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Original Article

Development of Visual Function Training Technologies through a Learning Model System Based on Iris and Pupil Recognition

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Abstract - *There is growing attention on the visual function to maintain a healthy life in an aging society. However, the prevalence of eye diseases that may lead to the deterioration of visual function and acuity continues to increase.[1)] To cope with eye diseases with refractive errors that lead to rapidly increasing visual dysfunction, it is required to develop a visual function training system for customized prevention and diagnosis of refractive eye disease, customized visual function treatment, and the analysis and management of treatment effects. To that effect, this study was intended to improve the visual functions by tracking the user's iris and pupil using AI technology, analyzing and diagnosing the state of eye disease using the acquired information in VR visual training. The scope of the design to be developed includes the deep learning design for software configuration for tracking the iris and pupil to diagnose visual impairments; the definition of configuration functions of the deep learning design for the application of AI; test results; the design of architecture to analyze the actual state of eye disease; and the development of a function for diagnosis.*

***Keywords* -** *Visual Function, Pupil Size, Learning Model System, Eefficiency, Iris.*

1. Introduction

Visual recognition plays a pivotal role in everyday life. Human sensory organs allow humans to adapt well to a given environment, and most information acquired through the sensory organs is absorbed through vision.[1)] The deterioration of visual recognition related to vision causes many difficulties in everyday life and learning ability, and the visual recognition impairment affects everyday life.[2)] Visual problems are largely categorized into structural visual problems caused by injuries and diseases and functional vision problems that affect the efficiency of the visual system. It is said that it may be difficult to distinguish between the two because they are closely associated.[3)] As to the efficiency problem among the visual problems, there may be confusion in the transmission of information to the brain due to problems related to the integration function of the eye or other aspects of binocular vision, which in turn may distort the recognized content.[4) ~5)]

To that effect, this study was intended to develop and evaluate the function of analyzing and diagnosing the state of eye disease by implementing focal length and refractive index analysis AI and building data through users' iris and pupil recognition.

2. Purpose of Study

The specific purpose of this study is to implement focal length and refractive index analysis AI through iris and pupil recognition and to the database. In addition, this study is to design an iris recognition and pupil size analysis training model based on VR wearable device FCNN.

The main specifications of the basic design include the software (specifications of main items for VR content and software operation), the network (specifications of standardized data communication protocol), and the deep learning (specifications of deep learning model design for iris and pupil recognition) aw shown in Fig. 1 below.

