Serious Virtual Reality Game Contents Implementation for Training of Strabismic Patients

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***Abstract*— As health care industry has grown in line with the development of IT due to Fourth Industrial Revolution, medical studies using virtual reality which receives special attention after Fourth Industrial Revolution have been conducted. Specifically, studies on strabismus treatment combined with virtual reality technologies at home and abroad have been made. This thesis studies how to acquire strabismus training effect in general virtual reality game by developing contents which can be used in treating patients with strabismus in virtual reality space through HMD and controlling prism diopter values. This thesis realized virtual reality contents in a form of plug in which can be applied to other virtual reality games or contents developed as Unity3D game engine to broaden user's selection of contents.**

I. INTRODUCTION

As health care industry has grown in line with the development of IT due to Fourth Industrial Revolution, medical studies using virtual reality, one of representative technologies of Fourth Industrial Revolution have been conducted. Virtual reality refers to one in which people can have an experience that is the same as they have real world in virtual space which is created and kept through communication using computer network[1].

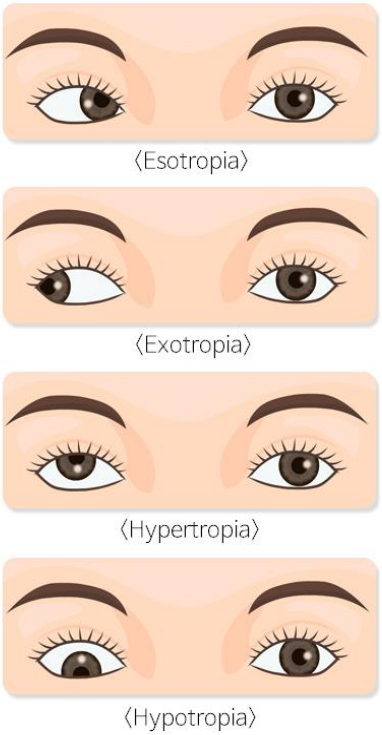
One of characteristics of virtual reality technologies is that it uses head mounted display (HMD) that emits a display to eyeball with excluding peripheral visual field as hardware. Ophthalmology among healthcare convergence technology field is expected to have the greatest effect due to above mentioned characteristics of virtual reality technology.

Specifically, studies for treatment of children with strabismus have been conducted actively. Strabismus refers to visual impairment that eyes see different points due to abnormal development of extraocular muscle. Strabismus is classified into anoopsia, catatropia, convergent strabismus and divergent strabismus according to direction and affects development of visual acuity among children[2].

For pediatric strabismus , it is important to detect strabismus early and prevent several abnormality that may cause strabismus. Correction through eyeglasses , pharmacotherapy through miotics and orthopic training are performed as nonoperative training with aforementioned purpose. Strabismus should be treated no later than a child enters elementary school[3].

In Republic of Korea, studies that combine strabismus treatment with virtual reality technologies are weak. There are a study on technology that can assist children with strabismus using Traking VR device by Heeyeon Kim and Jungkil Go [4], a study on technical elements for using vision therapy in VR HMD by Sangmi Choi[5], and a study on 3D game implementation for treatment of children with strabismus by Hongrak Lee[6].

Fig. 1. Types of strabismus



In foreign countries, development of HMD contents and clinical trials through convergence with virtual reality technology have been conducted actively.

Accordingly, this thesis implements virtual reality contents for convergence training for treatment of strabismus using Unity3D game engine and studies how to implement virtual prism diopter function so that strabismus training treatment is possible in virtual reality contents produced using Unity3D game engine.

II. RELEVANT STUDIES

A. *HMD(Head Mounted Display)*

HMD is a display device which a user wears to realize virtual reality and augmented reality contents. HMD enables virtual reality contents using 360 degree visual field technology via stereoscopic 3D technology, gyro sensor, high resolution display and lens.

Fig. 2. HMD and Controller of Oculus Quest.

Virtual reality contents via HMD is virtual reality hardware that enhances reality of contents through user's interaction and high degree of immersion unlike conventional display.

B. *Prism diopter*

Degree of refraction of light (refractive index) by prism is called prism diopter. When there occurs a change of 1cm at a distance of 1m, this is called 1 prism diopter. Light refracts towards base and phase moves towards apex in the opposite direction of base. Prism diopter enables phase to be placed on retina correctly by inducing refraction of light.

When observing visual optical instrument through prism, it is found that eyeball tends to move towards apex to get clear phase. This is called prism adaptability[7, 8]. In this thesis, prism diopter was implemented virtually through adjustment of degree of camera to virtual reality contents.

Prism diopter aims to maximize treatment of patients by a user adjusting up to 20 prism diopter.

C. *Unity3D engine*

Unity3D engine is at once game producing engine providing 3D or 2D video game development environment and integrated authoring tool that can produce interactive contents such as 3D animation, architecture visualization and virtual reality. Editing tools can be implemented on WindowOS and MacOS.

Unity3D engine can build release programs that can be implemented through platform abstraction on twenty seven platforms on Window, Mac, Iphone, Android, Web. Languages used in development are C# and Javascript. Unity3D engine can realize simulation environment easily with middleware such as physics engine which is similar to reality and realtime light mapping on editing tools and enables a user to control environment easily while checking environment realized in real time.

Recently, unity3D engine is also used to produce multimedia contents in artistic activities such as next generation contents, exhibition and performance in the field of various interactive contents, game production, virtual reality, augmented reality and merged reality[9].

In this thesis, unity3D engine was used to produce virtual reality game contents in order to enhance patient's immersion and simulate prism diopter function within virtual reality contents by adjusting camera angle.

