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Application of Human-Computer Interaction and Digital Image Processing Technology in Virtual Simulation Game Design

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Human beings perceive, understand and contact the world through five senses. These five senses are the most obvious way for human beings to perceive the world. However, the way for human beings to perceive the world is not limited to the five senses. Through the brain's information analysis and processing of the perception system, human beings can obtain richer feelings. Human beings' feelings of real life come from the feelings of human organs. Now, there is a virtual simulation technology that can let people express their feelings through virtual information. In virtual simulation, the information that human beings are exposed to may be unreal and not be truly perceived by the five senses. However, human beings can really perceive the information in it via virtual simulation technology. Nowadays, this technology has been applied in many industries. In this research, the design and application of virtual simulation was studies in relation to the game field. Because the key technology of the existing virtual simulation game is relatively simple, and the sense of picture and experience of the game is inadequate, this paper proposes a method whereby human-computer interaction and digital image processing technology are applied to the design of a virtual simulation tennis game. The effectiveness of the proposed method was tested via comparative experiments and a questionnaire survey. The results of the comparative experiment showed that among the four game-experienced players, Player A and Player B spent 47 minutes in the overall entry time in the virtual simulation tennis game with human-computer interaction and digital image processing technology. However, Player C and Player D spent 97 minutes in the overall entry time in the virtual simulation tennis game created with traditional technology. Overall, results indicate that the virtual simulation tennis game based on human-computer interaction and digital image processing technology is easier to operate, and is better able to capture and retain players' interest in the game and sense of participation. Therefore, the proposed approach can effectively enhance the game experience of virtual simulation tennis games, and improve the richness of the screen elements, giving players better visual enjoyment and game atmosphere.

Keywords: digital image processing technology, game design application, human-computer interaction, virtual reality, virtual simulation

1. INTRODUCTION

With the gradual improvement of social development, people's pace of life is accelerating, and an increasing number of people do not have enough time and energy to improve their physical wellbeing. At the same time, people's desire for fitness has skyrocketed. Although many want to exercise and improve their fitness, they are limited by their working hours and lack of sports facilities. Therefore, virtual simulation games have developed rapidly. There are many kinds of virtual simulation games, including a variety of fitness sports games. Among them, ball games are the focus of this paper, for which tennis was selected in order to design and explore a virtual simulation tennis game. It is found that there are some deficiencies in the sensitivity of and interest in the existing

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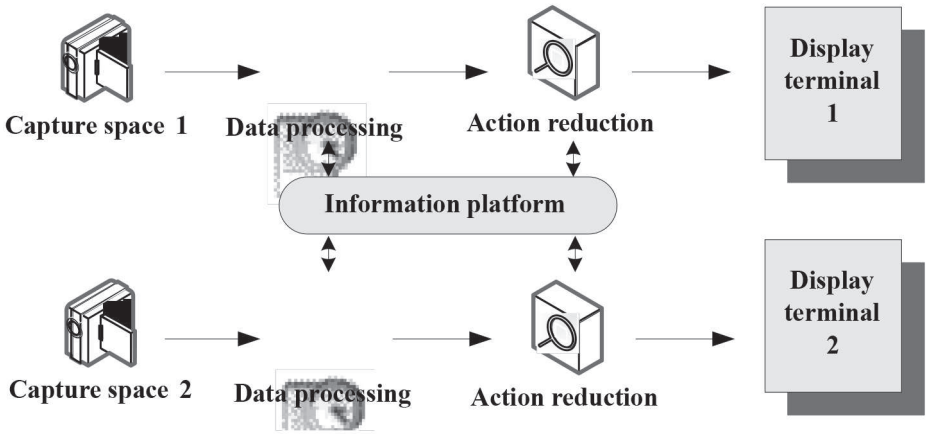

Figure 1 Game structure diagram.

virtual simulation tennis game, and the outcome of the game in terms of better fitness is not obvious. Therefore, this research study proposes the application of human-computer interaction and digital image processing technology in the design of a virtual simulation game. It was found that human-computer interaction and digital image processing technology can successfully deal with the technical shortcomings of a virtual simulation tennis game, and effectively enhance the entertainment aspect of the game. It is anticipated that this study will provide inspiration for the design of virtual simulation games by introducing human-computer interaction and digital image technology to make its technology better and more motivating, providing a reference for the continuous innovation of virtual simulation games.

