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Design of an Immersive Virtual Reality Mental Relaxation Game based on Multi-sensory and Multi-dimension Interaction Theory

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Abstract: This paper first analyzes the way in which the interaction between the real world which made of atoms and the virtual world which made of bits takes place as a multi-sensory and multi-dimensional interaction， then proposes a theoretical architecture that realizes multi-sensory and multi-dimensional interaction in virtual reality by means of sensors-controllers(chips)-virtual worlds (computers).Then an immersive virtual reality game with a relaxation theme is designed by the author based on previously proposed theory, the interface design, scenario design, level design, and interactive element design are introduced.

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Keywords: Multi-sensory and Multi-dimensional interaction;menta relaxation; immersive virtual reality; game design`

1 Multi-sensory and multi-dimensional interaction

Feeling is the root of human understanding and connection with the world. The goal of virtual reality is to make people fully immersed in the virtual world, currently only in the visual and auditory requirements to meet part of the future should be in touch, smell, taste, kinesthetic and vestibular sense of sensation simulation of the real world. The traditional way people interact with the game world is limited to some kind of key controller (keyboard, mouse, joypad), the body in the game is static, and the feedback consists only of visual and auditory information. Famous game designer Chris Crawford believes that "interactivity is what sells computer games" [1]. In the ideal immersive virtual reality environment, the player's body is dynamic and can interact with the virtual environment, and the interaction in the game is a natural physical interaction and not only visual and auditory but also touch, smell, taste and other senses.

In the real world, people and the world have multi-sensory and multi-dimensional interaction. Multi-sensory means that we receive information from the real world through our senses of sight, touch, hearing, smell, taste, etc. Multi-sensory means that the real world feeds back to us in various ways, and we also react to and get feedback from the real world in various ways. At present, the interaction between people and the virtual world is mostly limited to vision and hearing. The computer that provides the information of the virtual world is only the sender of the information, and the person is the receiver, and the device such as mouse and keyboard is used to interact with it indirectly. In order to obtain the best Presence, allowing the player to fully immerse in the virtual world, it should also increase the output of touch, taste and smell to achieve multiple senses. In addition to the traditional ways of mouse and keyboard, people can also interact with the virtual world in a natural way. We can have a dialogue with the virtual world and interact with it in natural ways such as eyes, gestures, posture, and voice. Even the information that anyone can convey can be understood by the computer. This is the multi-sensory and multi-dimensional interaction between people and the virtual world. To communicate with the virtual world, human beings must realize the communication between atoms and bits. The real world in which human beings exist is composed of atoms, and human behaviors belong to analog signals. The virtual world generated by computers (including various computing devices that process digital signals) is composed of bits, and what computers understand is digital signals. To let the computer understand people, interact with people and increase the interaction mode and fun, one way is to convert the analog signal generated by human behavior into the digital signal understood by the computer through various sensors, and conversely, the computer can also restore the digital signal to the analog signal through the sensor to make people feel, as shown in Figure 1.