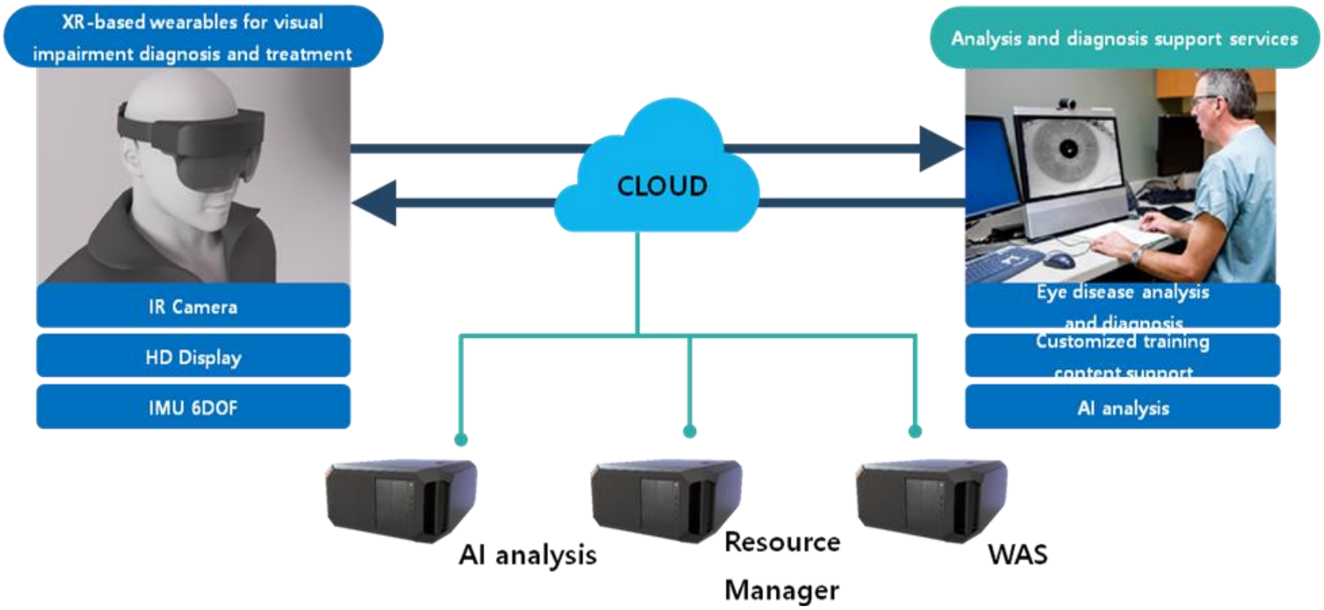


Fig. 1 Diagram of iris tracking AI data construction system

3. Method and Configuration

3.1. Method of Study

To achieve the purpose of this study, a literature study will be conducted; major algorithms for iris and pupil recognition will be designed and tested to demonstrate the basic learning models based on iris and pupil recognition and prepare a test to repot. The data set transformation model for the construction of learning data will be developed and tested. Furthermore, to prepare a design for the refractive index and focal length analysis model and prepare a test report, iris recognition will be developed through refractive image index, morphology, and threshold processing; transformation detection and area comparison and testing according to changes in pupil recognition size will be conducted, and a learning model based on FCNN will be designed and tested.

3.2. Study Configuration

The wearable VR system for diagnosing and treating visual impairments using iris recognition AI analysis technology comprises two concerned persons. The user, who is the subject for the training and treatment for visual impairments, uses VR as doctors and treatment subjects for visual abnormalities, tracks the iris, and provides the analyzed information to the administrator. This system is shown in Fig. 2 below.