As a new technology, virtual simulation technology has attracted many scholars. Keys developed a virtual simulation game as a pre-simulation preparation tool for students to learn cardiac resuscitation [1]. Tyerman said that, to date, there had been no pre-simulation preparation activity using virtual simulation games for clinical simulation [2]. Kardong-Edgren evaluated the usability of virtual reality game system for sterile catheterization practice [3]. Pallavicini said that virtual reality could provide innovative game experience for current and future game players [4]. With the continuous development of society and technology, virtual simulation technology has been applied in many fields. In particular, the rise of virtual simulation games has triggered a wave of virtual games. Previous research has not comprehensively explored the design technology of virtual simulation games, and their practical application still has several limitations.

As an example of virtual simulation technology, a virtual simulation game is of great significance to the widespread application of virtual simulation technology, so it has also attracted many scholars' research. Shafer said that variables that were important for enjoying console, mobile or action-based games were always important for enjoying virtual reality games [5]. Lam believed that virtual reality game simulation was not used enough by contemporary learners, although it provided learners with a different way to critically think and retain knowledge through a more pleasant learning experience [6]. Conti found that a simulation game could use the Internet as a transnational virtual space to develop cross-cultural capabilities, thus promoting cross-cultural dialogue [7]. Due to the limitation of existing virtual simulation game design technology, people's growing demand for game experience cannot be fully met. However, human-computer interaction technology and digital image processing technology can play a positive role in improving the game content of virtual simulation games.

In order to demonstrate the positive effect of human-computer interaction and digital image processing technology on the design of virtual simulation games, this current study carried out comparative experiments and conducted a questionnaire survey. According to the results of the questionnaire, 124 game players said that the virtual simulation tennis game became more interesting, and 119 game players thought that the virtual simulation tennis game with added technology made it easier to get started. Based on the role of According to the study participants, the virtual simulation tennis game has a stronger sense of picture and is more realistic thanks to digital image processing technology. Also, 128 people thought that the games were more conducive to fitness. The study results show that human-computer interaction and digital image processing technology can effectively improve the atmosphere and entertainment effect of the game so that players can experience the scene and enhance the sense of experience.

2. DESIGN OF VIRTUAL SIMULATION GAME

2.1 Design Content of Virtual Simulation Game

2.1.1 Game Structure Design

A feature of virtual simulation games is the simulation of real scenes. Therefore, in the game design, it is necessary to consider the relationship between the game site, scene, equipment and characters. Figure 1 shows the game structure of the virtual simulation game.

2.1.2 Game Mode Design

Four game modes are included in the design of the virtual simulation game: teaching mode, practice mode, single person mode and double person mode.

① Teaching mode

The teaching mode is the enrollment mode, which is launched for the zero-base players who have never experienced the virtual simulation game. Through this mode, players can understand the basic playing methods and operation of the game, as well as the basic knowledge of the game and the rules. For example, the experimental part of this paper uses virtual simulation tennis games for experimental analysis. Then, through the teaching mode, the zero-basis players can understand the basic movements of tennis, relevant skills, racket grip methods and selection of tennis rackets. For other types of virtual simulation games, there are also teaching modes to assist novice players to master how to play the game.

② Practice mode

The practice mode enables players to make game contact so that they become more proficient at playing the game. In this mode, the movement data and related scores generated by the players are not recorded; that is, the game scores in the practice mode do not affect the level of the game players. In addition, in the practice mode, there are specific training videos that show players how to improve their game skills. For example, in the virtual simulation tennis game of the test experiment, players can imitate the actions of the world's top players in the training video so as to improve their tennis skills.

③ Single person mode

The single player mode refers to the competition between the individual player and the antagonistic NPC (non-player character) in the game. By competing with the NPC, players can change their personal skill level. If they win, they can upgrade the relevant game equipment and get the corresponding level upgrade. If they lose, they are demoted.

④ Two-person mode

The two-person mode is also called the cooperation mode, which means that two game players cooperate with each other to compete against the NPC. The two-person mode requires game players to have higher game skills and better game mastery. Also, players need to be more immersed in the game and have a certain degree of tacit understanding and cooperation.