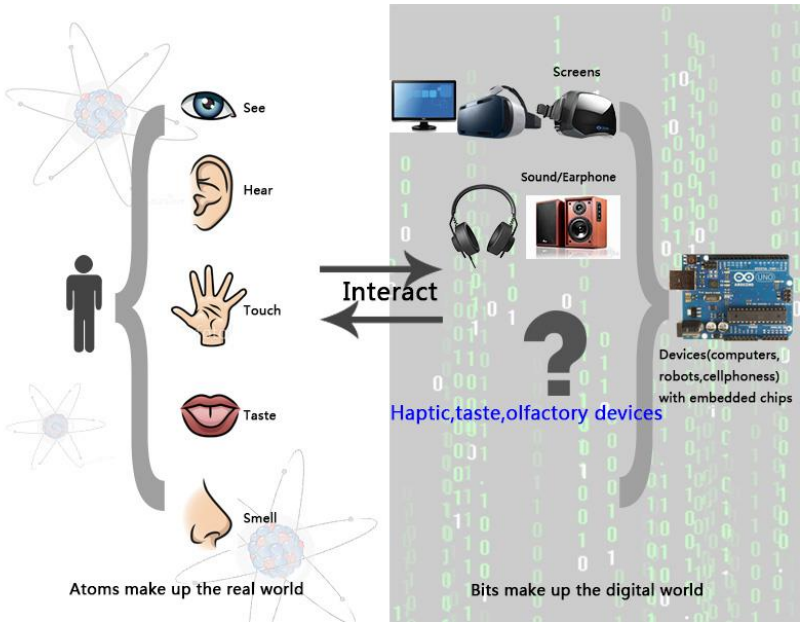

Fig. 1 Multi-sensory and multi-dimensional interaction between people and the virtual world

Based on the analysis of each sense, this paper proposes a way of sensor-controller (chip) -virtual world (computer) to realize multi-sensory and multi-dimensional interaction of people in virtual reality. Sensors, controllers and virtual world are all two-way interoperable and can carry out two-way communication, as shown in Figure 2. The sensor senses the analog signal of the human body and converts it into digital signal, and interacts with the virtual world generated by the computer through the controller composed of various integrated circuit chips, such as the Arduino microcontroller. Instead, the virtual world outputs digital signals that are converted by a controller into analog signals that are perceived by humans. For example, in the design of this study, human heart rate will be used as input, and the single chip microcomputer will be connected through the heart rate sensor. The single chip microcomputer will convert the analog signal into digital signal, connect the virtual world in the computer, and change the visual, auditory and other elements in the virtual world. At the same time, the computer can also convert digital signals into analog signals and output other senses such as touch, taste, smell, etc. In this study, a fan module will be used to output tactile experience.

The current dominant game model is the player as the receiver, passively receiving visual and auditory information. In some innovative games, the game world outputs not only visual and auditory information, but also touch, taste, smell, and even other feedback to the player. The multi-sensory and multi-dimensional interaction is two-way, and the player can also output a variety of senses to the game world as an output party. In addition to the traditional keyboard and mouse, the player's voice, gestures, posture, physiological information and other analog signals are converted into digital signals through the sensor-controller (chip) -virtual world (computer) to be understood by the computer and interact with the virtual world. Similarly, in the future, players will be able to interact with the game world in ways that touch, taste, smell, and even other unexplored ways, as shown in Figure 3. The multi-sensory and multi-dimensional interactive virtual reality environment composed of sensor-controller (chip) and virtual world (computer) will have better immersive effect than the virtual reality where computer only acts as visual and auditory output. This study will combine the sensor-controller (chip) -virtual world (computer) multi-sensory multi-dimensional interaction concept to design a virtual reality psychological relaxation game, which will be detailed below.

Fig. 2 People and the virtual world realize multi-sensory and multi-dimensional interaction through the way of sensor-controller (chip) -virtual world (computer)

