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Development of Training Instruments on Visual functions using HMD type Display and Investigation of its Demand

Seong Jae Lee, Se Hyun Oh

Department of Visual Optics, Kyungdong University, Gangwondo, Korea
lsj@kduniv.ac.kr

Abstract

We constructed 3-D images by HMD (Head Mount Display) type and polarization technique through which a training instrument of binocular function based on clinical vision therapy was developed and investigated its demand. To design the instrument that performs Test– Diagnosis - (Prescription) – Training - Treatment we provided a customized training method for the trainers using optical IT instruments of binocular test. Through the contents and the instruments of the vision therapy technology developed in this work we can replace the current vision test instruments to those costing 60% lower price in eye clinics and eye glasses shops. By replacing the existing vision test instruments it is possible to create a new market of the vision therapy in vision training instruments.

Key words: *HMD (Head Mount Display), vision therapy, binocular function, vision training instruments*

1. Introduction

According to survey results, performed in Korean gallop In 2015 requested by Korean opticians association, the percentage ^[1] of wearing eye glass or contact lens is 55.5% so that more than half of whole population in Korea. need to correct or improve their vision.

In case of advanced countries like United State or Canada medical workers caring human eye are classified as ophthalmologist, optometrist, and optician. Also, vision centers exist for caring, managing, and improving people's vision which works are different from ophthalmologist's work treating eye disease. The vision center runs vision function and vision improvement programs for managing or correcting people's vision not to deteriorate vision due to abnormal refraction. The work in the vision center is called 'vision therapy' ^[2] that is currently running even in EU countries.

In Korea, like advanced countries for vision center and vision therapy, it is necessary to develop vision caring and improving system through a well-designed vision recovery program for people deteriorated in vision function and refraction.

Hence in this research we developed a new vision therapy system (instruments) and related contents as well.

Also, we investigated market demand to keep our work going well.

2. User and Method

The existing ophthalmic instruments are divided into two categories that are diagnostic instruments and operating instruments. The diagnostic instruments including vision test consist of a camera part and a diagnostic part. The camera part includes a camera module that investigates and diagnoses refraction of eyeball. The diagnostic part performs calculations of refraction index of eyeball through a related algorithm.

The existing vision test and diagnosis instruments depend simply on the reaction of eyeball followed by simple vision perception in a vision table. According to the intended clinical test the kinds of vision stimulation are different and practical cure and description^[3] are followed by diagnosing the reaction of the stimulation.

Therefore, we developed the following one body typed vision perception/vision function test and practice instrument in which Test/Diagnosis/Training/Treatment can be performed altogether.

Vision test instrument (the same function of the existing test instrument)^[4] for short/long distance vision.

Test instrument measuring binocular function through a 3-D vision table (the same function of the existing test instrument)^[5]

Diagnosis instrument measuring squint and heterophoria through 3-D vision table.

Practice (Treatment) instrument for abnormal eye muscle of squint/heterophoria.

Practice instrument for preventing (improving) presbyopia through a convergence training program.

Prospective customers of the instrument are as follows

- Eyeglasses shop (usage of vision test/diagnosis instrument: replacement of the existing instruments)
- eye clinics (vision test/diagnosis instrument)
- vision class (vision training/vision recovery)
- Individual users for vision training

It is expected that new demand to replace the existing instruments in eye clinics and eyeglasses shops comes out and new users of vision class and prospective customers are also interested in this system.

The instrument including its contents in this research belongs to a field of vision perception/function training (Vision Therapy)⁷. The vision therapy shows various clinical examples in research works of north America and is reported to have an effectiveness in the following cases.