2.1.3 Game Character Design

For different users, game roles should meet the corresponding needs of players. This current study uses digital image processing technology to shape the characters in the game, and also provides the link of self-creation for the game. Game players can use digital image processing technology to design relevant game characters according to their personal preferences. Of course, if some players think that their own design requires too much effort, but want unique game characters, virtual simulation games can also meet their needs.

2.1.4 Game Scene Design

The essence of a virtual simulation game is virtual simulation. Therefore, the design requirements for the game scene and game atmosphere are extremely high. Because the game requires players to immerse themselves in the game, very realistic game scenes need to be designed. For example, in the virtual simulation tennis game, in order to create a realistic game atmosphere, the design of the game scenes, including tennis courts, tennis clubs, tennis training centers, comprises bothoutdoor and indoor scenes. It can also switch between animation scenes and real scenes according to the player's personal preferences.

2.2 Key Technologies of Virtual Simulation Game Design

2.2.1 Motion Tracking Technology

Motion tracking technology is included in the virtual simulation game because the motions of the player need to be tracked. The technology enables the tracking and analysis of the player's movement, the position, speed, distance of the player's movement, and so on. After that, the tracked player's motion data is quickly and accurately transferred from the tracking device to the computer system of the virtual simulation game for analysis and processing. After a series of data analyses and correction, the feedback and simulation of the game player's movement process are achieved.

2.2.2 Virtual Reality Technology

Virtual reality technology is a technical application of virtual simulation technology. Through virtual reality technology, game players can be in the game world created by virtual simulation games, and this world appears to be exactly the same as the real world. By simulating the game world formed by the real world and creating such a game environment, game players can have a sense of reality and enjoy a more vivid game experience. Especially for sports virtual simulation games, because sports require athletes to use five senses for motion perception, virtual reality technology can give full play to this feature.

2.2.3 Digital Image Processing Technology

The most important role of digital image processing technology in virtual simulation games is to improve the game quality. Since digital image processing can process images in three aspects, the use of digital image processing technology can effectively improve the visual sense of virtual simulation games and enhance the experience of game players. In addition, digital image processing technology can enhance the setting of scenes in virtual simulation games to make the scenes in games more similar to those in real life and strengthen the role of virtual reality technology.

2.2.4 Human-Computer Interaction Technology

Human-computer interaction, as the name implies, is the communication and interaction mechanism between people and computers. Human-computer interaction technology

has created a new means of communication between people and computers. Through human-computer interaction technology, the virtual simulation game is more user-friendly and intuitive. Motion tracking technology and virtual reality technology have laid a feasible foundation for human-computer interaction technology. Through human-computer interaction technology, players can achieve more complex actions in the game to obtain a sense of achievement.

In human-computer interaction technology, motion transformation in graphics is often used, including rotation transformation and translation transformation. In the virtual simulation game, the action transformation is actually a kind of rotation movement of the human body according to the individual's standard. In graphics, it can be understood that the human body is placed in the coordinate system, and the change of human body movement is actually the process of translation from one coordinate point to another through rotation. The process of moving from one point to another by rotation is called 'rotation change'. From a point to a fixed distance in a fixed direction, the position of such movement is translation transformation.

The formula expression for point $M_\alpha(x_{m1}, y_{m1}, z_{m1})$ is obtained after defining the point $M(x_m, y_m, z_m)$ to rotate α angle around the X axis:

$$[x_{m1} \quad y_{m1} \quad z_{m1} \quad 1] = [x \quad y \quad z \quad 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

The formula expression for point $M_\beta(x_{m2}, y_{m2}, z_{m2})$ is obtained after point M (x_m, y_m, z_m) is rotated about the Y axis for β angle:

$$[x_{m2} \quad y_{m2} \quad z_{m2} \quad 1] = [x \quad y \quad z \quad 1] \begin{bmatrix} \cos\beta & 0 & \sin\beta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\beta & 0 & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (2)$$

The formula expression for point $M_\gamma(x_{m3}, y_{m3}, z_{m3})$ is obtained by rotating point $M(x_m, y_m, z_m)$ around the Z axis for γ angles:

$$[x_{m3} \quad y_{m3} \quad z_{m3} \quad 1] = [x \quad y \quad z \quad 1] \begin{bmatrix} \cos\gamma & -\sin\gamma & 0 & 0 \\ \sin\gamma & \cos\gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (3)$$