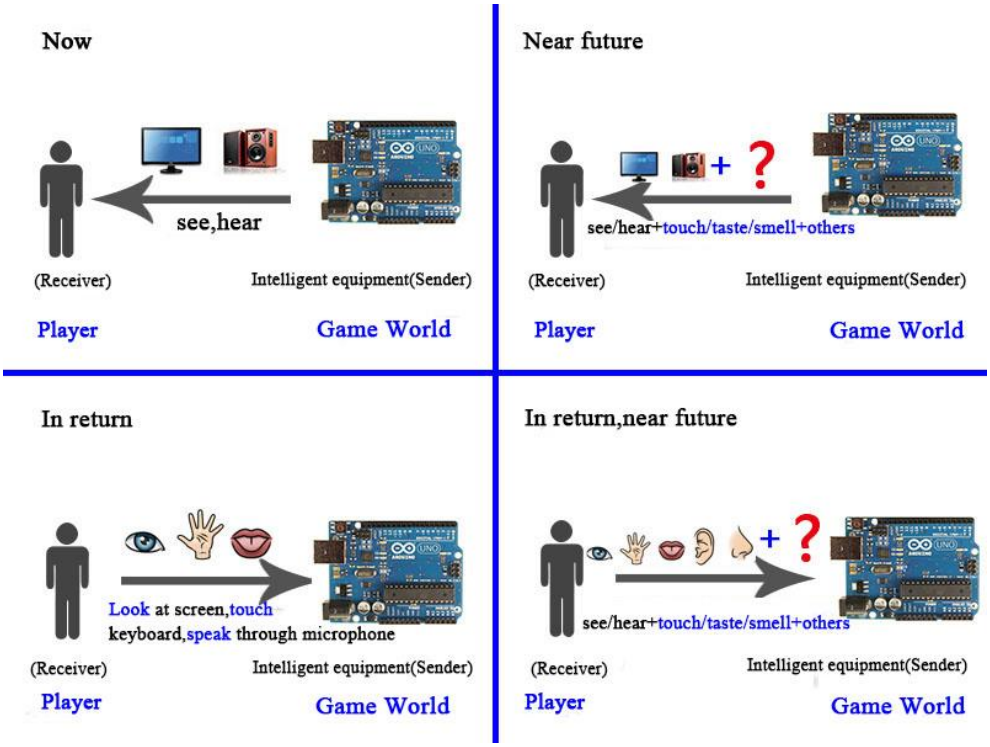

Fig. 3 Multi-sensory and multi-dimensional interaction of sensor-controller-virtual world

2. Immersive virtual reality psychological relaxation game design content

This design combines the concept of multi-sensory and multi-dimensional interaction proposed and refers to the basis of virtual reality games' effect on psychological relaxation. Under the guidance of virtual reality relaxation method, Unity3D game engine, 3DMax modeling software, Photoshop image editing software, helmet display, Arduino microcontroller, and Arduino microcontroller are used. A combination of software and hardware, including biosensors, has created a virtual reality game that acts on psychological relaxation. The game adopts the first-person perspective, including the scene composed of three natural environments. The game operation mode is that the player sits in front of the computer and puts on the virtual reality headset and headset, uses the mouse, keyboard, joypad and his own heart rate as the game input, and the game output includes vision, hearing and touch.

2.1 Game Overview

This design is a virtual reality game using the helmet display, named "Relaxation Tour". The goal of the game is to alleviate the anxiety of ordinary people with sub-health conditions and obtain psychological relaxation. The game takes a first-person perspective, players wear a helmet and sensors, using a mouse, keyboard or gamepad to play the game. There are several text and voice instructions in the game, and the player can relax according to the instructions. Players can freely choose their own relaxation scene between the three relaxation scenes of "Spring", "Summer" and "Autumn", and experience a variety of relaxation methods, including music relaxation, progressive muscle relaxation, biofeedback relaxation, breathing relaxation, etc. Players can roam, listen to music, sit on a chair or sofa, row and other behaviors in the game. In the game, there is no clear outcome of victory or defeat, as long as the player thinks he has obtained a certain degree of relaxation even if the purpose of this design is achieved. At present, virtual reality games are still in the exploration stage, and there is no recognized standard. Through searching a large number of existing materials and literatures, reading books, browsing the web, trying out VR experiences, and combining the capabilities and limitations of existing devices, the following points are summarized:

(1) Virtual reality has a 360-degree open horizon, players can observe everything up close, so every item in the game is best to be true, with rich details, so as to maintain immersion.

(2) The screen delay should be as small as possible, the number of Frames Per Second is not less than 60 times, and the time difference from the head to the new screen display should be less than 20 milliseconds;

(3) The design should consider the comfortable Angle

range of the head rotation, which is 30 degrees on the left and right, 20 degrees on the top, and 12 degrees on the bottom.
(4) Camera movement and head movement should be conservative consistent, head tracking and screen changes should be consistent, to ensure that the player can always observe the surrounding situation in the game.
(5) The walking speed of people is 1.4 meters per second, and the speed in the game is as consistent as possible with the real world. In order to avoid virtual reality motion sickness, try to use a similar speed in the game, and try not to use acceleration, maintain uniform movement, smooth forward movement is the most comfortable movement, it is best not to appear up and down bumpy movement.
(6) Input, because the user wears a helmet, the vision is completely isolated from the outside world, the keyboard that needs to look to determine the position of each key is not the best input device, the handle that can be used when the user does not look is the current compromise choice, and the current operation can only rely on the head. Virtual reality input devices should develop in the direction of natural interaction, and should fully play the movement ability of our bodies.
(7) In terms of size, first-person virtual reality games should be consistent with the real world, where we measure the size of objects and environments with our bodies, and the same is true in the virtual reality world. Our real height should be similar to the height in the game, and the objects in the game should be proportional, unless of course your game world is deliberately designed to be different from reality.

