Functional Cognitive Rehabilitation Game Technology Applying Orientation and Memory for Preventing Dementia

Chulhee Lee, Sungin Hong, Seongah Chin

Abstract—The incidence rate for dementia has been increasing worldwide because of an aging population and major social and economic concerns. Because a rapid rise in this rate annually increases social and financial burdens, and effective solutions should be developed to prevent dementia disorders. Nevertheless, practical measures for dementia disorders are still insufficient. Hence, a functional game technology, which reduces economic burdens and facilitates frequent diagnosis and prevention of dementia disorders in our daily lives, is proposed in this study. In this technology, a Leap Motion recognition controller is used to promote finger movements and a mini-mental state examination is applied to a game user interface. In addition, a prototype using this technology is presented in this study.

***Index Terms*—dementia prevention, serious game, gesture recognition, MMSE**

I. Introduction

The World Health Organization (WHO) has reported that 35.6 million people worldwide are afflicted with dementia as a result of an aging population. Fifty-eight percent of these are from low-income countries, in which 7.70 million people are diagnosed with dementia every year. Approximately 71% of people with dementia worldwide are estimated to reside in low-income countries. Elderly people in these countries, which in general have insufficient budgetary expenditures for preventing dementia, are exposed to relatively greater number of dementia disorders, thus rapidly increasing the incidence rate of dementia. As such, dementia disorders lead to social and economic problems worldwide. However, the practical preventive measures taken thus far have been inadequate compared to seriousness of dementia disorders and their rapidly increasing incidence rates. This is critical because of a lack of social attention and economic assistance. Effective policies on prevention of dementia have also not been established. Dementia disorders are unlikely to be prevented because of the difficulty of estimating the onset of dementia and increasing costs of prevention. Thus, conditions such as reduction of economic burdens should be realized in order to develop preventive measures against dementia.

It has been reported that when the physical conditions of diseased patients were constantly managed, patient well-being can be improved when they used functional health games. These games, which are commonly played, can be used effectively as a preventive measure for dementia by applying functions of promoting prevention of dementia and identifying a degree of susceptibility to this disease [1][2][3].

Thus, the functional health game proposed in this study uses a leap-motion controller [4] to provide operations designed to stimulate finger movements and promote brain training, which are both effective for preventing dementia disorders. Further, the mini-mental state examination (MMSE) was applied to a game user interface (UI) to add functions that promote prevention of dementia and identify the degree of susceptibility to this disease.

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II. . Methodology

A. Finger movements using the Leap Motion controller

Fingers movements effectively prevent dementia by improving brain functions. In other words, they can serve as an effective method for preventing dementia disorders through constant management because they can be easily performed in daily life without special equipment [5].

To recognize finger movements, an accurate motion recognition device of either Kinect or Leap Motion should be used. Considering that finger movements represent main motion patterns, this study selected Leap Motion, which can track even subtle finger movements. Kinect devices are generally more appropriate for recognizing big movements. In addition, the Leap Motion controller possesses a high recognition rate for finger movements [6].

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TABLE I
THREE HAND MOVEMENTS

Clapping	Hand raising and lowering	Moving two fingers
		

Table I shows the results of visualizing effective finger movements for preventing dementia when using the Leap Motion controller. Among various movements such as clapping, hand raising and lowering, and the moving of two fingers, clapping, which is a big movement and can be easily performed, was used in experiments conducted in this study.

B. UI composition using the MMSE

In 1975, Folstein developed an MMSE that is simple and convenient, and has been used most often in the assessment of a patient's initial susceptibility to dementia, which requires only a short period for sensitivity analysis. It was considered appropriate for this study in that special equipment or training is not required [7].

The MMSE examines orientation, memory, attention, visuospatial skills, language, and related functions. A patient provides answers to a MMSE questionnaire. Based on the including score (highest possible score: 30), a person's degree of susceptibility to dementia is considered high if a person receives a score of 9 or less, moderate if the score is in the range of 10 to 14, and low if the score is in the range of 15 to 19. is the person is considered to be in a normal state for dementia if the score is 25 or higher [8].

TABLE II
MMSE QUESTIONNAIRE

Examination item	Question	Score
Orientation	Year, month, day, date, season	10
	Country, county, town, hospital, ward (clinic)	
Memory	Examiner names three objects (for example, apple, pen, and table). Patient asked to repeat objects, one point for each.	3

Table II shows a portion of the questionnaire corresponding to orientation and memory. These represent two of the six examination items used in the MMSE. Regarding orientation, 10 questions on the year, month, day, date, season, country, county, town, hospital, ward (clinic) are asked, which account for 10 points. In terms of memory, the examiner presents three object names. Three points are earned when the patient repeats them accurately. One point is deducted if a participant requests that the object names be repeated.