The formula expression for the translation transformation of point $M(x_m, y_m, z_m)$ moving position in the direction of $N = [\alpha, \beta, \gamma, 0]$ is:

$$[x_{m4} \quad y_{m4} \quad z_{m4} \quad 1] = [x \quad y \quad z \quad 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \alpha & \beta & \gamma & 1 \end{bmatrix} \quad (4)$$

In the virtual simulation game designed in this paper, the key technologies are the four technologies described above and, in essence, the virtual reality technology can be considered as virtual simulation technology. Nowadays, virtual simulation technology is applied in many fields. For example, virtual simulation experiments have been widely used in the field of education and achieved good results [8]. Moreover, it is necessary for teacher candidates to prepare for the potentially challenging workplace reality by simulating the realistic school environment and practicing the difficult dialogue between cooperative teachers [9]. The use of virtual simulation to prepare for high-fidelity simulation can improve self-efficacy and let students participate in the simulation experience, so as to achieve a higher level of mastery through deliberate practice [10]. Future research should use more robust research design and give priority to the integration of virtual simulation courses to determine the best practice of virtual simulation methods [11]. Virtual simulation is also widely used in the medical field. In particular, computer-based virtual simulation nursing is a rapidly developing field [12]. Through virtual simulation combined with job reporting model, Chinese nursing students' clinical ability perception was significantly improved, indicating that virtual simulation can meet the learning needs of students [13]. Although the traditional clinical learning experience is still the "gold standard", the human body model and virtual simulation can adequately meet specific important learning needs [14]. In medicine, the clinical biochemical detection and disease diagnosis virtual simulation system has been established, and the liver biochemical detection virtual simulation experiment has been established [15]. From this perspective, virtual simulation becomes increasingly important [16–17].

3. COMPARATIVE EXPERIMENTS AND QUESTIONNAIRES ON VIRTUAL SIMULATION GAMES

3.1 Comparative Experiments on Virtual Simulation Games

In order to test the effect of human-computer interaction and digital image processing technology in the design of virtual simulation games, this paper selected four game players in order to conduct comparative experiments in the virtual simulation tennis game. These four players were all zero-experience players; that is, they did not understand tennis rules, could not play tennis, and had never played virtual simulation sports games. Therefore, the experimental results and game experience of the four players could more accurately indicate the design effect of the virtual simulation tennis game. In this paper, from the virtual simulation tennis game under the traditional technology and the introduction of human-computer interaction and digital image processing technology in the virtual simulation tennis game, the experimental analysis was carried out on: the game player's entry time, the score of the single game and the score of the double game cooperation. The control group comprised players who were playing a game designed by means of traditional technology.

Table 1 Basic information of game players.

Player code	Gender	Age (years)	Game experience	Game grouping
A	Male	18	No experience	Experimental group
B	Male	19	No experience	Experimental group
C	Male	18	No experience	Control group
D	Male	19	No experience	Control group

