Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 11, No. 3, 2024

Study of Ergonomics in the Development of Gamepads

Haipeng Xu [1, *], Ruilin Lu [1] and Linyu Fan [2]

[1] Southwest petroleum university, Chengdu, China
[2] Chongqing College of Humanities, Science & Technology, China

*** Corresponding author:** Haipeng Xu (Email: 2273961941@qq.com)

Abstract: This thesis explores the ergonomic factors in the development of gamepads. With the popularization of video games, the gamepad, as the main input device, plays a key role in the gaming experience. By applying the principles and methods of ergonomics, this study analyzes the impact of gamepad design on player experience and operation efficiency. First, we review the development history of gamepads, from early designs to the application of modern innovative technologies, as well as the differences in the design of gamepads for different platforms. Then, we explore the human factors in human-computer interface design, including the effects of ergonomics, operation control layout, joystick size and grip on the gaming experience. In addition, we examine the human factors of perception and feedback, including the application of haptic feedback technology, audio and visual feedback in gamepads. We also emphasize the importance of user experience in gamepad design and analyze the impact of gamepad design on user experience. Finally, we discuss current challenges and future directions, including possibilities for improvement and innovation, and the potential impact of emerging technologies on gamepad design. By examining the ergonomic factors in gamepad development, this thesis aims to provide a more user-friendly and optimized gamepad design to enhance the player's gaming experience and operational efficiency.

Keywords: Ergonomics; Gamepad; Human-Computer Interface; User Experience; Perception and Feedback.

1. Introduction:

1.1. Background of the Study

With the rapid development of the video game industry, the gamepad, as one of the main game input devices, plays a crucial role in the player's gaming experience and operation efficiency. The ergonomic factor of gamepad design is one of the key factors to improve the gaming experience and operation efficiency. However, despite the remarkable evolution and innovation that gamepads have experienced over the past decades, there is still much potential room for improvement. Therefore, an in-depth study of the ergonomic factors in the development of gamepads can help guide the optimization and innovation of gamepad design in the future.

1.2. Purpose of the Study

The purpose of this study is to explore the ergonomic factors in the development of gamepads in order to reveal the impact of gamepad design on player experience and operational efficiency, and to provide suggestions for improvement and optimization of gamepad design. Specifically, this study will focus on the application of ergonomic principles in gamepad design, the operation control layout and button design, the impact of handle size, shape and grip on the gaming experience, as well as the application and importance of the human factors of perception and feedback in gamepads.

1.3. Research Methodology

This study will adopt a comprehensive research method. Firstly, the development history of gamepads and the design of gamepads for different platforms will be comprehensively reviewed and compared through the literature research method and case studies. Secondly, the theories and principles of ergonomics will be applied to analyze and evaluate in-depth the ergonomic factors in gamepad design by combining ergonomic experiments and user experience research methods. In addition, feedback and opinions from players will be collected to obtain data on actual users' experiences and needs.

Through the comprehensive use of the above research methods, this study aims to comprehensively understand the ergonomic factors in the development of gamepad, to provide scientific basis for the improvement and optimization of gamepad design, and to provide valuable references for the future development direction of gamepad.

2. Overview of Human Factors Engineering

2.1. Definition and Principles of Human Factors Engineering

Human factors engineering is a discipline concerned with the interaction between humans and technological systems, aiming to optimize the design of human-computer interfaces to improve user safety, efficiency and satisfaction. The core principles of ergonomics include adaptability, usability, understandability and controllability. Adaptability requires that technology systems be able to adapt to the needs and characteristics of different users. Usability requires that technology systems are easy to learn and operate and provide effective feedback. Understandability requires that the functionality and operation of the technology system be clearly understood by the user. Controllability requires that the user be able to control the functionality and behavior of the technology system.

2.2. Application of Human Factors Engineering in the Game Field

The application of ergonomics in the field of gaming aims to improve the gaming experience, enhance game performance and increase user engagement. Through the principles and methods of ergonomics, game developers can

optimize game interfaces, control schemes, and interaction designs to provide a better gaming experience. Ergonomics plays an important role in gamepad design. Reasonable button layouts, ergonomic shapes and sizes, and accurate tactile feedback can help players better control their game characters and improve the precision and responsiveness of game operations. In addition, ergonomics can be applied to the visualization design of the game interface, menu navigation, and task prompts to provide an intuitive, easy-to-understand and operate game interface that enhances the user's sense of game engagement and satisfaction.

In summary, the application of ergonomics in the field of gaming is of great significance to improve the gaming experience and enhance user operation efficiency and satisfaction. In gamepad design, the principles and methods of ergonomics can guide developers to design more humanized and optimized gamepads to provide better game control experience.

