International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 22 (2017) pp. 12581-12584

Customized Treatment Through Ocular Image Analysis Platform Design

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Abstract

We conducted a study to solve the problems with technologies for treating eye diseases by designing a multi-modal sensing data-based ocular image analysis platform that enables effective eye disease prevention, real-time diagnosis, customized treatment, effect analysis and management. The purpose of this study is to provide a multi-modal sensing data-based ocular image analysis platform that performs unfocused iris center-point warping image processing, eye movement analysis, PHR (Personal Health Record) information, ocular and period-specific disease information to enable accurate ocular image analysis. Through this study, we intend to improve the accuracy of ocular image analysis through correlation analysis, clustering and classification of existing situations by linking automated multi-modal ocular image analysis with the platform. A multi-modal sensing data-based ocular image analysis system was designed to enable eye disease prevention, real-time diagnosis, customized treatment, effect analysis and management

Keyword: Sensing Data, Ocular Image Analysis, Eye Disease, Customized Treatment, Therapeutic Analysis, Real-Time Diagnosis

INTRODUCTION

In general, visual function is a function to process the information of eyes and brain. It is also called vision function, which transmits the information input from our eyes as well as information input through tactile, olfactory, and auditory system to the brain so that the brain can interpret the information and add meanings to it [1-2] The visual function occurs irrespective of the good or bad of the visual acuity. The problem with visual function makes it difficult to perform sports activities, to read, concentrate, and write, leading to reading impairment, dyslexia, attention deficit disorder, learning disability, writing disability, and social life disorder [3-4] In the case of medical image analysis research, which is an essential element for the treatment of eye diseases, specialists have made passive/ empirical judgment using existing ophthalmologic examination/treatment equipment (ARK, etc.), there are not many studies conducted on an analysis of medical images related to eye disease [5-6]. Therefore, in order to effectively cope with rapidly increasing eye disease, it is necessary to develop an automated medical equipment for customized eye disease prevention, diagnosis, treatment, and effect analysis/management [7-10]. This study was intended to provide a multi-modal sensing data-based ocular image analysis system that enables effective eye diseases prevention, real-time diagnosis, customized treatment, effect analysis and management.

MATERIALS AND METHODS

PLATFORM DESIGN

This study provides a multi-modal sensing data -based ocular image analysis system that is not restricted by location for optometry through circling binocular focus analysis/pattern reflection direction discrimination, and Table 1 shows the configuration diagram of multi-modal sensing data-based ocular image analysis system. The multi-modal sensing data-based ocular image analysis system was designed to include optometric model-specific analysis and circling, closeup module based on pattern analysis, and dynamic analysis module based on training VR expression data flow.

Table 1: System Configuration Diagram Having an Optometric Image Analyzer

Contents	Version
Doctor's Diagnosis/Service Component	Visual Enhancement Service
	Amblyopia
	Presbyopia
Analysis Framework	Hypothesis Testing (H0,H1)
	Statistical Analysis
	Deep Learning
	Analysis Based on Evidence
	Analysis Based on Data
	Image Analysis
Data Framework	EDC

	CDM
	SQM
	Security
	Regulation
	21CFR Part11
Customer Service	Service API
	Healthcare API
	PHR API

SYSTEM CONFIGURATION

Fig. 1 shows the detailed configuration of the multi-modal sensing data -based ocular image analysis system designed for this study. Fig. 1 shows ocular image analysis unit that analyses the ocular image provided through a visual function enhancement wearable device by interworking with healthcare platform; ocular image analysis-based diagnosis unit, that perform diagnosis based on the results analyzed in the ocular image analysis unit; period-specific disease progress analysis unit that provides results to support the entire treatment cycle including prevention, optometry/diagnosis, visual function training/treatment, effect analysis and management; and disease diagnosis process interworking unit that reflects the time series data analysis and the combined analysis to the disease diagnosis process through pupil image analysis unit that analyzes the pupil image by period.

