
# Innovative Interaction Mode in VR Games

Yi-Chun Liao(✉)

Department of Digital Multimedia Design, China University of Technology, Taipei City, Taiwan
ech_liao@cute.edu.tw

**Abstract.** Virtual reality (VR) games have gained significant popularity in recent years, offering immersive and interactive experiences. The success of VR games relies heavily on innovative interaction modes that enhance player engagement and immersion. This paper explores the concept of innovative interaction modes in VR games and their impact on player experiences. We examine various forms of interaction modes, including gesture-based controls, motion tracking, and haptic feedback, and analyze their effectiveness in enhancing gameplay. Furthermore, we discuss the challenges and opportunities in designing and implementing innovative interaction modes. Through a comprehensive review of existing research and case studies, this paper provides insights into the potential of innovative interaction modes to revolutionize the gaming industry. The findings underscore the importance of continuous innovation and experimentation to create compelling and immersive VR game experiences. By understanding and leveraging these innovative interaction modes, game developers can deliver more engaging and memorable gameplay, transforming the way players interact with virtual worlds. In this study, we conducted a prototype system to evaluate the impact of innovative interaction modes on player engagement and gameplay experiences in VR games. We developed two different interaction modes: gesture-based controls and in-game control tool.

**Keywords:** interactive tool · VR game · gesture tracking

## 1 Introduction

### 1.1 Background

Virtual reality (VR) has emerged as an innovative technology that offers immersive and interactive experiences across various domains, including entertainment, education, training, and healthcare. In recent years, VR gaming has gained significant popularity, captivating players with its ability to transport them into virtual worlds and provide a heightened sense of presence and engagement. Central to the success of VR games is the design and implementation of effective interaction modes that allow players to interact with the virtual environment and game mechanics.

The traditional modes of interaction in video games, such as keyboard and mouse or gamepad controls, may not fully leverage the immersive potential of VR. As a result, game developers have been exploring and implementing innovative interaction modes


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to enhance the player experience and create more intuitive and immersive gameplay. These interaction modes utilize the unique capabilities of VR devices, such as hand tracking, gesture recognition, motion controllers, and haptic feedback, to enable natural and immersive interactions within the virtual world.

The objective of this research paper is to explore the concept of innovative interaction modes in VR games and examine their impact on player engagement and gameplay experiences. By understanding and evaluating the effectiveness of these modes, game developers can make informed decisions in designing and implementing VR games that provide captivating and immersive experiences for players.

Specifically, this paper aims to:

- Identify and categorize different types of innovative interaction modes used in VR games.
- Assess the impact of these interaction modes on player engagement, presence, and enjoyment.
- Examine the challenges and opportunities in designing and implementing innovative interaction modes in VR games.
- Provide insights and recommendations for game developers to create compelling and immersive VR gaming experiences.

The study of innovative interaction modes in VR games holds significant relevance and implications for the gaming industry, academic research, and the broader field of virtual reality. By investigating and understanding the impact of these modes, this research contributes to the advancement of VR game design and provides valuable insights for game developers, researchers, and practitioners.

Furthermore, this research contributes to the academic discourse on VR gaming and interaction design. By examining the impact of innovative interaction modes, this study expands our understanding of the factors that contribute to player engagement and immersion in virtual environments. The findings can serve as a foundation for further research in this area and stimulate discussions on the design and implementation of interaction modes in VR games. The rest of this paper is organized as follows: In the next section, we review relevant literature on VR gaming and the importance of interaction modes in enhancing player experiences. This is followed by a theoretical framework that conceptualizes innovative interaction modes and discusses their significance in VR game design. The methodology section details the research design, participant recruitment, and data collection procedures. Subsequently, we present the results of our study, followed by a discussion of the findings and their implications. Finally, we conclude the paper by summarizing key findings, highlighting contributions to the field, and providing recommendations for future research and game development practices.

## 2 Related Work

### 2.1 Background

Virtual reality gaming has gained significant attention in recent years due to its potential to provide highly immersive and interactive experiences. VR technology offers a simulated environment that enables users to interact with three-dimensional virtual worlds

using specialized headsets and controllers. This immersive nature of VR gaming holds promise for creating more engaging and realistic gameplay experiences [1].