2.2 Game interface design

There are no boundaries in virtual reality, people are in a virtual space, and there is no screen in the traditional sense of the virtual world. The traditional game interface is directly overlaid on the screen, and the two-dimensional plane superimposed on the game world is no longer suitable for virtual reality, and the user interface of virtual reality must be redesigned. In Unity3D, the interface can be presented in the game world. All interface elements in Unity3D are in Canvas component. Select Canvas rendering mode as world space and adjust the size and direction of the canvas. In the game, you can see the interface in the game world rather than the traditional two-dimensional interface superimposed on the game world. Similarly, there is currently no recognized authoritative specification for virtual reality interfaces, but by looking at a lot of existing materials, browsing the web, books, and trying out VR experiences, there are the following interface design points:
(1) Limited by the current input, a gazeta-based interaction can be used, that is, by turning the head to change the direction of the line of sight, and using the cursor in the center of the line of sight to interact with the interface.
(2) The most comfortable interface distance should be 0.5 to 3 meters in front of the eye.
(3) Do not let the user turn to see the interface, the interface is best located in the center of the line of sight.
(4) To maintain immersion. It's better to have a level of integration between the interface and the virtual world, rather than popping out in front of the player. For example, the interface is displayed on the helmet or mask in the game, or the dashboard in the simulated vehicle, etc. The game interface in Figure 3-3 is a piece of paper in a suitcase, and the player can play with this three-dimensional entity.

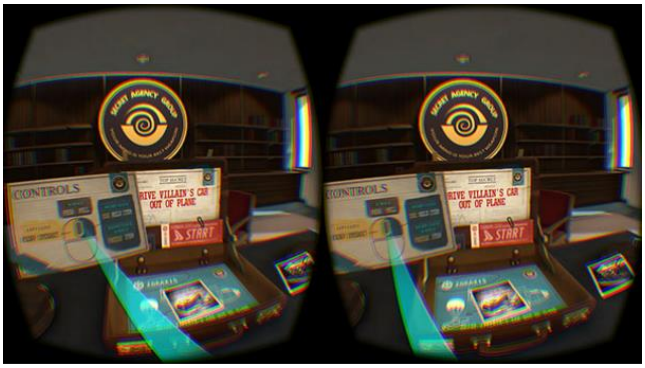

Fig. 4 Jesse Schell's VR game, I Expect You to Die, fully integrates the interface into the game world

The interface should satisfy the principle of serving immersion, especially in virtual reality. The main menu interface of the game is a separate scene with three doors and game instructions display cards. Each door and display board has spotlights shining down from above, and the rest is in darkness without light. When the player enters the game, through the guidance of light to attract the player's attention while maintaining the sense of immersion, the player first noticed the instructions on the front display board, and then the three doors under the spotlight, each door represents a game level, or scene, a total of "Spring", "summer" and "Autumn" three scenes, when the player enters the main menu, approaching the corresponding door, When the player is far away from the door frame, the picture will disappear, and when the player is close to the door frame, the picture will appear again, indicating that the scene can be activated, and the player can enter the corresponding scene through the door frame, as shown in Figure 3-4. Immersion is better served by using the natural interaction of crossing thresholds rather than clicking and selecting.
In the "Summer" scene, players get on a boat, take a boat tour in a lake covered with lotus flowers and reeds and collect Kongming lanterns. The interface that indicates

the number of Kongming lanterns collected by the player and the real-time heart rate index of the player is directly displayed in

The player sits on a ship that blends with the environment. In the game, the player sits on a boat, and the hollow Kongming lamp on the front divider displays numbers to represent the amount the player has collected, and the player's heart rate is displayed in real time.