Orientation and memory can be effectively used to evaluate quantitatively a degree of a cognitive function disorder score grading time, location, and objects, and by observing changes in the cognitive function through repeated measurements [9]. Thus, the UI for the functional cognitive rehabilitation game technology proposed in this study was developed by applying orientation and memory among the six items of the MMSE. To improve the game functions for examining cognitive rehabilitation, points related to deviation in orientation and memory account for 13 of the 30 possible points on the MMSE. Moreover, the degree of an experimental user's susceptibility to dementia was classified as high, moderate, and low based on the game score obtained. The susceptibility degree is determined to be high if 15 or fewer points are obtained, moderate if 15 to 24 points are obtained, and low if 25 or more points are obtained. The higher the score, the higher is the user's susceptibility to dementia. When the user obtains a moderate or high score, he or she is considered to belong to a risk group of dementia incidence.

C. Implementation of the prototype of the functional dementia prevention game

The prototype of the functional game technology for preventing dementia, which promotes finger movements by using the Leap Motion controller and applying the MMSE, was implemented by employing Unity. Fig. 1 shows an execution screen of our prototype. The UI consists of two parts related to orientation as shown in Fig. 1. It consists of three parts related to memory. During a communication process based on questions and answers from the MMSE, the game user is asked to respond to questions displayed on the screen by clapping within a fixed time. A single clap means Yes and two claps mean No. When a correct answer is given by means of clapping, the user receives seven, eight points. When a wrong answer is given, no points are added. At the end of the game, a degree of susceptibility to dementia is displayed as high, moderate, or low.

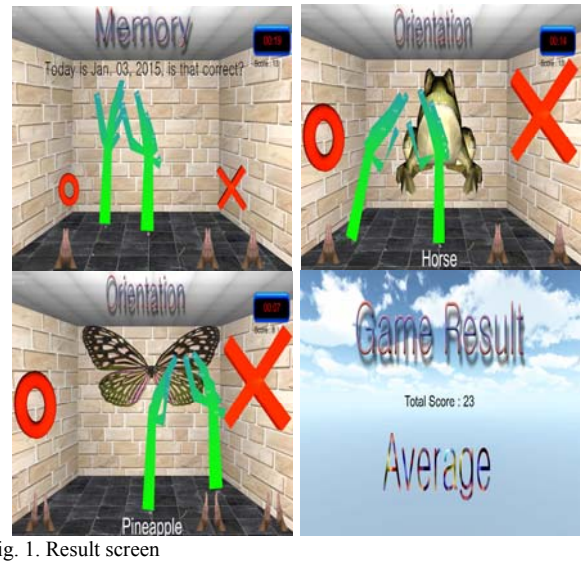

Fig. 1. Result screen

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Table III describes a mapping method of orientation and memory among the evaluation items of the MMSE.

TABLE III
MAPPING METHOD

Item	Mapping method
Orientation	The game user produces a single clap if the displayed date and location are correct (i.e., match those the user had in mind), and two claps if they are incorrect.
Memory	After being shown an object and text, the user produces a single clap if the name of the object matches the text, and two claps if it does not.

Regarding orientation mapping, a question related to a specific date and location is provided at the top of the screen. If the user deems them correct, the user claps once; twice if they are incorrect. When a correct response is provided, the user earns points.

In memory mapping, seven animals and fruits are compared to a given text. Object and text are randomly displayed in the middle and bottom of the screen. The game user claps once if the given text matches the object shown; twice if they do not. When correct responses are provided, the user earns points.

III. CONCLUSION

In this study, a functional game technology for preventing dementia was developed and a prototype using this technology was proposed to prevent dementia. We developed a game function that promotes finger movements which are effective in brain training. An MMSE is used to examine a person's degree of susceptibility to dementia disorders. The prototype for this study employs Leap Motion controller and is used for the purpose of assisting individuals and public institutions in preventing dementia disorders and identifying the degree of susceptibility to them. This technology requires no special programs and is not expensive.

This study can serve as a means of decreasing the incidence rate of dementia, improving early treatment rates, and solving social and economic issues related to the disease. In general, the functional game developed in this study can be used to prevent dementia and assess the degree to which a user is susceptible to dementia.

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