responsive to user actions.
	Responsive	VRChat responds well to user movements and voice in real time. When user wave the hand or nod the head or talk. The user avatar mirrors those actions smoothly. Other users also react to user right away which makes conversations feel natural. This quick and accurate feedback helps the whole experience feel more like real-life interaction.
Challenge	User Control	In VRChat. User have a lot of freedom to control how user move interact and express the expression. User can choose the avatar, environment and how user want to engage with others. Whether user are exploring worlds chatting or just hanging out everything feels like it's in user hands which makes the experience more personal and creative.
	Motion Engagement	VRChat keeps user physically and socially engaged through movement. Whether user are using hand gestures dancing in a virtual club or just turning to look around the environment user body is always part of the interaction. It's not a workout but the constant small movements make you feel active and present in the virtual world.

Table 5 Analysis of Interaction in Virtual Reality Applications

	Analysis	Sample 4 First Encounter
Affordance	Cognitive	First Encounter keeps user brain engaged by making user stay alert and react to playful situations. User have to pay attention to surroundings figure out what the other player is doing and respond in a fun and creative way.
	Physical	In *First Encounter*, user stay physically involved by moving around the space, aiming, shooting, and reacting to incoming threats. The game keeps the body active with quick movements and real-time responses, making the experience both energetic and immersive.
	Touching	In *First Encounter*, User use their hands to grab weapons, reload, and interact with the environment. The game gives a convincing sense of touch through gesture-based controls and object handling, making each interaction feel responsive and hands-on.
Feedback	Pressure	In *First Encounter*, the game responds to how users handle their virtual tools and weapons. Applying different levels of force can influence actions like gripping a weapon tightly for better control or easing up to switch items quickly. This sensitivity to pressure adds a layer of realism and control to the gameplay.
	Vibration	In *First Encounter*, vibration feedback brings the action to life. Players feel the impact of gunfire, explosions, and hits through subtle or intense vibrations, adding a physical layer to the experience that makes each moment more immersive and intense.
	Responsive	In *First Encounter*, the game reacts quickly to all move users make, from aiming and shooting to taking cover and interacting with objects. This fast and accurate response helps keep the action smooth and makes users feel fully in control of the experience.
Challenge	User Control	In *First Encounter*, users have full control over their actions, from choosing where to move to deciding when to shoot or interact. The controls feel natural and responsive, giving user a strong sense of agency as they navigate intense combat situations.
	Motion Engagement	In *First Encounter*, players stay physically engaged by ducking, dodging, aiming, and moving through the virtual space. The game keeps them on their feet and actively involved, making every encounter feel dynamic and physically immersive.

Table 6 Analysis of Interaction in Virtual Reality Applications

	Analysis	Sample 5 Asgard's Wrath 2
Affordance	Cognitive	In *Asgard's Wrath 2*, users are constantly thinking through puzzles, planning strategies, and making quick decisions during combat. The game challenges memory, attention, and problem-solving skills, keeping the mind deeply engaged throughout the adventure.
	Physical	In *Asgard's Wrath 2*, users stay physically active as they swing weapons, block attacks, and interact with the environment. The game encourages full-body movement, making the experience feel immersive and energizing as users take on the role of a powerful hero.
	Touching	In *Asgard's Wrath 2*, users use their hands to grab weapons, open doors, and manipulate objects throughout the world. These interactions feel natural and satisfying, giving a strong sense of touch that helps bring the virtual environment to life.
Feedback	Pressure	In Asgard's Wrath 2, Users can really feel the intensity of the action thanks to the pressure feedback in the game. When User are pulling back a bowstring, lifting something heavy, or clashing swords in combat, the game makes it feel like there's real weight and resistance. This helps user connect more with what the character is doing, almost like user are there in the moment. The way it responds to how hard user press or moves adds to the sense of realism and makes the whole experience much more immersive and engaging.
	Vibration	In term of vibration, user can feel the action through the hands. Every time user swings a weapon, block an attack, or touch something magical, the game sends vibrations that match what's happening. If user get hit hard, the controller gives a strong jolt, but if it's just a light tap or interaction, the vibration feels gentler. It's like the game is physically reacting to user in every move, which makes everything feel more real and exciting.
	Responsive	In term of responsive component, the game responds to user movements almost instantly. Whether user is swinging a sword, reaching out to grab something, or turning the head, it reacts smoothly and quickly. It feels natural as if the game is completely in sync with user. There is no frustrating delay, which helps users stay fully immersed in the experience. Everything users do feels connected, making the gameplay feel more lifelike and engaging.
Challenge	User Control	In term of user control, user is always in control of what user do. User can move around freely, pick up objects, fight enemies, and explore the world in a way that feels natural and smooth. The game listens to users' actions and responds just how user expect it to. User can also change the settings to match the comfort and play style, which makes the whole experience feel more personal. It gives users the freedom to play the way and stay in charge from beginning to end.
	Motion Engagement	In term of motion engagement, user are not just pressing buttons, user can move the whole body, swing the arms to fight, duck to avoid danger, and use real motions to cast spells or interact with objects. The game picks up to user movements with accuracy, making everything feel more real and exciting. It keeps user active and involved, pulling user deeper into the world. User can feel like you are truly part of the adventure, not just watching it happens.

