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A Study of Visual Function Training and Eye Disease Prediction Platform Through Image Analysis

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Abstract

With regard to the image analysis technology by pupil close up photography, fixed image analysis through the pupil change and focus change and time series pattern analysis technology on the video stream are used without analyzing the disease or eyesight, and the technologies that determine changes in eye diseases and the ability of visual function training are used, which is beyond the determination of the objects in ordinary image analysis.

Through this study, which is a milestone for analyzing the changes in focus, muscle and the progression of eye disease using images photographed by a device and developing and researching a specialized total eye care system for eye examination, eye training, analysis of eye training concentration in comparison with the conventional medical device for simple visual function training, the authors intend to provide a medical platform that enables the eye disease care platform to be linked with other devices without being limited to a specific device after the development of technology.

Keyword: Image, Pupil, Visual Function, Eye Disease, Eye Care, Device Analysis

I. INTRODUCTION

With the popularization of smartphones, continuous reading has caused eye function centralized on a single focus, which in turn causes many cases in which the whole eye functions are not interlocked. Therefore many researches are underway to early detect eye degeneration and eye diseases that are progressing slowly over a long period of time, or to combine image analysis technology techniques with eye concentration training. [1]

The maximum accommodation force is one of factors that determine the degree of presbyopia according to age. The maximum accommodation force is decreased from 0.20 to 0.45 D per year from the age of 5 due to the hardening of the lens and deceasing elasticity of phacocyst. Theoretically, it completely disappears at the age of 52 [2-4]

With increasing age, the object near the front of the eyes looks blurred and the near point of accommodation grows away, which is called presbyopia. To improve the symptom of blurry vision, (+) lens is worn and the amount of (+) lens added according to the magnitude of the accommodation force at the time of wearing the lens is called presbyopia addition. Although the presbyopia addition is gradually increasing with increasing age after the age of 40, but equilibrium of accommodation cannot be maintained due to presbyopia, which leads to symptoms such as blurred image, accommodative asthenopia and headache, etc. [6]

To solve these problems, the authors intend to study a medical platform through image research of respective eye diseases, creation of the graph of pupil recognition magnitude and system platform upload unit test by designing visual function enhancement training.

Ⅱ. PREPARATION OF EXPERIMENTAL APPARATUS

Ⅱ. Ⅰ Experimental Apparatus

For the experimental apparatus used in this study, a pupil tracking camera was implemented to record the pupil training according to the pupil movement through pupil photography. When a pupil of a patient with eye disease was photographed by a camera during visual function training, light and shade were created on the upper part of the pupil, resulting in errors in pupil recognition. To solve this problem, additional tests were performed by adding an infrared camera. Device screening tests were performed by the same method as shown in Fig. 1, and the intensity of the light was confirmed by selecting white colors of light. For the detailed works for testing the infrared camera, LED was inserted as shown in Fig 2.