<Users>

- Children and students
- Computer workers
- Athletes to improve the athletic performance
- Company worker using continuous vision function
- Senior suffering from vision trouble due to presbyopia

<Improvement effects>

- Improving vision function of eye in doing work requiring continuous vision usage
- Improving and strengthening children's vision having abnormal vision functions
- Helping the study of children having abnormal vision functions
- Improving computer binocular troubles due to abnormal vision functions
- Improving the symptoms such as headache, doziness, haze and diplopia in reading and studying caused by abnormal vision function

Vision perception/vision function training (Vision Therapy) is a specialized field developed in order to improve vision function through vision training in case of no effect in wearing eyeglasses and contact lenses.^[6]

Hence, the researchers in many countries report their works regarding vision therapy. Also, vision therapy becomes an important field to opticians and optometrists working in eye clinics. However, in domestic area the clinical understanding of the vision therapy must be more studied in order to be applicable to practical business.

3. Results and Investigations

1) Market demand

Market of Ophthalmic Instruments means the market of vision test/diagnosis instruments in eye clinics and eyeglasses shops. In 2006 the market was about 2 billion dollars in size and was also predicted to become almost 3 billion dollars in 2012. ^[7] In whole market categories of vision instruments it is estimated that about 20% can be replaced by our new instrument in test/diagnosis regions (near vision diagnosis instrument, chart projector, automatic re-collector etc.). ^[8]

In considering the technical and functional replacement of the existing vision instruments, about 60 million dollars can be allotted in this business. Digital re-collector and near vision diagnosis instrument etc. have an introductory new life cycle enough to easily launch to the market. In Table 1 the major diagnostic instruments are compared with the parts that can be replaced by the product developed in our work. ^[9]

(1) Replacement of vision test instruments in domestic eye clinics and eyeglasses shops

The vision instruments market is divided into a market of vision testing instrument and a market of vision training instrument where the whole market of vision testing instruments is about 20 million dollars in size. The price of overseas product similar to our instrument is about 20 thousand dollars which is much more expensive compared to our instrument having low cost and great convenience.

(2) New market of vision training instrument for domestic eye clinics and eyeglasses shops

Since the market of vision training instrument is now created by its necessity any companies having proper products do not exist yet. In particular, the existing vision test/diagnosis instruments are available in this system and additional function of vision training instrument is included as well. Therefore, it is considered that new market can be created by the instruments developed in this work. Domestic vision care classes use overseas cheap mechanical products, which means that new demand of the classes can show up.

(3) Export to advanced countries in the field of vision therapy

In the field of vision therapy, the advanced countries are developing PC software. In case of the existing products, color blindness may occur due to a special eyeglasses using Red-Blue type. Also long time training is not possible. The vision instrument in this work does not make inconvenient visual stimulation because it provides 3-D visual stimulation using polarization technique. In comparison with the existing products of vision therapy it gives better technique enough to draw people's attention.

(4) Export to Asia and the Third World

Domestic vision instruments show high market competitiveness in Asia and the Third World markets because of having excellent functions with low price. For example, domestic company 'Huvitz' achieved high sales outcome in the Third World. Therefore, it is considered that the advance to Asia market is not difficult. ^[11]

Table 1. Comparisons of major diagnostic instrumentation in eye clinics and glasses shops with the product developed in this work ^[10]

	Major items	Major diagnostic contents	
Diagnostic instrumentations of glasses shop	Automatic refraction / keratometer	Measuring corneal curvature for fitting contact lens	
	Automatic lens meter	Measuring diopter and progressiveness of lens	

	Proximal sight tester	Measuring vision at 1.1m long distance	Replacement by the product in this work is possible.
	Chart projector	Measuring vision at 3m long distance	
	Automatic refractor	Automatically measuring phoria, squint, stereopsis and aniseikonia etc.	
	Refraction table	Automatic table installing auto-refractor	
	Lens grinder	Fitting lens to the frame of eyeglasses	
Diagnostic instrumentations of eye clinic	Visual field screener	Measuring the power of visual field	
	Slit lamp microscope	diagnosing eye diseases by investigating retina illuminated with a thin light beam	
	Tomometer	Measuring ocular tension	
	Ocular fundus camera	Diagnosing eye diseases by photographing retina	
	Indirect ophthalmoscope	Diagnosing eye diseases by photographing retina	
	Ultrasonic tester	Diagnosing eye diseases by photographing cornea	
	Corneal topogometer	Diagnosing eye diseases by measuring corneal topography	