Research in the field of VR gaming has focused on exploring various aspects of player experiences, such as presence, immersion, enjoyment [2], and flow. Presence refers to the feeling of being physically present in the virtual environment, while immersion refers to the extent to which the user feels psychologically absorbed in the virtual world. These factors contribute to the overall enjoyment and engagement of players [3–5].

### 2.2 Interaction Modes in VR Games

Interaction modes play a crucial role in shaping the player's experience in VR games. Traditional input methods, such as keyboard and mouse or gamepad controls, are often inadequate for fully exploiting the immersive potential of VR. As a result, game developers have been exploring innovative interaction modes that leverage the capabilities of VR devices, such as hand tracking, gesture recognition, motion controllers, and haptic feedback [6, 7].

Gesture-based controls allow players to use their hand movements and gestures to interact with objects and navigate within the virtual environment. This mode enables more intuitive and natural interactions, enhancing the sense of presence and immersion. Motion controllers, such as handheld devices with built-in sensors [8, 9], provide precise tracking of the player's hand movements, enabling realistic interactions and object manipulation.

Voice recognition is another innovative interaction mode that allows players to use voice commands to control the game. This mode offers hands-free interaction and can be particularly useful in games that require verbal communication with virtual characters or complex command inputs.

Haptic feedback technology provides physical sensations [17] or vibrations to simulate the sense of touch and enhance the realism of interactions [10]. This mode can add a new dimension to gameplay by providing tactile feedback, such as the sensation of objects or virtual environments.

### 2.3 Impact of Innovative Interaction Modes on Player Engagement

Several studies have investigated the impact of innovative interaction modes on player engagement and gameplay experiences in VR. Research has shown that these modes can significantly enhance player immersion, presence, and enjoyment compared to traditional input methods.

Gesture-based controls have been found to provide a more intuitive and natural way of interacting with the virtual environment. Players report a greater sense of agency and physical presence [18], leading to increased engagement and enjoyment. The ability to reach out and grab objects or perform gestures that correspond to in-game actions enhances the sense of embodiment within the virtual world.

Voice recognition has shown promise in enabling seamless and immersive interactions. Players find voice commands to be convenient and immersive, as they can communicate with virtual characters or control the game without the need for physical

input devices. This mode can facilitate more natural and expressive communication in VR games, enhancing the overall gameplay experience.

Motion controllers, with their precise tracking capabilities, offer realistic hand interactions and object manipulation. Players feel a sense of control and agency as they physically reach out and manipulate virtual objects. This mode enhances the immersion and embodiment within the virtual world, leading to heightened engagement and enjoyment.

Haptic feedback has the potential to enrich gameplay experiences by providing realistic tactile sensations [17]. Players experience a stronger sense of presence and immersion when they can feel the virtual environment or receive feedback through vibrations. Haptic feedback can enhance the realism of interactions and contribute to a more engaging and immersive gameplay experience.

While there has been significant progress in understanding the impact of innovative interaction modes in VR games, there are still gaps and limitations in the existing research that warrant further investigation.

Firstly, many studies have focused on the immediate effects of different interaction modes on player engagement and enjoyment during gameplay sessions. However, there is a need to examine the long-term effects and sustainability of these modes over extended play durations. Understanding how players' experiences evolve and adapt over time can provide insights into the long-term effectiveness and potential challenges associated with innovative interaction modes.

Secondly, most research has primarily examined the subjective experiences and perceptions of players through self-report measures. While self-report measures offer valuable insights, objective measurements and performance metrics can provide a more comprehensive understanding of player engagement and gameplay experiences. Incorporating physiological measures, eye-tracking, or behavioral analysis can offer additional quantitative data to complement the subjective feedback provided by players.

Furthermore, the majority of studies have focused on specific genres or types of VR games, limiting the generalizability of the findings. Exploring a wider range of game genres and contexts can provide a more comprehensive understanding of the impact of innovative interaction modes across different game experiences. Additionally, investigating the preferences and experiences of diverse user groups, including individuals with varying levels of gaming experience or different demographic backgrounds, can provide insights into the effectiveness and accessibility of these modes for a broader audience [17, 18].

Lastly, the design and implementation of innovative interaction modes require careful consideration of technical constraints, such as hardware limitations, software compatibility, and development resources. Future research could explore the technical feasibility and challenges associated with implementing these modes in real-world game development scenarios. Understanding the practical considerations and potential barriers can assist game developers in effectively integrating innovative interaction modes into their projects.