Fig. 1. Infrared camera for visual function training

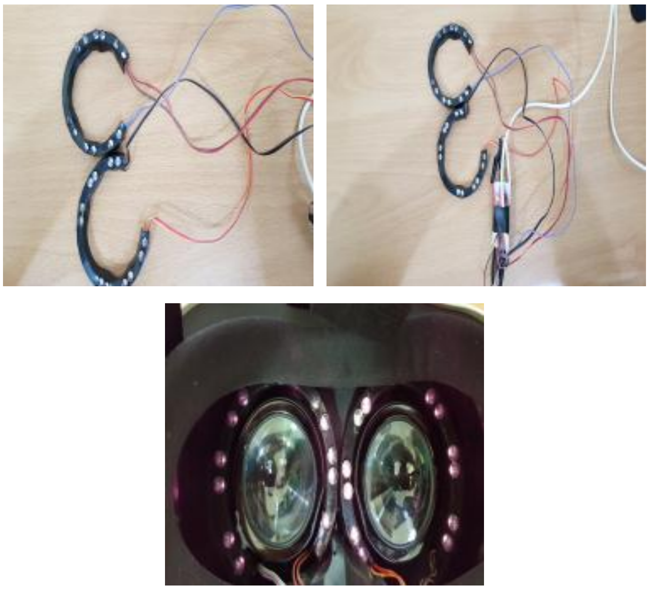

Fig. 2. Addition of the hardware infrared camera

Ⅱ.Ⅱ Conversion Design to Obtain Pupil Images

For the pupil recognition rate test, the recognition rate was confirmed through several pupil sampling images and the image correction (optimization of the numerical HSV values) was performed prior to image analysis. In addition, as shown in Fig. 3, the obtained images were converted into grayscale. The value of each pixel indicates one sample image representing the amount of light, and transmits only the information of light intensity. Such image is known as black and white or monochromatic image and ranges from black of the weakest light intensity to white of the strongest light intensity. The formula for conversion from RGB model to grayscale was expressed in (1) below.

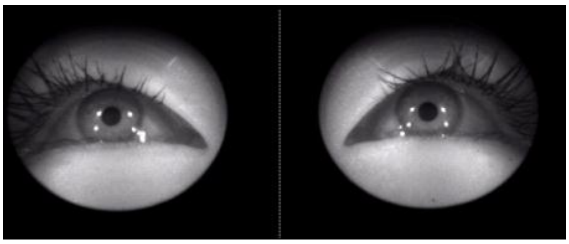

Fig. 3. Pupil image obtained from the equipment

$$Y' = 0.2126 \times R' + 0.7152 \times G' + 0.0722 \times B' \text{ ------------ } (1)$$

The differences between when only the infrared module was added without the basic LED and when the infrared module was added without the basic LED and when contents were implemented are shown in Fig 4.

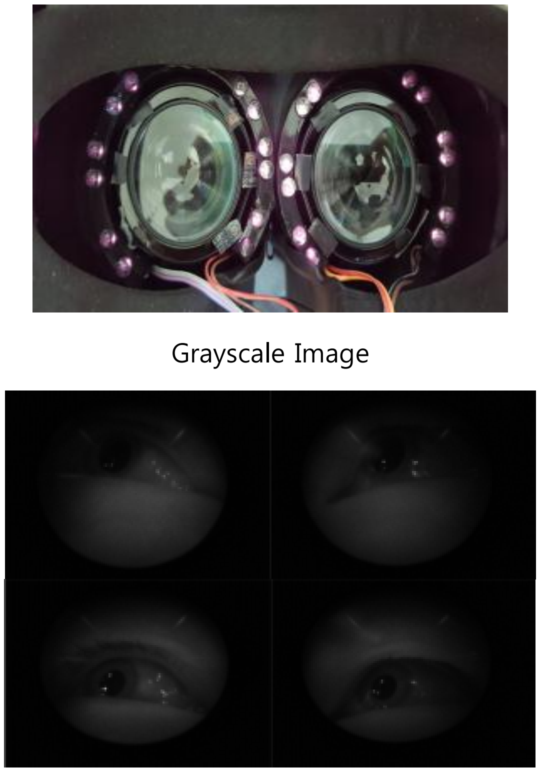

Fig. 4. Implementation of additional images obtained by adding an infrared module without LED

And the differences when the infrared camera + the basic LED + contents were implemented are shown in Fig 5.