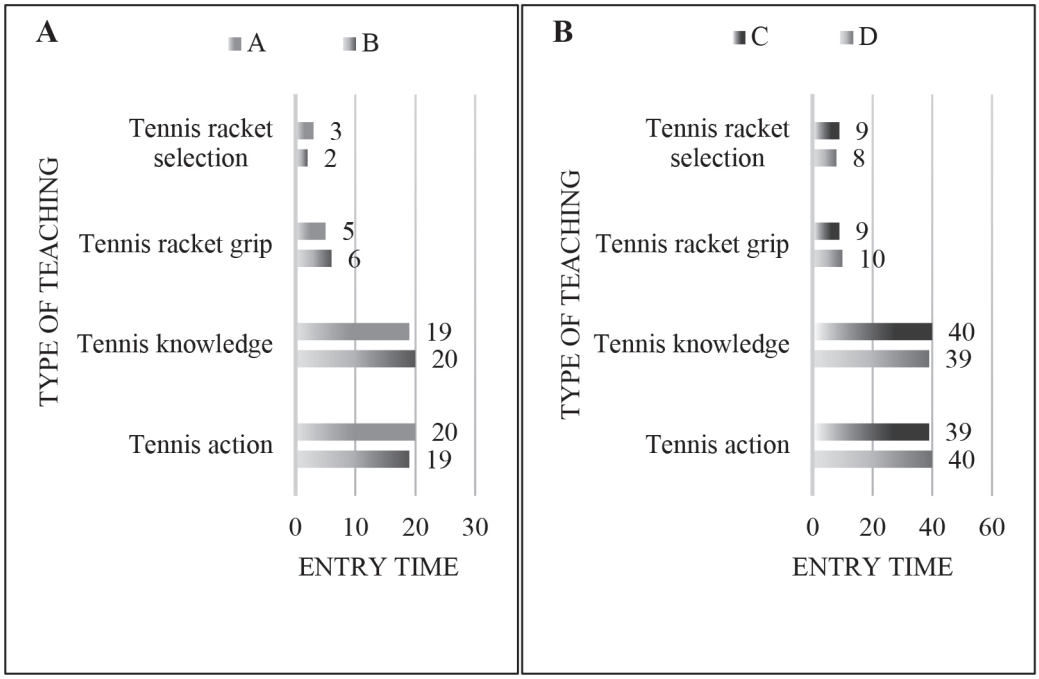

Figure 2 Comparison of entry time of game players. Figure 2A Entry time of game players in the experimental group Figure 2B: Entry time of game players in the control group.

Human-computer interaction and digital image processing technology are introduced into the virtual simulation tennis game played by the experimental group. Table 1 shows the gender and ages of the four game players.

3.1.1 Comparison of Game Entry Time

Since the four game players are all zero-experience players, the exploration of the game entry time of players in the virtual simulation tennis game can accurately Indicate the effect of human-computer interaction and digital image processing technology in the virtual simulation tennis game. It can be seen from Table 1 that Player A and Player B are in the experimental group participated in the virtual simulation of tennis game by introducing human-computer interaction and digital image processing technology, which is. Player C and Player D participated in the virtual simulation tennis game under the traditional technology, as the control group. In the design of virtual simulation tennis game, four zero-basis players can choose the teaching mode for game training. By learning the tennis player's actions, tennis related knowledge, tennis racket grip method and selection in the teaching mode video, the basic of tennis are mastered and understood. Figure 2 shows the comparison of the entry time of four game players.

Because of the differences in the ability of individuals to accept things, there are also some differences in the entry time of players in the same group. However, from the data in Figure 2, it can be seen that the entry time of game players in the experimental group i less than that of the control group. Player A spent 20 minutes in understanding the tennis movement, 19 minutes in mastering the basic knowledge of tennis, and 3 and 5 minutes in mastering the selection and grip of tennis racket. However, Player B spent 19 minutes in understanding the tennis movement, 20 minutes in mastering the basic knowledge of tennis, and 2 and 6 minutes in mastering the selection and grip of tennis racket. On the whole, Player A and Player B in the experimental group spent 47 minutes in the virtual simulation tennis game. On the other hand, in the virtual simulation tennis game under traditional technology, the overall entry time of Player C and Player D in the control group was 97 minutes, which was longer than that of the two players in the experimental group. When it came to mastering tennis movements and understanding tennis rules, Player C and Player D spent 39-40 minutes, nearly half the time required by Player A and Player B. It can be seen that the virtual simulation tennis game based on human-computer interaction and digital image processing technology is more conducive to mobilizing players' participation and immersive experience, and is easier to get started.

In the virtual simulation tennis game, in addition to teaching players how to get started, the game also helps players to carry out tennis training. The professional tennis players are set up as the opponent's single-player competition mode and

