Study on Application of Virtual Reality in Eye Disease Prevention

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Abstract. Virtual reality with computer technologies as the core and in combination with related sciences can generate a digital environment highly approximate to the real environment in aspects of visual sense, auditory sense and touch sense, etc., and characterized by high immersion and interactivity. It has been widely used in the medical field, but rarely used in disease prevention, especially in science popularization and prevention of eye diseases. This paper focuses on the study on the application of VR in eye disease prevention and presents a mobile phone App. It utilizes virtual reality as the presentation form, augmented reality as the connection tool, Unity3D as the development engine, and Oculus as the device carrier for further display and experience. It uses shader to add special effects for the camera lens in its simulation of eye disease's symptoms, which allows common people to experience the world seen by the patient of eye disease through the mobile phone camera, understand their inconveniences in daily life, and thus offer them more respects through understanding. At the same time, it can allow people to know the hazards of these diseases, and pay more attention to eye health, thus reaching the result of eye disease prevention.

1. Introduction
The virtual reality technology can simulate and generate a 3D virtual world with the computer, offer the user simulations of visual sense, auditory sense, and touch sense, etc., and allow the user to make observations in a 3D space like in a real world. Its three main characteristics are its immersion, interactivity and conceivability. Among them, the conceivability means that the virtual reality technology possesses a vast conceivable space and can expand people's perception scope; it not only can reproduce the real environment, but also can conceive an environment not existing objectively and even not possible. Therefore, the virtual scene simulated through VR technology can be that well-known to people and achievable through tools, and also can be that hard and even unable to be felt by people.

The virtual reality system is usually divided into four categories: ordinary PC platform based desktop system; the immersive system that utilizes head-mounted display to seal the visual sense, auditory sense and other senses of the user and put the user in a virtual environment; the distributive virtual reality system that allows multiple users to observe and operate the same virtual world through the network to fulfil coordinated work; and the augmented virtual reality system that allows the superposition of non-existent and even impossible environment to the simulated world.

The augmented reality technology is a new technology developed on the basis of virtual reality, and used to augment the user's perception of the real world through the information provided by the
computer system; it can superimpose the virtual object, scene or system generated by the computer to the real scene, thus realizing the "augmentation" of reality.

The most remarkable difference between augmented reality and virtual reality lies their different requirements for immersion. The virtual reality system emphasizes the complete immersion of users in a virtual environment in aspects of visual sense, auditory sense and touch sense, etc., and the insolation of user's senses from the real world and immersion in an information space controlled by the computer. That is to say, the virtual reality simulates a virtual world which does not exist in reality and only tries to make your feelings real (mainly referring to sensory feelings). On the contrary, the augmented reality does not isolate the surrounding real environment; moreover, it is devoted to integrating the virtual environment generated by the computer with the real environment, thus augmenting user's understanding of the real environment.

"The eyes are the windows of the heart." The visual sense is a principle way for people to feel the outside world. Abnormal eyesight can incur great inconveniences in people's daily life; however, people with normal eyesight can neither feel the views of those with abnormal eyesight nor their pains and inconveniences. This paper studies the simulation of eye diseases through virtual reality technologies and adding filters to the common mobile phone camera to create a "real" world seen by the patients of eye diseases and build a "bridge" between patients of eye diseases and healthy people. Through experience, the user can better understand and show more respect patients of eye diseases, and get aware of the importance of eye disease prevention [1].

2. VR application in the medical field
The application of VR in the medical area is of great practical significance. This technology has been widely used in surgical medicine, sports medicine, rehabilitation medicine, ergonomics, traumatology and preventive medicine, etc.

The virtual reality system can effectively treat soldiers' posttraumatic stress disorders. During the treatment, VR equipment will bring the soldiers back to the battlefield, and make them "experience" war and death again, and gradually learn to control their emotions under proper pressure. In traditional therapies, soldiers might feel ashamed to expose their inner heart to the therapist due to their performance on the battlefield, while the application of virtual scenes can reduce the soldier's sense of "shame", and allow the soldier to avoid confiding to any people and accept the treatment without scruples. The application of the virtual reality in the treatment of posttraumatic stress disorder can effectively reduce harms possible in traditional treatment and improve the treatment efficiency.

The virtual reality system can eliminate the phantom pain of an amputee. The most common annoyance troubling an amputee is the phantom limb pain, namely the amputee can still have itch, pain, cold, warm and torsion feelings, etc. about their non-existent limb; so far, there is no therapy thereof applicable to all amputees. During the treatment with virtual reality technologies, a researcher uses a headphone and a sensor to bring the patient into a virtual world, and the patient can still feel his/her amputated limb and control his/her virtual limb to engage in some work or game. At present, researchers are planning to test this system among more amputees.

VR can be applied in medical education and virtual surgeries. Some virtual reality system applied for medical training, practice and research feature a high degree of simulation. The virtual environment built with a virtual human body model allows student to easily learn organ structures within the human body with the help of tracking ball, HMD and feeling gloves, and carry out autopsy and various surgical practices, a way more effective than the existing textbook way. The virtual surgery training system can effectively improve students' surgery level and operating skills. For example, the eye surgical simulator can create 3D images based on the structure of the human eye and is equipped with real time tactile feedback; students can use it to observe and simulate the whole process of crystalline lens removal, and observe the blood vessel, iris and sclera tissues in the anterior structure of the eye and the transparency of cornea, etc. Before the actual implementation of the surgery, the surgeon can repeatedly simulate it on the display with the help of virtual reality technologies to find the best surgery solution and improve proficiency [2]-[3].
VR technologies can be applied in the eye health examination. There are 285 million people worldwide suffering from eyesight problems; among them, 39 million being blind, with 80% of them possible to avoid blindness. The application Peek can make use of smart phone and portable ophthalmic examination devices to conduct eye health examinations on people in underdeveloped areas without any professional ophthalmologists. The examination device Peek Retina is buckled on the smart phone camera; this combination can easily capture the internal structure of the eyes and acquire clear retina images. At present, the technology can help diagnose cataracts, glaucoma, and other eye diseases. Peek supports to transmit the retina images captured back to the eye hospital for analysis and diagnosis. The appearance of this product has in some degree alleviated the circumstances of illness deterioration resulted from restrictions, and late examinations. Moreover, it is easy to use; users, even not a professional doctor, can easily master it after simple training and learning; it can also reserve the diagnostic results and data for the patient, and thus help doctors understand the patient's pathogenic and medical history [4]-[5].