2) Technical proficiency of developed item

(1) Distinction from the existing products

Table 1 shows vision test/diagnosis instruments except for vision operating equipment (instruments). This vision test/diagnosis market can be separated from current market of vision training instrument and the existing vendors do not produce the vision training/treatment instruments because it just began.

Although the test/diagnosis market and the vision training market are separated in industrial circumstances it is needed that customized programs must be made in developing the vision instruments because the two markets have the same root in clinical nature.

Table 2 indicates the distinction of the vision instrument developed in this work from the existing vision test/diagnosis and training/treatment instruments as follows.

- The test, diagnosis, training and treating can be functionally unified through one body equipment compared to the existing products separated out by test/diagnosis and training/treatment.
- It does not have any spatial or circumstantial trouble in installing the equipment because of light and potable

weight and size.

- Testing and diagnosing binocular eye are possible because it provides 3-D contents (vision table and test program) compared to the existing instruments.
- The existing training/treatment instruments are made by a mechanical process but the vision instrument in this work is made through an electronic process using IT technique.
- Compared to the existing training/treatment instrument it gives the individual setup service of the training programs.
- It provides an easy managing for user's information through computer program and memory function.
- Through computer programs and memory function the upgrade of the contents (test vision table, diagnosis and training programs) is possible.

Table 2. Distinctions of the product in this work from general diagnosis and treatment instrumentations

Classes	Style	Installation environment	Spatial use	Binocular/Stereoscopic support	Functions
Conventional vision test chart	Mechanical	Illumination control needed	Excellence	Impossible	Test/Diagnosis
Mirror type test instrument	Electronic	Illumination control needed	Excellence	Impossible	Test/Diagnosis
Projector type instrument	Electronic	Illumination control needed	Not good	Binocular	Test/Diagnosis
Conventional training instrument	Mechanical	Free	Excellence	Possible	Training/Treatment
Stereoscopic training instrument	Electronic	Free	Excellence	Imperfect	Training/Treatment
The product in this work	HMD/Electronic	Free	Excellence	Possible	Test/Diagnosis/Training/Treatment

(2) Uniqueness of the developed item (technology)

The vision instrument developed in this work is a visual perception/function test and training instrument in which vision test, diagnosis, training and treatment can be carried out in one body system. The existing vision instruments are only test/diagnosis instruments focused on prescription of eyeglasses and contact lenses by opticians and optometrists. However, this work makes it possible to meet the vision therapy with individual customer's needs.

Table 3. Utility and uniqueness of the item developed in this work

Function	Test/Diagnosis/Training/Treatment
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Customer	Conventional Instrumentation (Test/Diagnosis) The product in this work (Test/Diagnosis/Training/Treatment)
Technology	Diagnosis & Training program 3-D stereoscope (Polarization), DSP

In short, uniqueness of the item (technology) is as follows.

- It combines the two fields (test/diagnosis and training/treatment) in one body system. The two fields were separated in the existing products.
- It extends vision therapy technology to individual customers from vision experts such as opticians and optometrists.
- The extension of function and usage is possible in diagnosis and training program, 3-D program and DSP (Digital Signal Processing) technology.


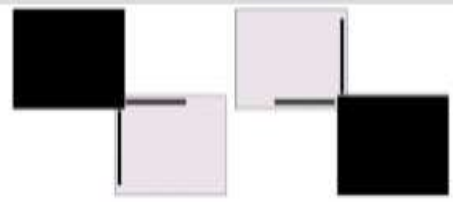

Normal binocular function (normal vision)	
Perception part of binocular vision chart using polarization	
Abnormal binocular function (abnormal vision)	

Figure1. Example of test and diagnosis (squint/phoria test)

The examples for constructing test, diagnosis, training and treatment programs of this instrument are as follows. The program is designed to do upgrading as well as continuous saving the training and diagnosing results through memory chips under application programs of firmware of the system.