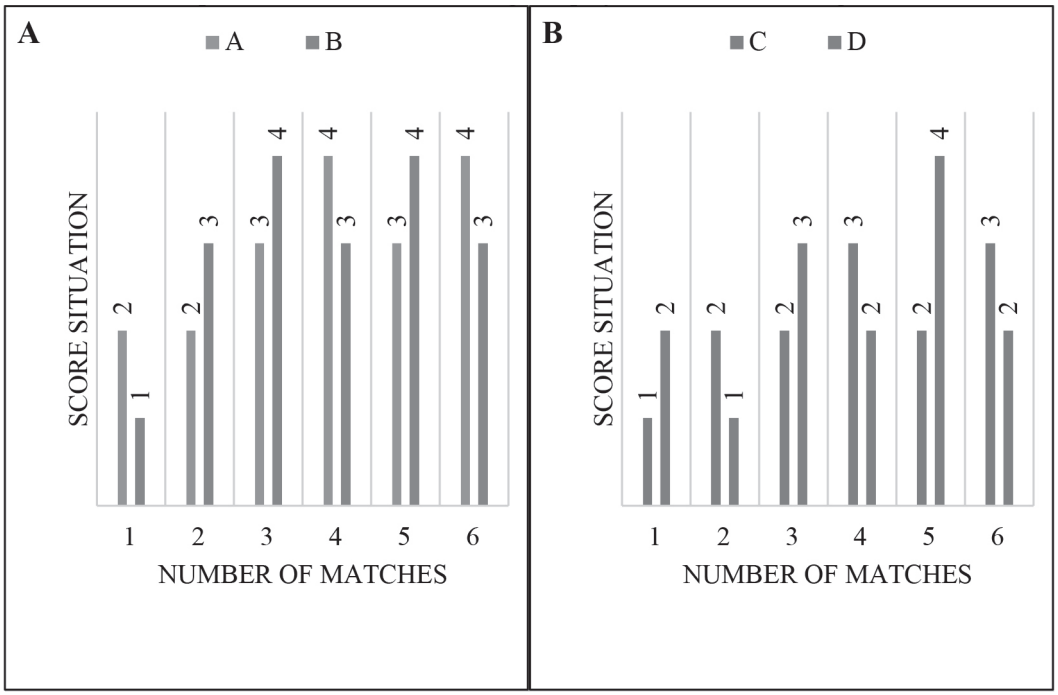

Figure 3 Comparison chart of scoring in single-player matches. Figure 3A: Scores of game players in the experimental group Figure 3B: Scores of game players in the control group.

the two-player competition mode in which two game players participate in cooperation at the same time, which is referred to as the 'two-player competition' mode. After four game players have mastered the basic skills of tennis, their scores in singles and doubles matches were recorded and compared.

3.1.2 Comparison of Scores in Singles

In this study, the scores of four game players in six singles matches were recorded. By comparing the individual scores of four game players, the role of human-computer interaction and digital image processing technology in virtual simulated tennis games was explored. In a tennis match, the maximum score is 4 points, and the winner is the one who is the first to score 4 points in each game. In the singles game, the players play against the adversary NPC (non-player character) in the virtual simulation tennis game.

Figure 3 shows the comparison of the scores of four game players in six individual games.

From the comparative data in Figure 3, it can be seen that the score of the single game of the experimental group is better than that of the control group. At first, the two groups of players were in a weak position in the confrontation with NPC, and both scored 1 or 2 points. This may be because the players are all beginners in regard to playing tennis. They have not entered the state of confrontation with NPC, and are not proficient in the game. When the third game started, Player B scored the full 4 points and defeated NPC. Player B obtained the highest possible score in the third and fifth games of the sixth game. Player A, like Player B, also scored four points twice in six games, in the fourth and sixth games. In the control group, only Player D scored 4 points in the fifth game. Player C's score was 2 or 3 points, and only 1 point was obtained in the first game. It can be seen that the adaptation of the players in the experimental group is better, indicating that human-computer interaction and digital image processing technology plays an obvious positive role in virtual simulation of tennis games. It can better mobilize the enthusiasm and participation of game players, and increase the game experience of players, making it easier for players to participate in the game.

3.1.3 Comparison of the Scores of the Two-Person Cooperation Match

In this study, the scores of six pairs of cooperative games of four game players were recorded. By comparing the cooperative scores of the two players in the experimental group and those of the two players in the control group, this study explored the role of human-computer interaction and digital image processing technology in a virtual simulation tennis game. In the conventional tennis doubles match, the scoring rule is generally the three-set two-win system, and one set contains six games. In the experiment conducted in this study, it is simplified to six games. The scoring method is the same as that for a singles game. The full score is 4 points, and the winner is the one who scores 4 points first in each game. Figure 4 shows the comparison of the scores of the two groups of experimental game players in the two-person cooperative game.