The existing research suggests that these innovative interaction modes can enhance player immersion, presence, and enjoyment in VR games compared to traditional input methods [16]. However, there are gaps and limitations in the current body of research,

such as the need for long-term investigations, objective measurements, wider game genre exploration, diverse user group analysis, and consideration of technical constraints.

## 3 Theoretical Framework

The theoretical framework section aims to provide a conceptual foundation for understanding the role and significance of innovative interaction modes in VR game design. It explores theoretical perspectives and frameworks that inform the design and implementation of these modes, as well as their influence on player engagement and gameplay experiences (Fig. 1).

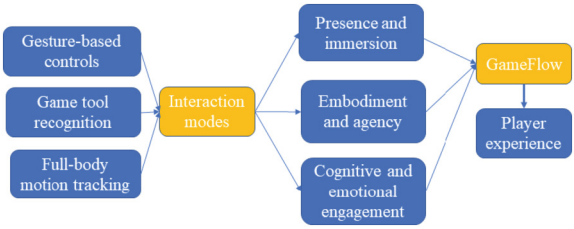


**Fig. 1.** The theoretical framework

### 3.1 Presence and Immersion

Presence and immersion are two key concepts that underpin the theoretical framework of this study. Presence refers to the subjective feeling of being physically present in a virtual environment, while immersion refers to the extent to which an individual becomes psychologically absorbed in the virtual world. These concepts are fundamental to understanding the impact of innovative interaction modes on player experiences.

According to the presence theory, a high level of presence is essential for creating a sense of realism and engagement in virtual environments. It is influenced by various factors, including sensory feedback, interactivity, and the extent to which the virtual world aligns with users' expectations and cognitive processes. The use of innovative interaction modes can enhance the sense of presence by providing more natural and intuitive ways of interacting with the virtual environment.

Immersion, on the other hand, is associated with the depth and richness of the virtual experience. It involves the feeling of being fully engrossed in the virtual world and losing awareness of the physical environment. Innovative interaction modes can contribute to immersion by enabling more realistic and embodied interactions, enhancing the player's sense of agency and involvement within the virtual environment.

### 3.2 Flow Theory

Flow theory, developed by Csikszentmihalyi, provides insights into the psychological state of optimal engagement and immersion in an activity [11]. Flow is characterized

by a deep sense of focus, enjoyment, and a feeling of being fully absorbed in the task at hand. It occurs when the challenges presented in the activity match the individual's skills and abilities.

In the context of VR gaming, innovative interaction modes can facilitate the experience of flow by providing a seamless and intuitive interaction process. When the player's actions and inputs align with the virtual environment's feedback and challenges, a state of flow can be achieved. This leads to enhanced enjoyment, sustained engagement, and a sense of accomplishment.

Embodiment and agency are key aspects of player experiences in VR games and are closely related to the effectiveness of innovative interaction modes. Embodiment refers to the feeling of being physically present and connected to a virtual body or avatar. It involves the perception of bodily sensations, movements, and interactions within the virtual environment [12–14].

Innovative interaction modes, such as gesture-based controls and motion tracking, enable a greater sense of embodiment by allowing players to use their own body movements to interact with the virtual world. This embodiment can enhance the player's sense of presence and immersion, as they perceive the virtual body as an extension of their own. Agency, on the other hand, refers to the sense of control and influence over the virtual environment. Innovative interaction modes that offer precise tracking and responsive feedback enable players to have a greater sense of agency, as their actions directly impact the virtual world. This sense of agency contributes to player engagement and satisfaction.

### 3.3 Cognitive and Emotional Engagement

Cognitive and emotional engagement are important dimensions of player experiences in VR games. Cognitive engagement involves mental processes such as attention, problem-solving, and decision-making. Innovative interaction modes can enhance cognitive engagement by providing more intuitive and immersive interactions that require active mental involvement.

Emotional engagement, on the other hand, refers to the player's emotional responses and attachment to the virtual experience. Innovative interaction modes that elicit emotional reactions, such as joy, excitement, or fear, can enhance the emotional engagement of players. This emotional engagement contributes to the overall enjoyment and memorable experiences in VR games.

## 4 Proposed Interaction Mode and Prototype System

### 4.1 Theoretical Framework

The theoretical framework provides a conceptual lens for understanding the impact of innovative interaction modes in VR games. It explores key theoretical perspectives such as presence, immersion, flow theory, embodiment, agency, cognitive engagement, and emotional engagement. These concepts help frame the understanding of how innovative interaction modes influence player experiences in VR games.