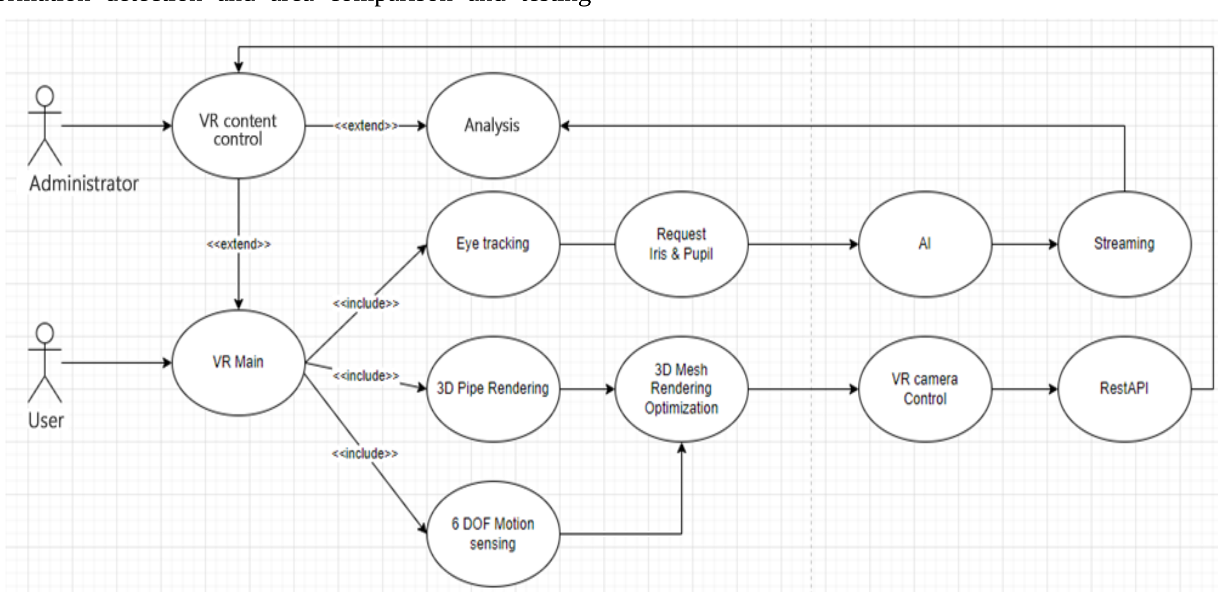


Fig. 2 Configuration of system's main use cases

In this study, by applying AI technology to the iris and pupil, the author designed the classification model of the iris and pupil for diagnosing eye diseases related to refractive errors, constructed the learning data and established a plan for pre-processing the learning data through simple algorithm experiments, and establish a plan for the advancement of the AI model

4. Results of Learning Model Demonstration

4.1. Demonstration design of the basic learning model based on iris and pupil recognition

This study aims to develop a model that can detect abnormalities in the pupil and iris and classify the recognition accuracy of the eyeball by classifying the iris and pupil from the eye and learning them. To that effect, this study aimed to design a neural network model that classifies and recognizes the iris and pupil and test the model. CASIA V1.0 and MMU 2 learning data were used for the main learning. The DenseNet model was used for the learning model, and the design was conducted as shown in Fig. 3.

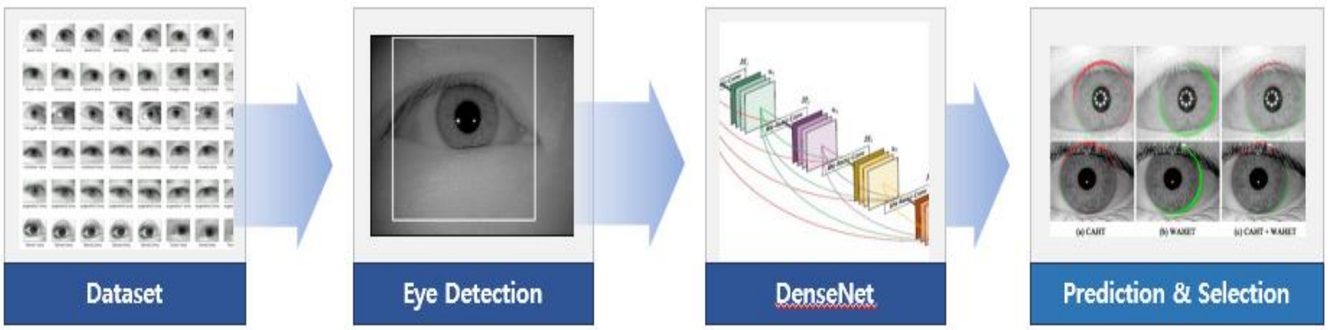


Fig. 3 Deep learning process

4.2. Classification and tests based on learning data

CASIA V1.0 and MMU2 models were used for the learning data for classifying the iris and pupil. The CASIA v1.0 data set is in JPG format with a resolution of 384 x 256 and provides 756 images. The MMU data set is Bitmap format with a resolution of 320x240 and provides 450 images. As shown in Fig. 4, it is characterized in that the data set is classified so that it can learn by distinguishing the right and left sides.