VR has been widely used in the medical field, but rarely used in disease prevention, especially in science popularization and prevention of eye diseases.

3. Study on the application of VR in eye disease prevention apps

Eye diseases mainly include near-sightedness, glaucoma, central serous chorioretinopathy, cataract, and color blindness, etc. The latter four diseases with high prevalence rates can incur serious consequences, and change obviously the visual effects. Patients with glaucoma can only see the centre position of the vision field and lose their peripheral vision field. Patients with cataract have a blurred vision, and in their vision field, all objects are seemingly covered by a film and the colors lose their vividness. Patients with central serous chorioretinopathy see deformed and diminished objects with a reduced contrast. Bright colors are seen as total grey by patients of achromatopsia, with difference only in grey level and without color difference. Therefore, to make users have a deeper sensory experience, the 4 eye diseases are selected as the design content in this paper and the design work is named as Different Worlds. It is an immersive, augmented virtual reality application system.

3.1. Selection of VR equipment

VT helmet is a kind of 3D visual display device, the display principle of which is that the left and right screens respectively display images for the left and right eyes, and stereoscopic impression can be incurred when human eyes receive such differentiated information. It features small size and high degree of closure, and can be widely used in military training, virtual driving, virtual city, and other projects [6].

Oculus Rift is a kind of head-mounted display originally designed for video games which is shown in Figure 1. It connects virtual realities to games, allowing the players to be immersive and greatly improving the immersion sense to the game. At present, it has been used in a wider range of fields, including sightseeing, film, medicine, architecture, space exploration and battlefields.

Figure 1. Oculus Rift

Figure 2. Cardboard
Cardboard shown in Figure 2 is a kind of inexpensive 3D glasses created by engineers under Google's "20% time" rule. A VR device can be formed with the combination of the glasses and a smart phone. It enables each person to experience VR technologies in simple, interesting and inexpensive manners.

In comparison, the former one features a higher immersion sense and better effects in experience, and the latter is cheaper. Therefore, the device finally selected in the work is Oculus Rift.

3.2. Design of lens effects
The work mainly comprises two parts; one refers to the lens effects, namely, providing filters to the lens to simulate the view of eye disease patient realistically; the other refers AR identification card, functioning for the conversion between special effects.

In this paper, the shader equipped originally in Unity is adopted to realize lens effects for the simulation of the view of an eye disease patient [7].

According to the symptoms of glaucoma, a diminished vision field should be simulated. Therefore, the invisible position is darkened, a circle is drawn from the center point, and the area outside the circle is black, and the area inside the circle is the normal view field. With the circle as the boundary, the area inside the circle is rendered based on the real-time image captured by the camera, and the area outside the circle is rendered into black, As shown in Figure 3.

Patients with central serous chorioretinopathy have a distorted vision, and the object in center of vision field is distorted; the symptom will be especially obvious, if the object seen is in a certain shape. For this effect, UV center of the rendered image is taken as the center of a circle, and image distortion is imposed in the area within a certain radius, As shown in Figure 4.

![Figure 3. Glaucoma smaller effect](image1)

![Figure 4. Chorioretinopathy distort effect](image2)

Patients with cataract have a blurred vision, and multiple methods are available for shader to render a blurred image. UV based on image rendering is adopted in this paper, in which, the displacement of image rendering takes place when moving UV point and produces superimposition on the normal image to simulate a blurred vision, As shown in Figure 5.
Patients with achromatopsia can only see a dull world only with black, white and grey. The RGB color value of each pixel is picked up and processed into grayscale values when rendering the image.

3.3. Identification card design
In the design of the identification card, color blindness test card, the letters of English word "eye", and eye pattern are taken as main design elements.

In the identification card for color blindness, the circular patterns shown in Figure 6(a) in red-green color blindness table are replaced by words; in the identification card for glaucoma, a circle of letters compacted tightly in the periphery represents the peripheral circle is blocked and only the middle part is visible, which is shown in Figure 6(b). The symptom of cataract is blurred vision, and that of central serous chorioretinopathy is distorted vision. Therefore, in the identification cards for both, corresponding eye disease elements have been added; the pattern shown in Figure 6(c) is pixelated to simulate the effect of blurring; the pattern as Figure 6(d) is distorted to simulate symptom of central serous chorioretinopathy. To strengthen identification effects, some small diamonds arrayed differently are added around the identification card.
4. Conclusion
As a kind of experience software, this VR technology-based mobile application for eye disease prevention possesses positive educational significance. The work's concept that "seeing is believing" enables people to better understand relevant knowledge compared with texts and pictures.

The work simulates eye disease's symptoms through adding special effects to the camera lens, which allows common people to experience the world seen by the patient of eye disease through the mobile phone camera, understand their inconveniences in daily life, and thus offer them more respects through understanding. At the same time, it can allow people to know the hazards of these diseases, and pay more attention to eye health, thus reaching the result of eye disease prevention.

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