From the data comparison chart in Figure 4, it can be seen that the cooperation results of the two game players in the experimental group are better than those of the two game players in the control group. The two game players in the experimental group achieved a full score of 4 points in the second, fourth and sixth games respectively, while the number of times the two game players in the control group scored 4 points was 0. Overall, the cooperation effect of the game players in the experimental group is also better than that of the two game players in the control group. This is because the flexibility and game atmosphere of the virtual

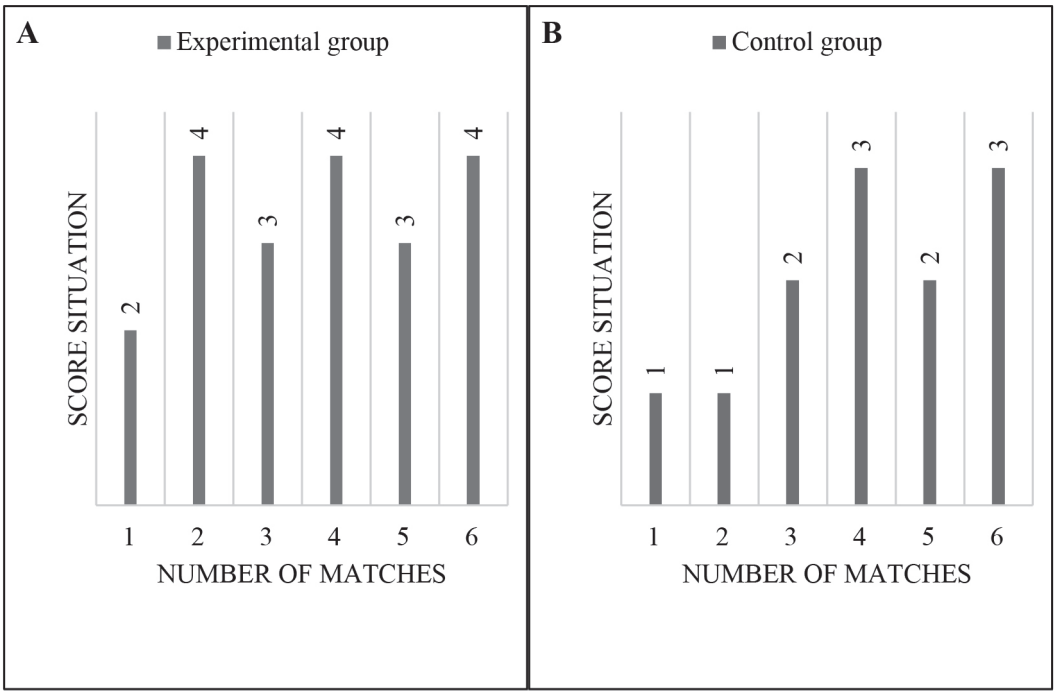

Figure 4 Comparison chart of the scoring situation of the two-player cooperative game. Figure 4A: Scores of game players in the experimental group Figure 4B: Scores of game players in the control group.

simulation tennis game based on traditional technology are not as good as those of the experimental group's game, so the cooperation scores of the game players in the control group are lower than those of the experimental group. This indicates that human-computer interaction and digital image processing technology can effectively improve the design of virtual simulation tennis game. The authenticity and agility of virtual simulation tennis games have been improved to make it easier for players to have an immersive experience of the game.

3.2 Questionnaire on Virtual Simulation Games

3.2.1 Questionnaire Reliability

In order to determine the impact of human-computer interaction and digital image processing technology on virtual simulation games, this study conducted a questionnaire survey of 130 game-experienced players. A total of 150 questionnaires were distributed and 130 were returned. There were no mistakes or omissions. Therefore, the final number of questionnaires included in the statistics was 130. The questionnaire results were analyzed by SPSS (Statistical Product and Service Solutions) software, and the Cronbach coefficient α was selected as the reliability coefficient. The reliability coefficient of the questionnaire was 0.8917, indicating that the reliability of the questionnaire was good.

3.2.2 Questionnaire Results

This questionnaire survey was conducted to obtain the opinions of game players after the introduction of human-computer interaction and digital image processing technology into virtual simulation tennis games. The results of the questionnaire are shown in Figure 5 (multiple choices are allowed).