Fig.1 is an example of the program to decide squint and heterophoria due to abnormal eye muscle or abnormal ocular position. It gives a training/treatment program on the base of information obtained from vision test and diagnosis. In other word the described program using prisms (optically clinical description) and eye muscle training let the people do self-training to expect healing effect. ^[12]

Fig.2 is an example of convergence in training in training/treatment functions. The program lets the long distance focusing be trained through a designed scenario. Therefore, deepening the symptoms of presbyopia can be deferred and eye fatigue of workers doing many near-looking jobs can be decreased by relaxing the stress of eye muscle. ^[13]

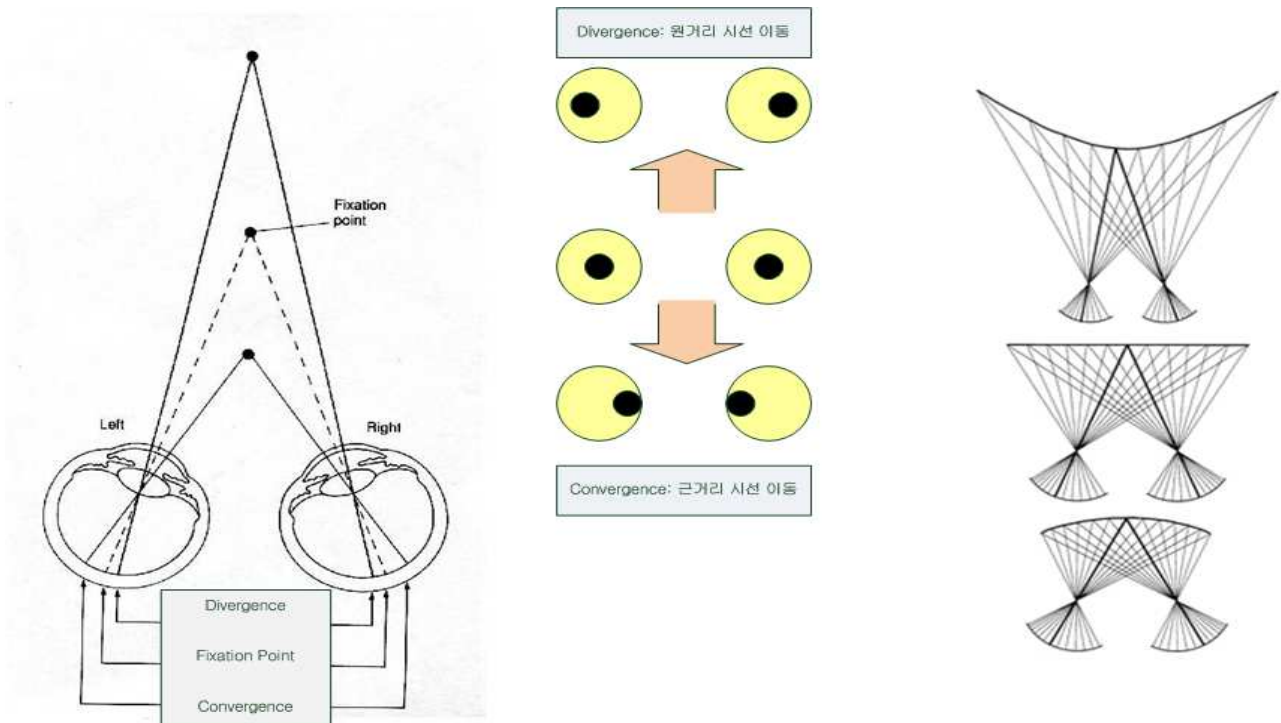


Figure 2. Example of training treatment (Prevention of presbyopia by convergence training) [14]

4. Conclusions

1. Competitiveness and propagation effect of the developed item

(1) Competitiveness of the developed item(technology)

<System diagram>

The system developed in this work consists of four modules according to functional regions and Embedded PC using 3-D vision test. Main S/W components on the base of the four modules are as follows.