The proposed interaction mode has two key parts, all shown in Fig. 2:

- **Gesture-based controls**: offer the benefits of providing a more embodied interaction experience, allowing users to engage in actions and expressions that are closer to real-world counterparts. This control method also offers increased freedom and expressiveness, enabling users to interact with digital content, virtual worlds, or applications in a more natural and intuitive manner. Designing gesture-based controls involves considerations for gesture recognition and interpretation to understand the user's intentions and translate them into appropriate actions. This involve technologies such as machine learning, computer vision, sensor technologies, and algorithms.
- **In-game Control tool**: has implications for gameplay mechanics, player immersion, and overall game design. By accurately recognizing and responding to the player's use of tools, the game can provide a more dynamic and interactive experience, allowing players to fully utilize the available tools and enhance their engagement with the game world. Proposed system implements specific algorithms to handle in-game tool recognition based on the game's design and mechanics. This allows for more precise and context-aware interactions, enabling players to fully leverage the functionalities and possibilities offered by the in-game tools.

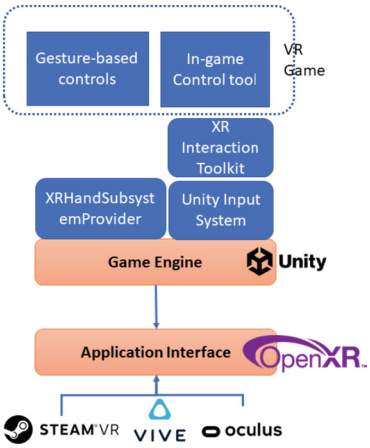


**Fig. 2.** Game system architecture

### 4.2 Prototype Implementation

In the hardware and software architecture, it includes a virtual reality (VR) headset, the game program main body, and Arduino sensing devices. Our project implements the following features:

- Arduino Communication Module.
- VR Control Module.
- Character Control Module.

- UI Module.
- Monster AI Module.

Arduino Interfacing Devices: Utilizing Arduino devices to interface with Unity for achieving a multiplayer-operable VR effect. To connect Arduino to Unity, follow these steps:

1. Ensure that your Arduino board is properly connected to your computer and functioning correctly. Make sure you have the correct drivers installed and the Arduino IDE set up.
2. Create a new project or open an existing project in Unity.
3. Download and install the Arduino connection package for Unity. You can find the relevant package from platforms like the Unity Asset Store or GitHub. These packages typically provide APIs and tools for communication with Arduino.
4. Create a script in Unity for serial communication. You can use the C# programming language to write this script. This script will handle the communication with Arduino, such as reading or writing data.
5. Set up and manage the serial communication using the SerialPort class in Unity. This class provides a range of methods and properties to communicate with Arduino through the serial port.
6. Use your script in Unity to configure the parameters for serial communication, such as the serial port number, baud rate, and data format.
7. Use the appropriate methods in your script to send or receive data to/from Arduino. You can send commands to Arduino through the serial communication and read sensor data or other feedback from Arduino.
8. Test and validate the connection. Run your Unity scene or application to ensure that Unity can communicate correctly with Arduino. Check for any communication errors or warnings in Unity's console or logs (Fig. 3).

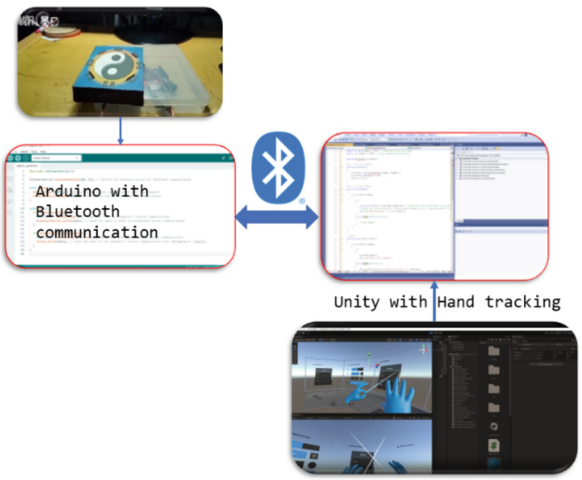


**Fig. 3.** Proposed communication module.

## 5 Conclusion

In this study, we explored the impact of innovative interaction modes in VR games, specifically focusing on Gesture-based Controls, In-game Control tool, and Handheld Controllers. The findings of this research contribute to our understanding of player experiences and provide insights for game designers and developers in creating immersive and engaging VR gaming experiences.