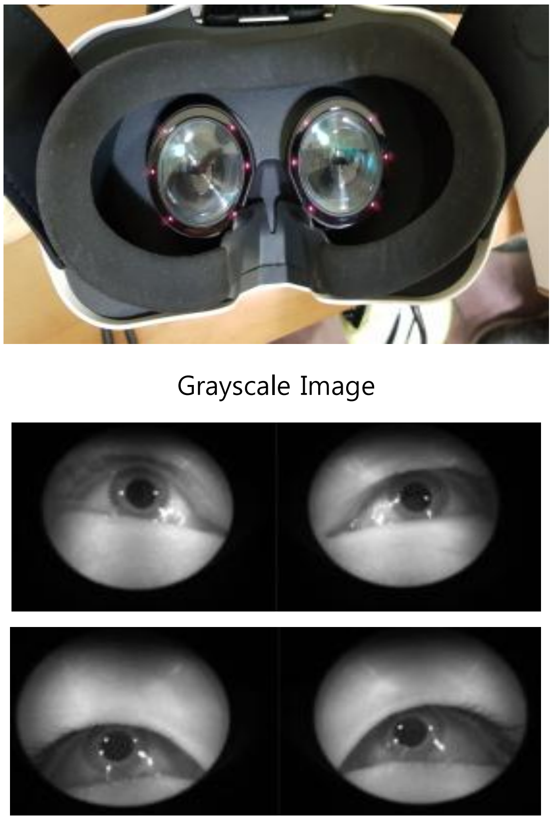

Fig. 5. Implementation of additional images obtained by adding an infrared module with LED

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The image was brightened overall, and it was confirmed that the use of high-brightness LED affected the contents. The dioptric power adjustment lens is mounted on the outside of the lens, with may require angle correction. Therefore it is considered necessary to conduct further researches by changing the angle of camera through raising the part that contact the nose of forehead.

Ⅲ TESTING VISUAL FUNCTION TRAINING PLANTFORM UPLOAD UNIT

Ⅲ.Ⅰ Implement Pupil Recognition Image

The pupil recognition rate was tested using a pupil tracking camera, and the pupil size was measured by photographing the pupil of the patient with eye disease using a low-light camera during training. The pupil area found in the process of testing are shown in Fig 6.

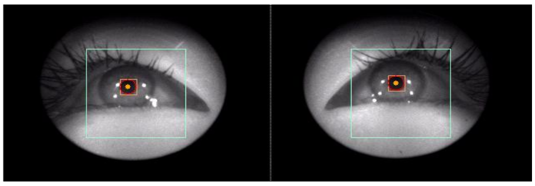

Fig. 6. Implementation of images displaying pupil area

The numerical values were expressed as the sum of the left pupil radius and the right pupil radius. Diagnosed training method was implemented and the training status was confirmed through pupil recognition during training. When the training was over, the pupil image and the file of images in which the patients did not concentrate during training were transmitted to the platform. Fig 7 shows the monitoring of the expressed and the patient's training and training activities were monitored through the quantitative values of graph in Table 1.

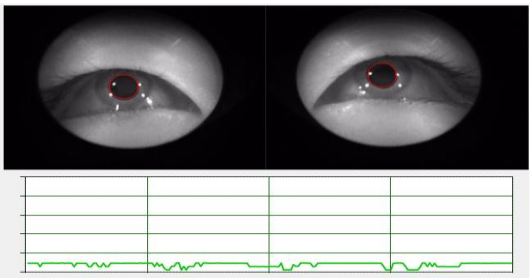

Fig. 7. Quantification of pupil training images

Table 1. Graphed values of pupil training images

count	result	count	result	count	result
1	37	11	37	21	36
2	37	12	36	22	37
3	37	13	37	23	37
4	37	14	19	24	37
5	38	15	0	25	36
6	37	16	0	26	38
7	37	17	37	27	38
8	37	18	37	28	19
9	19	19	36	29	0
10	37	20	19	30	38

Ⅲ.Ⅱ Analysis of Eye Disease Images Obtained by Camera Tracking

The types of diseases that can be classified into the pupils photographed by the pupil tracking camera were screened and converted into black and white images to confirm the differences. The original images and the images converted into black and white images are shown in Fig 8.