D. *Vision Therapy*

As virtual reality HMD is hardware based on user's visual sensation, it is expected that vision therapy will be used in various fields of health care.

Vision therapy which is also called as visual sensation training is a clinical approach that improves relevant symptoms by correcting ocular movement disorder, binocular vision disorder and strabismus.

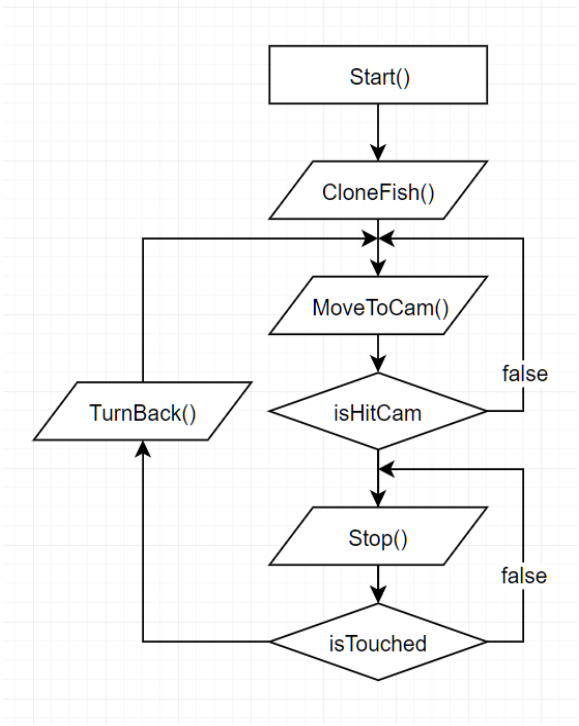
This includes various methods that improve visual function through training by nonoperative method[7].

Types of visual sensation ability include visual functions such as amplitude of accommodation that adjusts focal point of object in a short distance, fusional amplitude that two eyeballs fuse each phase into one and saccadic eye movement that allows two eyeball to move in the same direction. This thesis aims to develop contents to improve symptom by correcting disturbance in accommodation among various visual function disorders[8, 9].

III. DESIGN AND REALIZATION

In this thesis, game contents including interaction based on unity3D engine to produce and test contents for convergence training were produced. Design of convergence training simulation is as follows "Fig. 3."

Fig. 3. Diagram of strabismus training contents.



Hardware reproducing contents is Oculus Quest and enables a user to interact through hands using controller and object realized in contents including two 3 axis controller. Hardware information is indicated in Table 1 below.

Table I
Hardware Information of Oculus Quest

Category	Spec
Application Processer	Snapdragon 835
Display	OLED
Resolution per Eye	1440 x 1600 per Eye
Refresh Rate	72Hz
Headset Tracking Technology	6DoF
Weight	570g
Stroage	>128GB

Background of contents that a user conducts convergence training was realized in a form of remains in sea.

An object that a patient should see for training was realized in a form of orange colored tropical fish so that a user can concentrate on an object easily.

Fig. 4. Main view of the training contents.

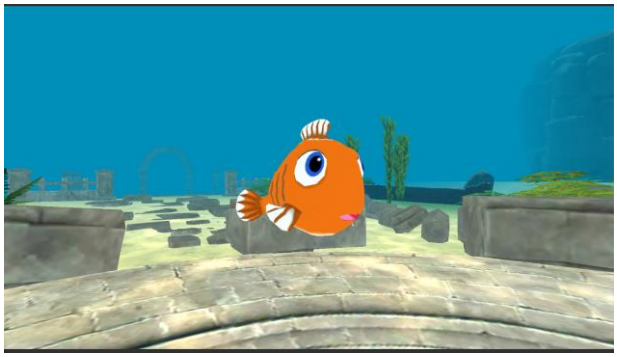


Fig. 5. Route of the Fish Object.

Orange colored tropical fish within contents swims up to 15cm from center of a camera coming under user's two eyeballs in virtual reality and then stops and a user touches tropical fish through controller embedded in HMD which makes it repeat moving away from a user for 10 seconds and returning to a user in ten seconds inducing a user to change focal point in eye naturally so that a user can carry out convergence training in virtual reality.

Fig. 6. Prism diopter view

Content in this thesis was realized in a way that strabismus training can be performed through general virtual reality game by setting visual field according to virtual prism diopter values by a user adjusting camera angle coming under each eyeball via UI in contents realized as general unity 3D engine besides content for convergence training with realization of prism diopter option.

IV. Conclusion

Content realized in this thesis is interactive serious game content for treating convergence among people with strabismus using virtual reality technology.

In this content, a user wearing head mount display (HMD) approaches up to 15cm from the center of camera coming under two eyeballs and when a user interacts with an object using a controller, an object moves away from a user and then returns to a user in ten seconds inducing a user to carefully watch an object repeatedly for training of people with strabismus to improve convergence.

Content in this thesis was developed by referring to training methods which are related to visual function training conducted for people with strabismus. Virtual reality serious game content realized in this thesis is expected to help train and treat people with strabismus.

In this thesis, virtual prism diopter control simulation that is applicable to other virtual reality contents using principle of eyeglasses for correction of strabismus.

However, further research in cooperation with eye specialists based on careful design is needed. Prism diopter with virtual reality is designed in a way that it can be set up to 20 prism diopter virtually.

More precise calculation formula should be realized and values should be adjusted based on clinical trial and advice from eye specialists. Clinical trial for realized virtual reality serious game content's testing convergence training effect among people with strabismus should be conducted as well.

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