3. Development history of gamepad

3.1. Early Gamepad Design

Early gamepad designs were based primarily on the needs of arcade games and home consoles. These joysticks usually consisted of simple buttons and joysticks to fulfill the control needs of the games of the time. Early arcade gamepad designs (Figure 1) utilized a simple layout to accommodate the fast-paced and competitive nature of arcade games. Home console joystick designs (Figure 2), on the other hand, focused more on user-friendliness and ease of use, such as incorporating arrow keys and additional function buttons.

Figure 1. Arcade handle layout

Figure 2. Early nes home machine handle

3.2. Application of Innovative Technologies

With the advancement of technology and the development of the gaming market, gamepad design has gradually incorporated more innovative technologies. For example, touch screens, motion sensors and vibration feedback technologies have been introduced. The application of these innovative technologies has brought more interaction methods and enhanced immersion to gamepads. The addition of the touch screen allows the joystick to have multi-touch functionality, expanding the operational possibilities of the game. Motion sensor technology allows gamers to control characters or manipulate game objects through the movements of the joystick. Vibration feedback technology provides a more realistic tactile experience and enhances game immersion.

3.3. Comparison of Joystick Designs for Mainstream Game Platforms

Gamepad designs for different gaming platforms vary in layout, number of buttons, shape and size. For example, Sony, Microsoft, and Nintendo, jokingly referred to by gamers as the Royal Three, have each released gamepads with their own distinctive features. Sony's PlayStation's DualShock controller (Figure 3) has a symmetrical layout and haptic feedback technology that is suitable for all types of games. Microsoft's Xbox's controller (Figure 4), on the other hand, features an asymmetrical layout and expanded button functionality for more control options. The Nintendo Switch's controller design innovatively utilizes detachable Joy-Con grips (Figure 5), allowing gamers to choose different ways to use the controller depending on their gaming needs. The joystick designs of these mainstream gaming platforms are each distinctive in terms of meeting the needs of players and providing different gaming experiences.

Figure 3. DualShock grip for Sony PlayStation 5

Figure 4. Controller for Microsoft Xbox

Figure 5. Nintendo switch JoyCon grip

4. Human Factors in HMI Design

4.1. Application of Ergonomic Principles in Gamepad Design

Ergonomics is an important concept in human factors engineering that aims to match design with human characteristics and behavior to provide a comfortable, safe, and efficient use experience. In gamepad design, the application of ergonomic principles can help designers optimize the shape, size, and layout of the joystick to accommodate different players' hand shapes and finger mobility. For example, through ergonomic principles, the curved shape and recessed areas of the joystick can match the natural curve of the hand, reducing hand fatigue and discomfort. The layout and spacing of handle buttons can be optimized according to the movement characteristics of the human hand and the frequency of key operations to improve the accuracy and speed of operation.

4.2. Operation Control Layout and Button Design

Operation control layout and button design are important factors in gamepad design, directly affecting the player's game operation experience and efficiency. A reasonable operation control layout can make it easier for players to find the required buttons and reduce the possibility of misuse. The design of buttons includes factors such as the size, shape, protrusion and depression of the buttons. Designers need to consider the accessibility and maneuverability of the buttons to improve the accuracy and reaction speed of the player's keystrokes. In addition, depending on the type of game and functional requirements, the introduction of programmable buttons or expansion of button functions can be considered to increase the variety and flexibility of operations.

4.3. The Effect of Handle Size, Shape and Grip on the Gaming Experience

The size, shape and grip of the handle have a significant impact on the player's gaming experience and operation. Different handle sizes accommodate different hand shapes and sizes to provide better grip and comfort. The shape of the handle can be designed according to the anatomical structure and mechanical properties of the hand to minimize hand fatigue and discomfort. Grip style is also a key factor in handle design, such as the traditional horizontal grip, vertical grip and split grip. Different grip styles can be adapted to different game types and individual player differences, providing better operational precision and control flexibility. By comprehensively considering human factors such as ergonomics, operation and control layout and button design, handle size, shape and grip, gamepad design can provide a more optimized human-computer interface and improve the user's gaming experience and operation efficiency. In the design process, combined with user research and human factors experimental data, designers can more accurately understand user needs and feedback, and thus provide gamepad design solutions that better meet user expectations.