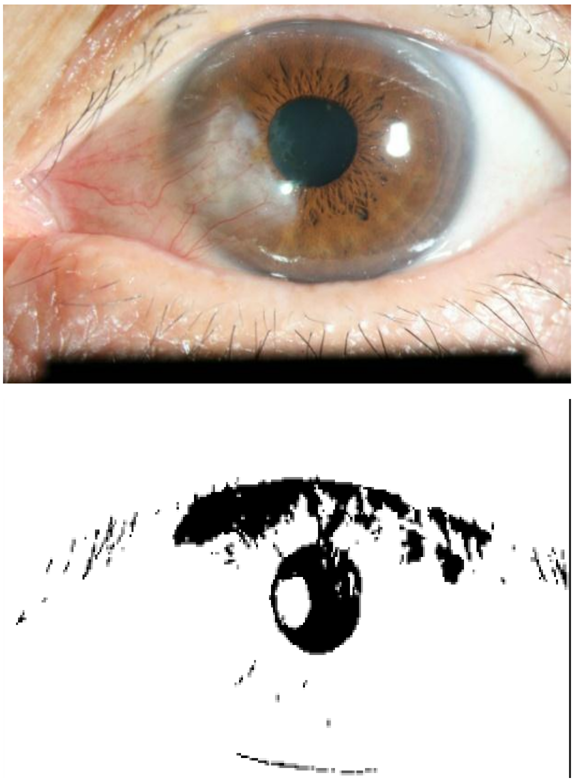

Fig. 8. Quantification of pterygium disease images obtained by pupil photography

Some people misunderstand the cataract as a disease that the fibrovascular tissue grows, invades and progresses from the inner conjunctiva of the eye (the white of the eye) to the cornea (the black of the eye), but it was found to be able to easily distinguish. It was confirmed that the distortion of pupil and the layer covering the white of the eye was confirmed by distinguishing pupil area and the white of the eye, indicating obtaining additional images will enable it determine similar diseases. In other diseases, subconjunctival hemorrhage can be detected as shown in Fig 9.

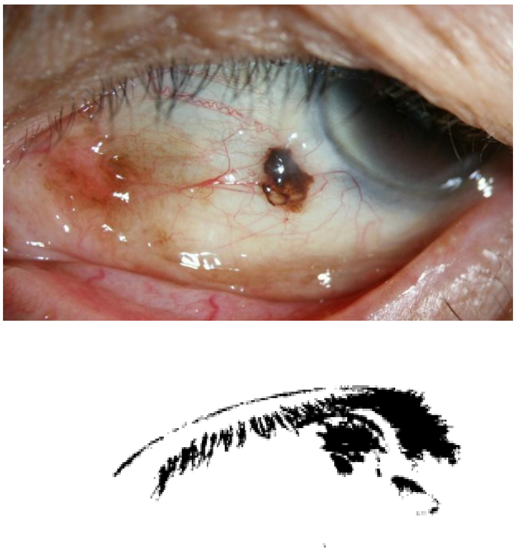

Fig. 9. Quantification of submucosal hemorrhagic disease images obtained by pupil photography

This disease indicates a phenomenon of hemorrhage in the blood vessels of the conjunctiva. In the conjunctiva, there are numerous small and soft blood vessels, which can easily rupture. When the disease occurs, blood flows into the space between the conjunctiva and the sclera. The image enables it to observe a layer covering the while of the eye, indicating that it will enable it to predict and observe the eye disease by pupil photography. It is possible to diagnose the need for additional medical care by determining the disease this way.

VI. CONCLUSION

In this study, recognition rate was tested using an eye tracking camera, and the obtained images were analyzed to study eye function training and eye disease prediction platform. The results of this study can be summarized as follows:

1. It is possible to detect the pupil recognition rate through a pupil tracking camera and to obtain the optometrist information that is verified for efficiency and accuracy through automated image analysis.
2. Analysis of the images obtained by a pupil tracking camera is effective in early detection of disease and
3. minimization the financial loss in the national health insurance, improving the quality of patient's life through preservation of eyesight.
4. It is possible to research and develop a remote medical support system that can detect important causes of eye diseases at an early stage and observe the progress rapidly and continuously.
5. It is possible to provide customized treatment and prevention services by analyzing and diagnosing diagnoses individual visual functions and the eye disease status and linking with services of experts.

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