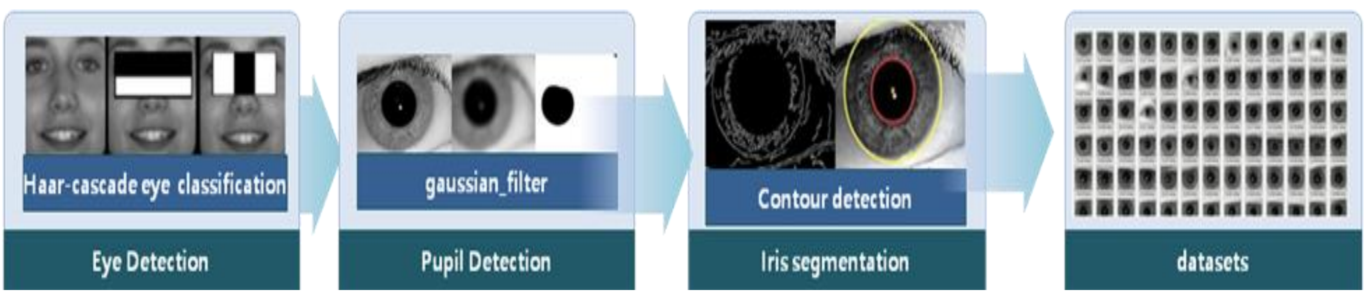
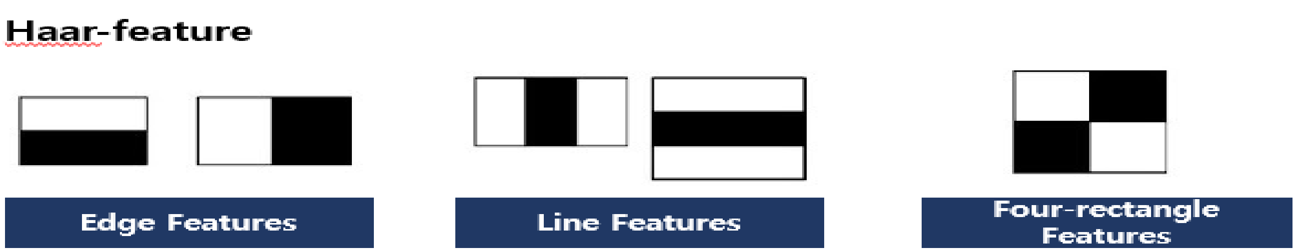


Fig. 4 Dataset processing process

To classify the iris and pupil, the classification of the eye is important. Since, under the actual development environment, the eye is measured by an IR camera, the model that analyzes the eye's position was excluded. Eye tracking extracts the Haar-cascade features. The Haar feature uses the difference in the sum of pixels within the area of adjacent rectangles that scan the image and move the position. The Haar feature has three features, as shown in Fig. 5.



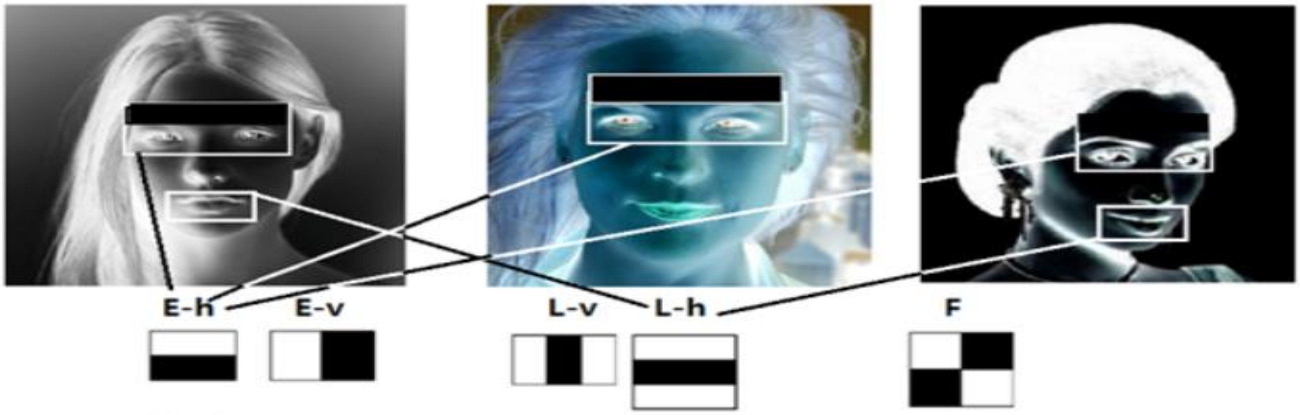


Fig. 5 Haar-feature

4.3. Results of iris and pupil classification algorithm

The actual Cascade structure is an algorithm that finally determines that it is a face by classifying what is not the face using Haar-features by detecting the range of the face so that it can achieve higher performance than other face detection algorithms. As shown in Fig. 6, the eye is classified into the iris and pupil, and the pupil can be classified most easily in an IR camera. The application algorithm was proceeded as a procedure to obtain a circle by applying the Huge transform algorithm.