According to the results of the questionnaire survey (Figure 5), 117 game players said that the virtual simulation tennis game after the introduction of human-computer interaction and digital image processing technology has become more flexible, and the game has a more sensitive response to character movements and a higher degree of restoration. One hundred and twenty-four game players said that the virtual simulation tennis game has become more interesting. Based on the role of digital image processing technology, the virtual simulation tennis game has a stronger sense of picture and greater authenticity. Therefore, 121 gamers said that the atmosphere of the game was more intense, and the sound effect and venue of the game were more authentic. There were 119 game players who thought that the virtual simulation tennis game with added technology made it easier to get started. Due to the improvement of technology, the game has increased the degree of control, and the game has become better to use. It is believed that 128 people have stated that virtual simulation tennis matches have become more conducive to fitness after introducing human-computer interaction and digital image processing technology.Through tennis sports and training in the game, the goal of fitness can be achieved for game players. Another 108 people proposed other functions, which are not discussed here. The results show that game players have a strong liking for this game after it has been enhanced by human-computer interaction and digital image processing technology. Game players are more satisfied with the performance of virtual simulated tennis games, and human-computer interaction and digital image processing technology play a positive and obvious role in promoting virtual simulated tennis games.

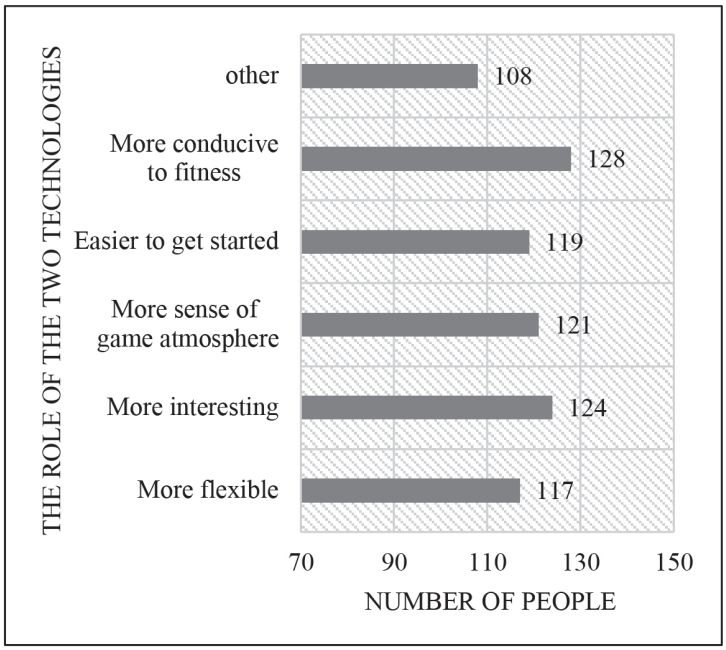

Figure 5 Questionnaire survey results.

4. CONCLUSIONS

The application of human-computer interaction and digital image processing technology in virtual simulation game design is of great significance. The experimental data indicates that the introduction of human-computer interaction and digital image processing technology into the design of virtual simulation games is an inevitable trend. The experimental results showed that human-computer interaction and digital image processing technology can effectively enhance the fun and entertainment of virtual simulation games, and offers players better fitness benefits and better game experience, as well as improving the game's graphics and atmosphere. The results of the questionnaire also indicate that human-computer interaction and digital image processing technology can significantly improve the design of virtual simulation games. However, although this study achieved several promising results, it still has several shortcomings. First of all, due to time constraints, the duration of this experiment was short, which may have led to some errors in the experimental results. Secondly, in regard to the experimental data, this study selected only the virtual simulation tennis game as the experimental research subject, and did not consider other virtual simulation games. The amount of experimental data was small and therefore not representative. Finally, virtual simulation technology is continuously being updated and improved to keep pace with the development of society. For virtual simulation games, there are still too many unknowns about their future development. In this paper, the research on virtual simulation games is only at the superficial level of the research on key technologies, and future research on virtual simulation games should be more comprehensive. In order to better understand the impact of human-computer interaction and digital image processing technology on the design of virtual simulation games, the analysis results could be further improved in subsequent research to address current problems.

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