In conclusion, this research contributes to the field of VR game design by examining the impact of innovative interaction modes on player engagement, immersion, and presence. By considering the strengths and limitations of different modes, game designers can create more immersive and captivating experiences for players. Future research should continue to explore and refine interaction modes to enhance player experiences and push the boundaries of VR gaming. With the continued advancements in VR technology, there are exciting opportunities to create more immersive and interactive experiences that captivate players and elevate the gaming industry.

## References

1. Bowman, D.A., McMahan, R.P.: Virtual reality: how much immersion is enough? Computer **40**(7), 36–43 (2007)
2. Radianti, J., Majchrzak, T.A., Fromm, J., Wohlgenannt, I.: A systematic review of immersive virtual reality applications for higher education: design elements, lessons learned, and research agenda. Comput. Educ. **147**, 103778 (2020)
3. Xi-Ning, W., Gareth William, Y., Adéla, P., Conor, Mc G.: Utilizing virtual reality to assist social competence education and social support for children from under-represented backgrounds. Comput. Educ. **4**, 104815 (2023)
4. Ifanov, J.P., Salim, S., Edo Syahputra, M., Andam, S.P.: A systematic literature review on implementation of virtual reality for learning. Procedia Comput. Sci. **216**, 260–265 (2023)
5. Castelo-Branco, R., Leitão, A.: Algorithmic design in virtual reality. Architecture **2**(1), 31–52 (2022)
6. Vishwakarma, D.K.: Hand gesture recognition using shape and texture evidences in complex background. In: Proceedings of the 2017 International Conference on Inventive Computing and Informatics (ICICI), pp. 278–283, Coimbatore, India (2017)
7. Wu, M.Y., Ting, P.W., Tang, Y.H., Chou, E.T., Fu, L.C.: Hand pose estimation in object-interaction based on deep learning for virtual reality applications. J. Vis. Commun. Image Represent. **70**, 102802 (2022)
8. Baudel T., Beaudouin-Lafon M.: Charade: remote control of objects using free-hand gestures. Commun. ACM **36**(7), 28–35 (1993)
9. Ruiz, J., Li, Y., Lank, E.: User-defined motion gestures for mobile interaction. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM, Vancouver, Canada, pp. 197–206 (2011)
10. Jin, R., Yang J.: Domain adaptive hand pose estimation based on self-looping adversarial training strategy. Sensors **22**(22), 8843 (2022)
11. Csikszentmihalyi, M.: Flow: The Psychology of Optimal Experience. Harper & Row (1990)
12. Sweetser, P., Wyeth, P.: GameFlow: a model for evaluating player enjoyment in games. ACM Comput. Entertainment **3**(3), 1–24 (2005)
13. Hunicke, R., LeBlanc, M., Zubek, R.: MDA: a formal approach to game design and game research. In: Proceedings of the AAAI Workshop on Challenges in Game AI, vol. 4, p. 1722 (2004)

14. Cardona-Rivera, R.E., Zagal, J.P., Debus, M.S.: GFI: a formal approach to narrative design and game research, interactive storytelling. In: 13th International Conference on Interactive Digital Storytelling, ICIDS 2020, pp.133–148 (2020)
15. Reyes-Lecuona, A., Diaz-Estrella, A.: New interaction paradigms in virtual environments. In: Proceeding on IEEE Mediterranean Electrotechnical Conference, pp. 449–452 (2006)
16. Theodoropoulos, A., Stavropoulou, D., Papadopoulos, P., Platis, N., Lepouras, G.: Developing an interactive VR CAVE for immersive shared gaming experiences. Virtual Worlds **2**, 162–181 (2023)
17. Sebastian, V., Panagiotis, K., Ferran, A., Claudio, P., Maud, M.: Design evaluation and calibration of wearable electrotactile interfaces for enhancing contact information in virtual reality. Comput. Graph. **111**, 199–212 (2023)
18. Yukang, Y., Xin, Y., Chun, Y., Yuanchun, S.: Gesture-based target acquisition in virtual and augmented reality. Virtual Reality Intell. Hardware **1**(3), 276–289 (2019)