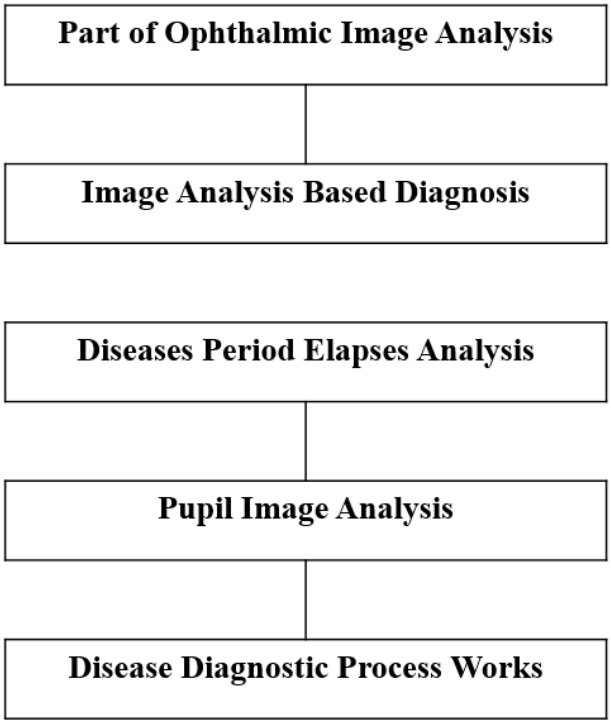

Figure 1: Detailed Configuration Diagram of an Optometric Image Analyzer Based on Multi-Modal Sensing Data

RESULTS AND DISCUSSION

Analysis Scope

The multi-modal sensing data-based ocular image analysis system includes optometric model-specific analysis and circling, closeup module based on pattern analysis, and dynamic analysis module based on training VR expression data flow. In addition, it provides optometry/training embedded analysis engine results, cloud server and app service protocol, and includes a configuration for providing eye disease-specific video learning DB and a conversion layer for leaning disease-specific image photographed by the device.

Analysis Design

It includes an algorithm to detect the possibility of over-fitting by disease, and includes a configuration for providing a utilization process and visual function training data / disease discrimination data analysis engine for each result during the entire treatment cycle. We defined function training device internal photography protocol, designed and construct a training scenario-based pupil model through the configuration of the photography SW structure design, the pupil reflection pattern, the circling resolution, the tracking model design, and the optometric data based training scenario adjustment process that conforms to the optometric measurement criteria.

Platform Calculatioin

The overall configuration of multi-modal sensing data-based ocular image analysis system according to the present system is shown in Fig. 2. It performs a program for enhancing the visual acuity based on VR and lens. It includes visual function enhancement wearable device that receives the customized service program for visual function enhancement by interworking with the healthcare platform and provides real-time optometric information to ocular image analysis through healthcare system; ocular image analysis system that performs visual function enhancement wearable device training control and state sensing with an analysis framework based on use data and device sensing data, processing of the iris center point warping image based on the eye ball close-up and eyeball movement analysis by interworking with device use data and service platform; ocular image analysis system that performs multi-modal sensing data-based ocular image analysis such as personal health record (PHR) , period-specific disease information; visual function diagnosis/training management system by providing expert diagnosis service and user service program for visual function enhancement; an app for receiving user services, and user terminal for providing information for visual function enhancement.

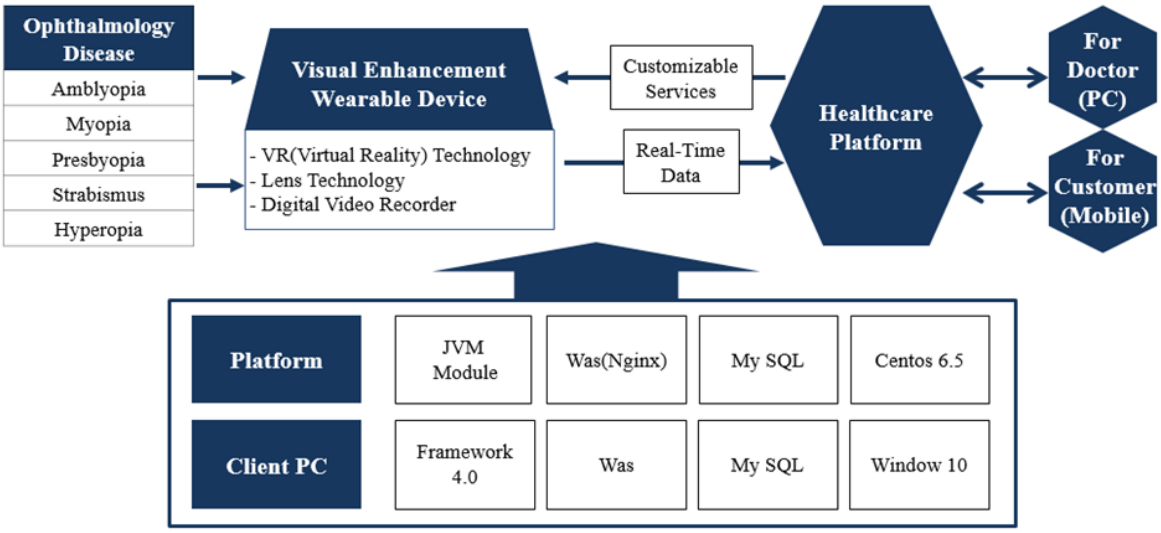

Figure 2: Overall Configuration of a System Having an Optometric Image Analyzer Based on Multi-Modal Sensing Data