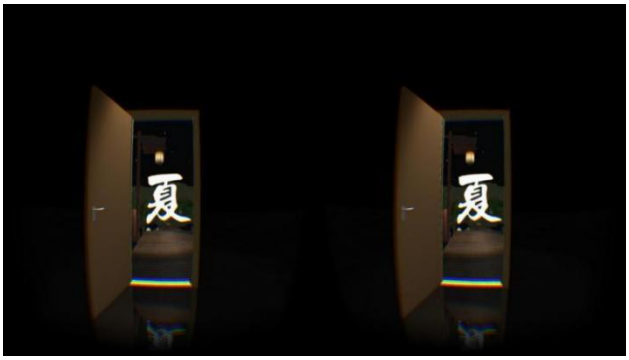

Fig. 5 The scene picture is automatically displayed when the player approaches the door

The interface should satisfy the principle of not distracting, should not attract too much attention from the player, the interface should serve the content of the game. The interface in the game should not interfere with the game experience. In order to create the best sense of immersion, this design uses a responsive interface controlled by the player's head posture. The interface will appear when the player looks down at the ground in the game, and the interface will disappear when the player raises his head. The interface is simple and clear without any text. There are three ICONS representing restarting, returning to the main page menu and entering the next scene respectively. When the player lowers his head and focuses his eyes on the icon, a circled cursor will appear and stay on the icon, and the color of the icon will change in response, as shown in Figure 3-5.

Fig. 6 Responsive interface in a game

2.3 Game scene design and level design

The game consists of different scenes, and the different Settings in the scene determine the playability of the level. Levels construct the space and environment of the game. Levels are inseparable from the scene. Levels include not only the scene, but also the game objectives, plot, various objects in the game, enemies, etc. The purpose of level design is to grasp the rhythm of the player in the game, maximize the playability of the game, and create the best game experience.

The design includes a main menu and three main natural relaxation scenes, which can be switched between scenes. From the main menu, you can select one of three scenes to enter the game, and in each scene, you can also directly switch to the next scene or return to the menu. The three seasons of spring, summer and autumn are respectively used to show three scenes, three scenes are three levels. Unlike traditional players who win the previous level to move to the next level, in this design, players can freely choose a level to play. The game uses a first-person perspective, there are two modes of operation, players can choose the traditional "WSAD" keyboard mode or joystick to walk left and right, in order to prevent motion sickness, you can also press the number keys on the keyboard to instantly move to various relaxation locations.

In the scene of Spring, the player comes to an island, the player travels along the SLATE road around the island, the player can rest on the swing, listen to music on the sofa under the tree, play the guitar, visit the cabin, lie under the tree to watch the flowers fall and so on. In the game, players are guided to roam and experience various relaxation methods, such as music relaxation, progressive muscle relaxation, biofeedback relaxation, breathing relaxation, and imaginary relaxation. The relaxation locations and scenes in the game are shown in Figure 7. Among them, music relaxation adopts the method of music synchronization in receptive music therapy and new century music. On the one hand, the music selected in this design is Western classical music with an excessive rhythm from cheerful and positive to gentle, quiet and slow. Because these music have no cognitive differences in lyrics, they are widely spread and have the same effect on people with different cultural backgrounds. Gao Tian, professor of music therapy at the Central Conservatory of Music, believes that the most suitable music for relaxation is "New Age" music [2], which does not have the structure of traditional music and obviously repeated melody and rhythm, but feels relaxed after listening to it, creating a feeling of being in nature and inner peace. The mind and body develop a sense of openness. This type of music has a simple structure, repeated melody, and often adds the sound of nature, which is easy to be accepted by the public. Music synchronization method selected Beethoven's "Spring Sonata", Beethoven's "Pastoral