Functional factors of the developed vision instrument

- Diagnosis: Setting the scenario of training/treatment in individual cases by deciding abnormal ocular position through image stimulation checked in binocular function
- Training: 3-D vision training and developing visual function with focusing power for people having normal vision
- Treatment: Treatment by cooperative training of vision correction and developing visual perception of abnormal ocular position

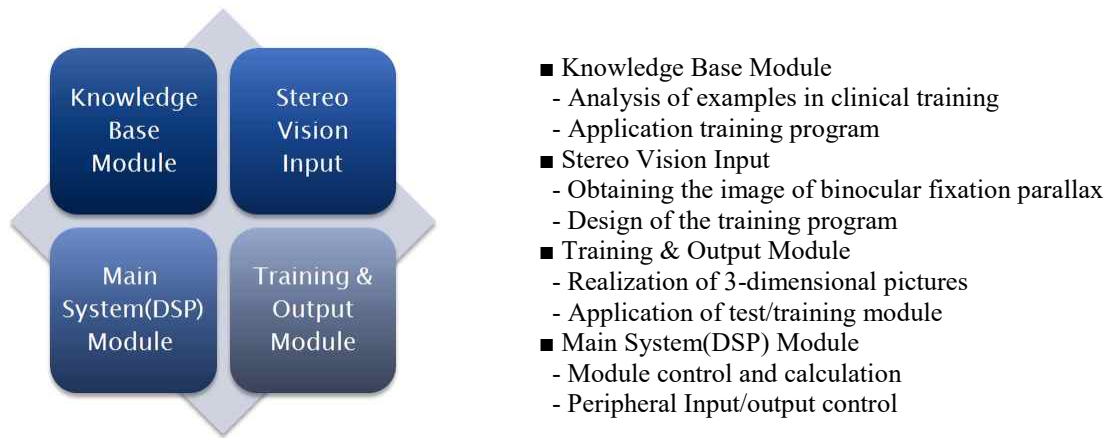


Figure 3. Functional component of the system instrumentation in this work

<Technical factors of the developed instrument>

- Polarization: Image separation between right and left eye perception by an image blocking method
- 3-D structure: Convergence expression of near distance and long distance
- DSP: Providing 3-D image structure and registration considering image fixation disparity

Table 4 indicates main functional specifications of the instrument developed in this work.

Table 4. Specification of the product developed in this work

Fields	Module	Major functions
H/W	HMD & Control Box	- Left/Right Display Panel and HMD Body - H/W providing the program connected to HMD
	Accessory	- Optical(Test) lens set needed in diagnosing and vision testing - Polarization filter to realize the stereoscopic vision
S/W	Knowledge Base	- Clinical program according to vision test/diagnosis/training functions - Database for setting the trainer(user) program
	Chart Design	- Design of vision test chart for basic test/diagnosis - Design of the training chart for visual perception and vision therapy
	Stereopsis Control	- Mergence and separation of image/picture to realize the stereoscopic vision - Control of special vision test chart for squint/phoria and low vision
	Peripheral Control	- Communication with HMD Display hardware - Storage for the programs and trainers D/B managements

(2) Propagation effect of the developed item (technology)

In this work, the system as alluded earlier can be used even in ordinary users without seamless situation with clinical logic for test, diagnosis, training and treatment regions.

This result means that the instrument developed in this work can help individual vision care even without support of clinical experts. Therefore, it is expected that new market giving better vision life in well-being

society can be created by the vision instruments in this work.