5. Human Factors in Perception and Feedback

5.1. Application of Haptic Feedback Technology in Gamepads

Haptic feedback technology is an important human-computer interaction method that conveys information and feedback to the user by simulating force, vibration or tactile feedback. In gamepad design, haptic feedback technology can provide a more realistic game experience and a more intuitive sense of operation. For example, with vibration feedback, players can feel the collisions, vibrations and impacts in the game, enhancing the immersion and immersive feeling of the game. Haptic feedback can also be used to indicate specific events or provide cueing information, such as pulsing vibrations to indicate a low battery or the achievement of a mission objective. Designers can finely tune the intensity, frequency and timing of haptic feedback according to the game context and operational requirements to enhance player experience and engagement.

5.2. Importance of Audio and Visual Feedback

In addition to haptic feedback, audio and visual feedback also play an important role in gamepad design. Audio feedback can provide sound effects such as game sound effects, character dialog, and ambient music through the speaker or headphone jack on the gamepad. Audio feedback not only enhances game immersion, but also provides important information cues and guidance to help players better understand the game context and dynamics. Visual feedback, on the other hand, conveys information through LED indicators on the joystick, on-screen displays, or the touch screen. For example, LED indicators can indicate different states or game events, on-screen displays can provide information about the game interface, menus, and prompts, and touchscreens can serve as additional operator interfaces. Visual feedback provides an intuitive way of presenting and interacting with information, enabling players to react more quickly and accurately.

5.3. User Experience and Gamepad Design

User experience is one of the crucial factors in gamepad design. Through rational HCI design and the application of human factors engineering principles, gamepads can provide a better user experience, making it easier for players to get started, enjoy the game and achieve their goals. Ergonomic factors for gamepads include ergonomics, operation and control layout, tactile feedback, audio and visual feedback, etc. Designers need to have a deep understanding of the needs and behavioral characteristics of the target user group and incorporate the principles and methods of ergonomics in order to design a gamepad that meets the user's expectations, is easy to operate and comfortable to use. Considering haptic feedback technology, audio and visual feedback, and other human factors, gamepad design can provide a more comprehensive and optimized user experience. By

appropriately applying the human factors of perception and feedback, designers can create gamepads that are more engaging, interactive, and compatible with player needs. Such a design will provide players with a more immersive and interactive gaming experience, thus improving overall user satisfaction and game quality.

6. User Experience and Gamepad Design

6.1. Definition and Importance of User Experience

User experience refers to the overall feelings and emotional responses that users feel when using a product or service. In gamepad design, user experience is an important indicator for evaluating the performance and quality of gamepads. An excellent gamepad design should be able to provide a comfortable grip, sensitive control, intuitive interface, as well as functions and feedback that meet players' expectations. A good user experience can increase player satisfaction, improve the attractiveness of the game, and establish a good brand image and reputation.

6.2. Impact of Gamepad Design on User Experience

Gamepad design directly affects the quality and effect of user experience. A good gamepad design should take into account the individual differences of players, operating habits and the use of the environment. Factors such as comfortable grip, reasonable button layout, flexible operation, and accurate feedback will directly affect the player's gaming experience. In addition, the gamepad design should also match the game type and platform characteristics to ensure the accuracy, responsiveness and diversity of operation. Through reasonable human-computer interaction design and user interface design, gamepads can provide players with a more natural, intuitive and smooth gaming experience.

6.3. The Importance of User Research and Feedback

User research and feedback is a crucial part of the gamepad design process. Through user research, designers can understand users' needs, preferences and behavioral habits so as to target design and improvement. User research can include questionnaire surveys, user interviews, user observations and user tests to obtain qualitative and quantitative data about the gamepad experience. Meanwhile, receiving feedback and opinions from users is an important way to improve the design. By communicating and interacting with users, designers can keep abreast of changes in users' needs and problems, so that timely adjustments and improvements can be made. The importance of user research and feedback lies in incorporating the user's voice into the design process to ensure that the gamepad design matches the user's needs and maximizes the quality user experience.

By rationally applying the factors related to user experience and gamepad design, designers can create gamepads that better meet user needs and enhance user experience. The focus on user experience will help design gamepads that are more humanized, comfortable and easy to operate, thus improving the quality of games, user satisfaction and market competitiveness.

7. Current Challenges and Future Directions

7.1. Problems and Challenges in Current Gamepad Design

In the current gamepad design, there are still some issues and challenges that need to be addressed. First, compatibility and consistency between different game platforms is an important issue, as there are differences in gamepad design across platforms, and players may need to adapt to different layouts and operating styles. Second, the complexity and functional diversity of gamepads may also cause confusion and learning difficulties for players in using them. In addition, some players may face ergonomic problems such as inappropriate joysticks and uncomfortable grips, which may lead to inconvenience or fatigue. Meanwhile, with the continuous development of gaming technology, the design of gamepads needs to be followed up and innovated to meet the needs of emerging game forms and interaction methods.