Symphony", Schubert's "Serenade", Debussy's "Moonsong" and Massenet's "Meditative" five classical songs played in turn. the New Century music selected five works by The famous New Century music composer Llewellyn (Llewellyn) : Across the Field, Reiki Gold, The Prophecy, White Light and Yellow Kanji. His works are therapeutic and relaxing. In the game, players can control the music player in the game to switch music. The specific method of biofeedback relaxation drives changes in game sound and visuals for the player's heart rate. In the biofeedback relaxation location, the player lies under a tree to calm his mind, and when the heart rate drops below a certain range, the tree drops petals and is accompanied by music. Breathing relaxation and imaginary relaxation are both ways for the player to sit on a chair or swing and listen to the relaxation instructions. The player can also listen to the instructions while roaming and can end the instructions at any time. Among them, the relaxation guidance language selected by imagining relaxation is the audio data attachment in the book Introduction to Music Therapy written by Gao Tian, associate professor of music therapy at the Central Conservatory of Music. Progressive muscle relaxation allows the player to travel to another time and space, where a full-body glowing human figure appears in front of the all-black scene, and the player listens to the instructions and relaxes various parts of the body according to the figure. Players can quit the relaxation exercise at any time in the game to continue the tour, the goal of this level is to let the player experience a variety of relaxation methods to get physical and mental pleasure, peace of mind. There is no specific quantifiable goal to be achieved, and there is no penalty for the player.

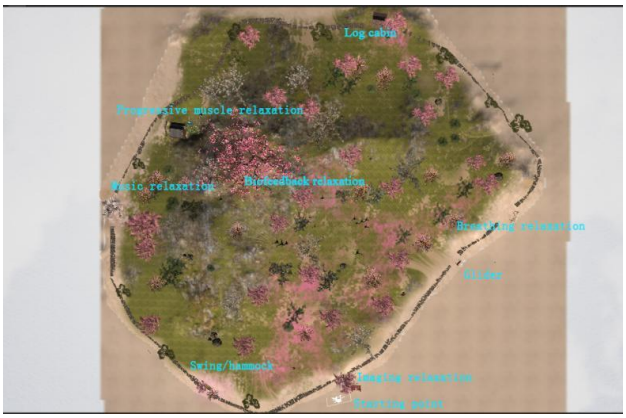

Fig. 7 Top view of the scene of Spring

"Summer" This scene is set in the summer night of the lake, players take a boat tour in the lake and collect floating sky lanterns. The lake has lotus flowers, reeds and other vegetation for players to watch, players use the keyboard or handle to control the boat movement. Using a biofeedback relaxation method, the player's heart rate is used to interact with the game world and get haptic feedback. Real-time feedback of players' heart rate In the game world, players calm down their mood, when the heart rate drops to the range of relaxing heart rate, connect the Arduino fan module for tactile output, players can feel a breeze while sitting on the boat, which deepens the game's presence experience. The level has a bonus designed to release fireworks when all ten Kongming lanterns have been collected.

Autumn is similar to Spring in that it uses paths to guide the player through the game. The autumn scene is covered with maple trees that are falling leaves. Following the road signs, players can experience a variety of relaxation methods, such as music relaxation, biofeedback relaxation, self-generated relaxation, imaginary relaxation and breathing relaxation. The top view of the scene is shown in Figure 8. Players can also simply walk along the path and experience the beauty of nature. The various relaxation methods in this scene are similar to those in Spring, and will not be introduced one by one. Biofeedback relaxation allows the player's heart rate to interact with the game world, the player's heart rate changes the game world and feeds back to the player's sense of touch. When players come to the hut in the game, calm down and control their heart rate, the fans in the hut start to rotate, while the fans in the real world also start to rotate. Combined with the multi-sensory and multi-dimensional interaction theory, the visual and tactile experience in the game is consistent, deepening the player's presence experience and consolidating the relaxation effect.

Fig. 8 Top view of the scene of Autumn

2.4 Game interactive element design

In addition to the traditional way of interacting with the game world through keyboard and mouse input, this game uses the physiological information of human heart rate to interact with the game. The heart rate is a physiological index closely related to people's relaxed state. Heart rate can be controlled in the game visual,

auditory elements can be changed, and can even bring a tactile experience to the player.