The existing instruments of eyeglasses shops and eye clinics have been produced only for single purposes such as test, diagnosis, training, and treatment respectively. However, the instruments developed in this work combines each functions into one body system through a well-managed and seamless process of the information obtained in each steps. This can draw vision care market into a new paradigm based on multi-functional vision instruments.

Vision instruments for vision test and diagnosis are indispensable for work doing in eye clinics and eyeglasses shops. The vision instrument developed in this work can do all jobs (projector, re-collector, and near vision diagnosis like in Table 1) together. Therefore, it is easy to install the equipment without considering illumination, space and test condition etc. Also low price of the instruments can create new demand to make more industrial research works possible.

The field of vision therapy is defined as follows

Vision Therapy

Vision therapy is a series of eye exercises designed to improve the functioning and efficiency of the visual system.

- Training for normal vision: keeping normal vision/visual function
- Diagnosis and treatment of abnormal visual function: improving visual function
- Training eye muscle: keeping eye health and improving focusing power
- Enhancing visual perception power: enhancing reading power for baby and child
- Improving Ellen symptoms: improving visual perception of colors
- Developing of eye/hand cooperative training model: occupational therapy of cerebral palsy patients

In the field of vision therapy, therefore, it is possible to draw global attention of the instrument developed in this work because of still using mechanical products even in advanced countries.

References

- [1] The Korea Optical News: Eyeglasses and C/L Wearing Percentage of Korean Adults 55.5%. 2015. <http://www.opticnews.co.kr/news/articleView.html?idxno=24919>(15 October 2015).
- [2] Korean Vision Therapy Center: Vision Therapy. 2015. <http://www.visiontherapy.co.kr/about/eye.php>(10 October 2015).
- [3] Hoopes, Ann M, Appelbaum, Stanley A. Eye Power : An Updated Report on Vision Therapy. 1st Ed. USA: Booksurge. . 2009;97-108
- [4] Kim JH, Shin JA. Refraction. 2nd Ed. Korea: Hanmibook. 2014;135-141
- [5] Ma KJ. Binocular Test. 1st Ed. Korea: Daihaks. 2007;18-19
- [6] Levoy, Robert P. 201 Secrets of a High-Performance Optometric Practice. 1st Ed. USA: Butterworth-Heinemann. 2002;37-42
- [7] Financial News: Global Coupling of Optometric Instrumentation. 2012. <http://www.fnnews.com/news/201211051305495808>(12 October 2015).
- [8] Itooz: Hubitz, Strong and Small Enterprise. 2010. <http://www.itooz.com/common/iview.php?no=2012080917582157539>(10 October 2015).
- [9] Scoop: Turnaround of Achievement to Eye Business. 2015. <http://m.thescoop.co.kr/news/articleView.html?idxno=16178>(25 September 2015).
- [10] Ministry of Food and Drug Safty: Annual Export of Domestic Medical Instruments. 2012. <http://m.zum.com/news/home/7143688>(8 October 2015).
- [11] The Optician's Association of Korea: Optician's Law that Guarantees Basic Eye Care Service for People. 2014.

http://www.optic.or.kr/cate_03/eOpticnews.asp?nmode=view&OnsSeq=2097&search_type=0(5 October 2015).

- [12] Griffin, John R., Grisham, J. David. *Binocular Anomalies: Diagnosis and Vision Therapy*. 4th Ed. USA: Butterworth-Heinemann. 2002;242-250
- [13] KAPLAN, Robert-Michael. *The Power Behind Your Eyes: Improving Your Eyesight with Integrated Vision Therapy*. 1st Ed. USA: Healing Art Press. 1995;143-160
- [14] Scheiman, Mitchell Scheiman, Bruce Wick. *Clinical Management of Binocular Vision (Paperback)*. 1st Ed. USA: Lippincott Williams & Wilkins. 2008;318-322