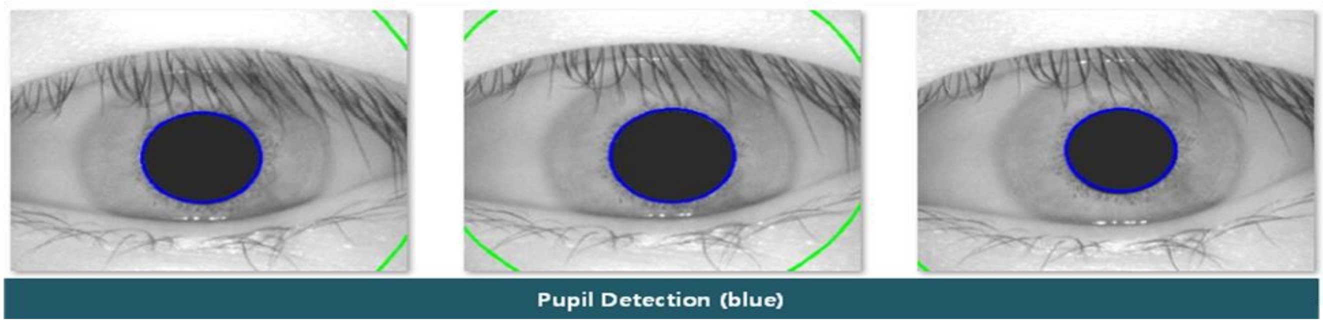


Fig. 6 Results of Huge transform algorithm

The Huge transform algorithm's performance was tested using the HoughCircles function of OpenCV, and the image resolution of the training data and the size of the recognized pupil were defined and processed. In addition, the iris segmentation was classified by applying the extraction algorithm for the outline. The accuracy was verified by detecting the pupil and processing the detection of the ellipsoid larger than the pupil, as shown in Fig. 7 below since it was difficult to classify the refraction and the actual colour of the iris in the learning data.