7.2. Possible Directions for Improvement and Innovation

In order to solve the problems and challenges in the current gamepad design, the following directions of improvement and innovation can be considered. First, promote the standardization and unification of gamepads to improve compatibility and consistency between different platforms so that players can switch platforms and adapt to new gamepads more easily. Second, focus on user experience and ergonomic principles, and design more ergonomic joystick shapes, sizes and grips to provide a more comfortable and natural sense of operation. In addition, simplify the layout and operation of the joystick to avoid over-complexity, so that players can get started quickly and operate smoothly, and improve the playability and user satisfaction of the game. In addition, user research and feedback can be strengthened to collect users' needs and opinions in a timely manner and incorporate them into the design process to ensure that the design is closer to users' expectations and habits.

7.3. Potential Impact of Emerging Technologies on Gamepad Designs

Emerging technologies will have a potential impact on gamepad design. For example, the development of virtual reality VR such as PlayStation Vr glasses introduced by Sony (Figure 6) and augmented reality AR such as visionpro introduced by Apple (Figure 7) may require joystick design to match the interaction methods of the virtual environment to provide a more immersive and realistic experience. The application of gesture recognition technology and touch screen technology may make the handle design more diverse and flexible, providing more interaction methods and operation options. In addition, the development of artificial intelligence and machine learning technologies may bring more intelligent functions and personalized user experience to gamepad design. The application of these emerging technologies will bring more innovation and possibilities to gamepad design, but they also need to be combined with the principles of ergonomics to ensure that the technology matches the user's needs and the smoothness of interaction.

Figure 6. Sony PlayStation vr

Figure 7. Apple visionpro

8. Conclusion

8.1. Summary of the Study

This paper discusses the importance and application of human factors engineering in gamepad design by studying and analyzing the ergonomic factors in gamepad development. First, through the overview of human factors engineering, we understand the definition, principles, and applications of human factors engineering in the game field. Then, through the history of gamepad development, we reviewed the early gamepad designs and the application of innovative technologies, and compared the gamepad designs of different mainstream game platforms. We then explore the human factors in human-computer interface design, including the application of ergonomic principles, operation control layout and button design, and the impact of joystick size, shape and grip on the gaming experience. Next, we discuss the human factors of perception and feedback, including the application of haptic feedback technology and the importance of audio and visual feedback. Finally, we explore the relationship between user experience and gamepad design, emphasizing the definition and importance of user experience, the impact of gamepad design on user experience, and the importance of user research and feedback.

8.2. Vision for Future Work:

Although much progress has been made in gamepad design, there are still some challenges and room for improvement. Future research can continue to explore the following areas in depth:

First, further research on the relationship between user experience and gamepad design is needed to explore how user experience can be enhanced through human factors engineering methods and principles. More detailed user studies, including user behavior observation, user feedback and user satisfaction surveys, can be conducted to obtain more comprehensive and accurate data.

Secondly, with the continuous development of emerging technologies, gamepad design can further explore the application of new technologies such as virtual reality, augmented reality, gesture recognition and touch screen. The combination of these technologies will bring more innovations and possibilities to gamepad design, enhancing the immersion and interactivity of the game.

In addition, sustainability and environmental friendliness of gamepads are important directions for the future. Researchers can explore strategies such as the use of sustainable materials, energy-efficient designs, and recyclable components to reduce the environmental impact of gamepads.

Finally, strengthening the cooperation and communication between academia and game industry is also an important direction for future work. The academia can provide more theoretical support and scientific methods, while the game industry can provide practical experience and market demand to jointly promote the development of gamepad design.

References

[1] Deng Ming, Zhao Jianchao. Research on gamepad experience under perceptual engineering theory system[J]. Design, 2020, 33 (21):20-23.

[2] PENG Ziwei. Research on gamepad based on human factors engineering[J]. Modern Manufacturing Technology and Equipment, 2017(09):58+ 60.DOI: 10.16107/ j.cnki. mmte. 2017. 0779.

[3] Chai Hua. Construction of the "human-machine-environment" model for game controllers[D]. Nanjing University of Science and Technology, 2008.

[4] Zhang, Honglin. Human factors engineering [M]. Higher Education Press. 2005.

[5] Jingbo Z, Ruize A, Ruolin X, et al. Comparing hand gestures and a gamepad interface for locomotion in virtual environments [J]. International Journal of Human - Computer Studies, 2022,166.