System Analysis

The configuration of multi-modal sensing data-based ocular image analysis system is shown in Fig. 3. It has binocular imaging means inside the visual function enhancement wearable device, binocular imaging means photographs the left/right pupillary images, performs circling enlargement and reduction, change of illumination Hz, and measures fusion power, monocular maximum adjustment power, ease of adjustment, relative adjustability, and control lag. In addition, it has the iris inner/outer parts separation processing means, and the iris inner/outer parts separation processing means extracts monocular iris outer shape, separates the iris foreground and the outer region, and extracts the iris inner pupil region. Finally, it has the pupil position and magnitude time series data processing means, and the pupil position and magnitude time series data processing means analyzes the concentration of the visual muscle training, extracts adjustment power according to individual training ability, reaction characteristics and also extracts reflection characteristics according to pattern flow and circling changes.

The data analyzed by the multi-modal sensing data-based ocular image analysis system having such a configuration is stored in the healthcare platform. The multi-modal sensing data-based ocular image analysis system interworks with the healthcare platform to perform eyeball closeup, unfocused iris center point warping image processing, eye movement situation analysis, PHR (Personal Health Record), eyeball sensing image and period-specific disease information, enabling it effective eye disease prevention, real-time diagnosis, customized treatment, effect analysis and management.

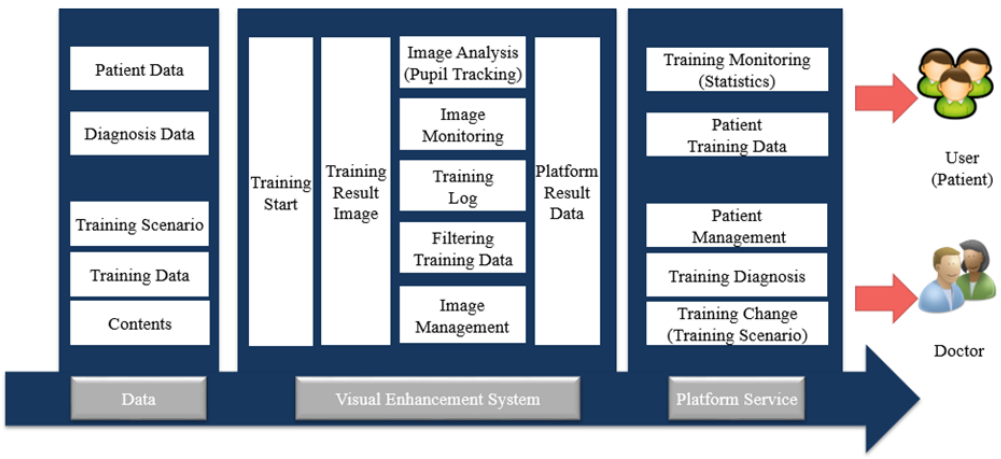

Figure 3: Configuration of Optometric Image Analyzer Based on Multimodal Sensing Data

CONCLUSION

In this study, we designed a multi-modal sensing data-based ocular image analysis system to enable eye disease prevention, real-time diagnosis, customized treatment, effect analysis and management. The conclusions derived from this study can be summarized as follows:

1. By interworking with the cloud platform for multi-modal ocular image analysis, it could improve the accuracy of ocular image analysis through correlation analysis, clustering and classification for existing situations.

2. It is possible to apply photographed image data heterogeneity transformation layer technology and dynamic pupil change detection technique corresponding to VR expression image through image/panorama warping transformation.

3. By interworking with the eye disease healthcare platform which supports entire treatment cycle including prevention, optometry/diagnosis, visual function training/treatment, effect analysis and management, enabling effective treatment of eye disease and restoration of visual function.

4. It can be used for to early diagnosis of other diseases that are caused by eye disease as well as preventive/therapeutic effects on eye disease.

ACKNOWLEDGEMENT

This research was financially supported by the Ministry of Trade, Industry and Energy(MOTIE) of the Republic of Korea Institute for Advancement of Technology(KIAT) through the Regional Specialized Industry Development Program (Grant Number : R0006352)

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