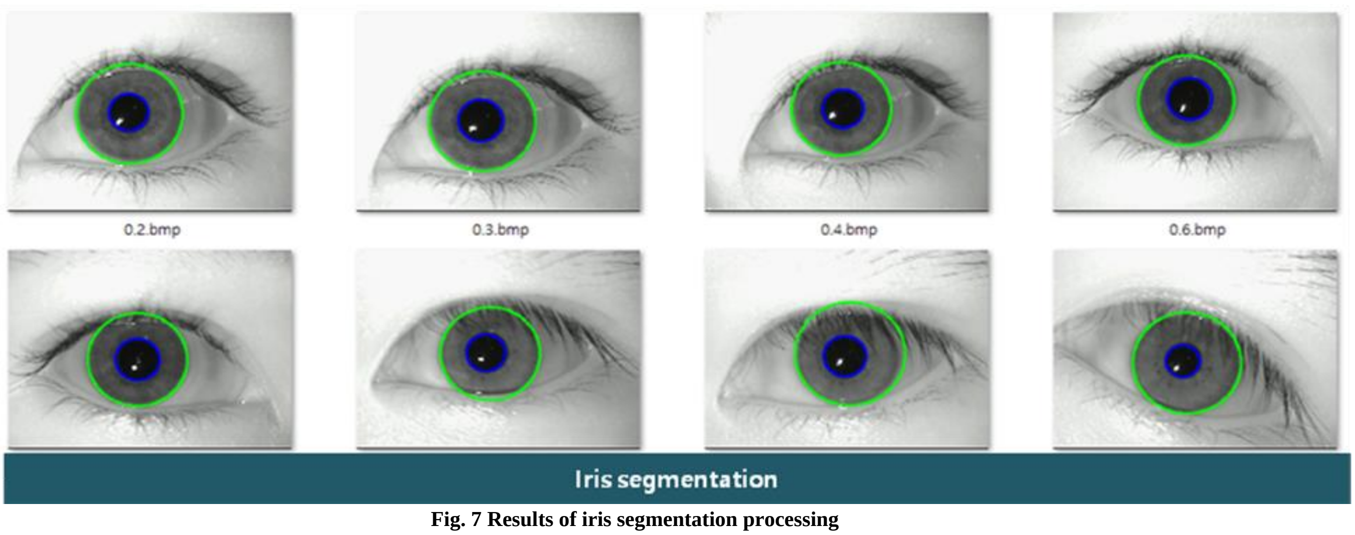


Fig. 7 Results of iris segmentation processing

The analyzed image of the iris and pupil was transformed into a dataset for processing as a training dataset for deep learning, as shown in Fig. 8. The resolution was fixed at 200 pixels for learning.

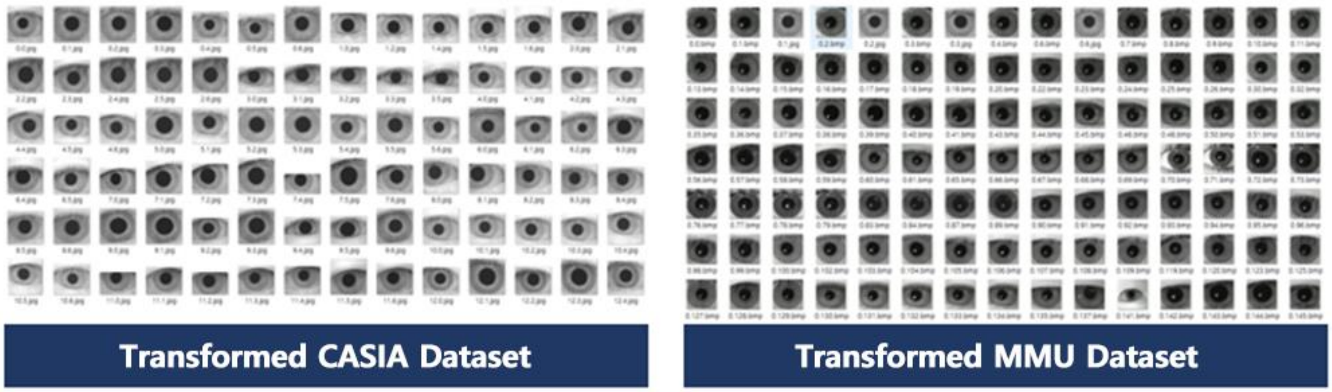


Fig. 8 Constructed learning data set

For the area for constructing the learning data set, the learning data set was applied based on the iris segmentation area. Image clipping and then resolution processing were proceeded based on the maximum area of the iris and pupil segmentation information.

5. Conclusion

Based on the iris and pupil of a normal eye, the function for the detection of the test iris and pupil recognition in the basic design stage for the recognition processing algorithm was implemented, and its application as learning data. The following conclusions were drawn.

Through iris recognition, the size of the iris and the size of the ellipsoid can be calculated and based on this, the characteristics of the size change and distortion of the iris can be considered.

In the actual development stage, there is a possibility that the data set may change according to the characteristics of the IR camera and the brightness of the light. Thus it is judged that it would be necessary to adjust the factors for related calculations when the IR camera is determined in the future.

For the labelling processing and data set according to the actual distance, a function to process changes according to pupil recognition and size change was constructed, and it is judged that it would be used in the application of learning ability to improve the deterioration of visual recognition through additional learning data.

The basic learning data construction module for basic iris and pupil analysis was designed and tested, and classification technology for iris and pupil was established. The results of this study are considered to contribute to implementing the basic AI model of region detection for the iris and pupil.

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