6 RESULT

Table 6 Result analysis of affordance (cognitive) in Virtual Reality Applications

Affordance (Cognitive)

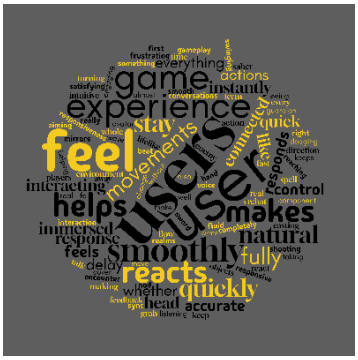
Affordance (Physical)

Feedback (Touching)

Feedback (Pressure)

Feedback (Vibration)

Challenge (Responsive)



Challenge (User Control)

Challenge (Motion Engagement)

Table 7 Finding of Interaction Design Features Analysis in Virtual reality Applications

Affordance		**Feedback**				**Challenge**	
Cognitive	Physical	Touching	Pressure	Vibration	Responsive	User Control	Motion Engagement
Constantly	Experience	User Touch	Pressure user	Feel	Feel	User	Feel
engaged	Movement	Sense	Respond	Action	Experience	Move	Body
Thinking	Body	Present	Realism	Vibration	Helps	Actions	Physically
Brain	Interact	feeling	Feel	Make	Smooth	Control	Movement
Attention	Involved	hands	Pushing	Buzz	Natural	Experience	Active

7 FINDINGS & DISCUSSION

Based on the word cloud, the findings reveal that the affordance of the system is centred on both cognitive and physical aspects. Users are constantly engaged and thinking, as they experience movement and interaction that keep their attention focused. The system allows the body and brain to work together, creating a space where people feel involved and present as they touch and explore the interface naturally.

When it comes to feedback, the responses of the system feel very real and responsive to the user's actions. The presence of pressure, vibration, and touch make the user experience smooth and engaging. This sense of realism and the feeling of the interface responding to each subtle action create a more intuitive and enjoyable interaction. There are also notable challenges that focus on user control and motion engagement. Users need to feel in control of their movements, as this directly impacts their experience of immersion and naturalness. Balancing this control with the need to keep the actions smooth and the experience engaging is important for making the overall interaction feel both active and intuitive.

Altogether, the findings highlight that the combination of affordance, feedback, and challenges shapes the user's experience. Users appreciate a design that keeps them constantly engaged, responds to their touch and actions, and allows them to feel fully in control of their movements. By addressing these aspects carefully, we can create a more realistic and immersive system that feels both responsive and natural.

8 CONCLUSIONS

In conclusion, the results show that a good interactive system needs to make people feel fully involved, supported, and in control. By keeping the body and mind engaged, the system feels more natural, and the responsive touch, pressure, and movement help people connect to it in a smooth and realistic way. Giving users control over their actions and making the experience feel easy and intuitive keeps them comfortable and focused. Overall, this balance of engagement, clear feedback, and simple control is what makes the experience feel enjoyable and truly immersive.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to the development and completion of this paper.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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