The traditional interaction is mouse and keyboard key clicks to change the game. In this game, players can walk through the gamepad or mouse, click to play music, switch the next song and other operations, space or gamepad keys to jump. Taking into account the effects of virtual reality motion sickness, the game has also added the method of instantaneous transfer by pressing a number key to directly reach various relaxation experience locations. The position of the head in the game is used to replace the mouse for selection operations in the game. When an arrow prompts interaction in the game, a circle cursor will appear when the player's line of sight is aligned with the arrow to assist the player in positioning, and the arrow will turn red as a response, as shown in Figure 9. Combined with the viewpoint of embodied cognition, it emphasizes the importance of the body in the game, and the body and its environment affect our cognition of the game. By using natural interaction and responsive interaction, the menu is displayed when the player lowers his head, while the menu disappears when the player raises his head and continues to visit. In the Start menu, instead of the traditional abstract method of mouse click, the player walks directly through the door to enter the corresponding scene, which is consistent with our behavior in the real world, a door serves as a metaphor for a scene/level, and passing through the door represents entering another space, which is similar to our behavior in real life.

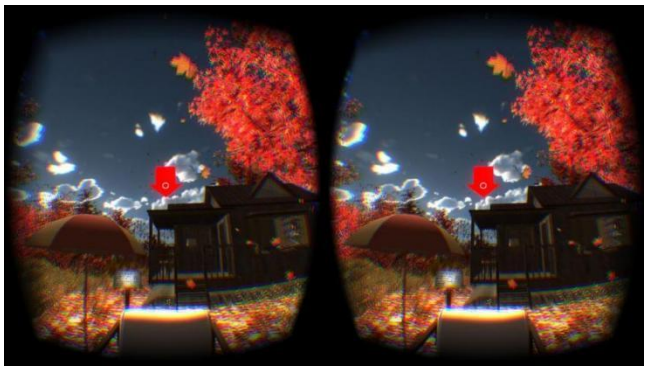

Fig. 9 Line-of-sight based head manipulation

Biofeedback relaxation based on the player's physiological information interacts differently in these three scenarios. In the Spring scenario, the heart rate changes the visual and auditory information of the game, the player lies under a tree, the heart rate calms down, the petals float down, accompanied by music, as shown in Figure 10. In the Summer scenario, the changes in heart rate bring haptic feedback to match the situation of the player sitting on the boat, and the rotation of the fan brings a breeze, which is the same as the feeling of a person on the boat. In Autumn's scenario, heart rate changes vision and touch, triggering animations of fans spinning in the game, while fans spinning in the real world bring about a tactile experience, as shown in Figure 11.

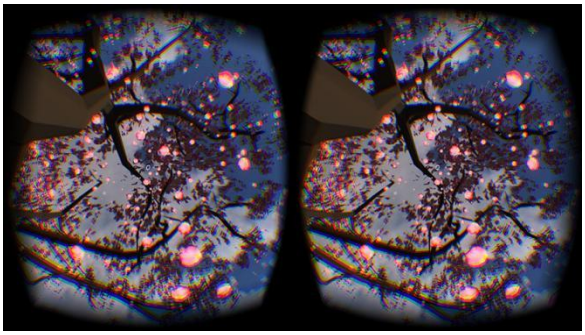

Fig. 10 Biofeedback in the Spring scene relaxes

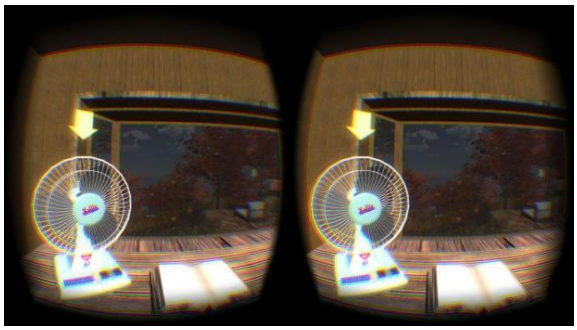

Fig. 11 Biofeedback relaxation in the Autumn scene

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[2] Gao Tian. Receptive Music Therapy [M]. China Light Industry Press, 2011:23.

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