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The Collection System of Eye Movements for Psychological Disorder

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Abstract

ADHD is one of the psychological disorder of children and the national health insurance of korea reported the 55,000 of infants and children have ADHD in 2014. Since the features of ADHD lead to various side effects, such as the learning disability, memory ability, it is required to diagnose ADHD in childhood and start the treatment of ADHD. However, it is difficult to diagnose ADHD in childhood if the child does not show the hyperactivity symptom. Also, since the questions are too professional or the diagnosis test requires the cognitive and activity abilities, the children have the difficulties to understand the questions and show the proper response. To solve this problem, we propose the collection system of eye movements for ADHD diagnosis. The proposed system displays four types of korean texts: a letter, a word, a sentence and a paragraph. When a subject watches the sample texts, the system collects the coordinates and time of eye movements and transforms them into gaze pattern data for ADHD diagnosis. The benefit of the proposed system is that the physical interventions for the subject are not required to collect the diagnosis data during the assessment for ADHD.

Keywords: *psychological disorder, ADHD, eye movements, eye tracker, machine learning*

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1. INTRODUCTION

Attention Deficit Hyperactivity Disorder(ADHD) is frequent psychological disorder of children showing inattention, impulsiveness and hyperactivity figures[1][2][3][4][5][6]. The statistical data presented at the national health insurance service of Korea shows that the infants and children patients under 19 years old are 50,000 roughly in 2009. In 2014, the children patients of ADHD are 55,000 and still growing. In the US, it is supposed that 3 ~ 10% of children have ADHD[2]. On the past, medical doctors deal with ADHD as temporal disorder which becomes better as getting old. However, in present, ADHD is chronic disorder since the figures are still observed at adults which had ADHD during childhood or youth. It is reported that one or two thirds of childhood patients continue to suffer from the symptoms of ADHD throughout adulthood.

To improve the symptoms of ADHD, it is required to diagnose ADHD in childhood and start the treatments for ADHD. However, it is difficult to diagnose ADHD in childhood. If a child does not show the hyperactivity symptom and communicate with other people well, the parents does not feel the needs of assessments for ADHD before the child starts the reading or learning. Also, the existing diagnosis schemes have the problems for the child subjects to do the test of ADHD. The schemes for ADHD analyze the results of test responses or want to do other actions in addition to the reading. Since the questions for ADHD diagnosis are too professional or the tests require cognitive and activity abilities, the children have the difficulties to understand the questions and show the proper responses.

[1] presents an overview of recent eye movements studies in psychiatric disorders during childhood. In [2], the effect of word frequency for ADHD patients is presented. [3] proposes a differential diagnosis scheme using the eye tracking for ADHD and Reading Disorder. [4] shows the relationship between ADHD and vision impairments. The medication effects for ADHD patients using eye movements are shown in [5] and [6] proposes the rehabilitation system of cognitive functions in children with ADHD. Using a sequence of images, the eye movements of subjects are collected and analyzed in [7]. [8] surveys the recent eye tracking methods and classifies them into three categories. [9] proposes the statistical model to classify the subjects with dyslexia using a Support Vector Machine(SVM) scheme and the screening model for dyslexia using the eye tracker in [10].

To solve this problem, we propose the collection system of eve movements for ADHD diagnosis. The scheme of eye tracking supposes that the cognitive activity of a brain rises at the location the eyes are watching. Since ADHD is the psychological disorder, it is possible to infer the patterns of ADHD patient differ from them of normal children. To do this, it is important to gather the raw data tracking the eye movements for children. In the proposed system, it shows four types of korean texts. When the subject watches the sample texts, the system collects the coordinates and time of eye movements using an eye tracker. The collected data are transformed several types of gaze data to diagnose the ADHD symptoms.

The rest of the paper is as follows. In section 2, the related works are presented. the concept and the design of the proposed system is described in each `section 3 and 4. Section 5 shows the results of the implementation and the conclusion is presented in section 6.

2. RELATED WORKS

In [1], they present an overview of recent eye movements studies in psychiatric disorders during childhood and the specificity of eye movement findings across disorders. In the conclusion, they suggest to track the eye movement parameters in childhood continuously since eye movement parameters may be used to form a subgroup of patients having eye movement deficits in common. [2] shows the effect of word frequency for ADHD patients. To do this, eleven ADHD children and the same number of controlled children are selected. The results show that major word frequency effects are reveled in the fixation duration, the single fixation time, the gaze duration and the increased number of fixation for both group. A differential diagnosis scheme using the eye tracking for ADHD and Reading Disorder(RD) is presented in [3]. The children of RD group show longer reading time, fixation duration and unusual eye movements. The children of ADHD also show similar results compared with the controlled group. However, the only difference between ADHD group and RD group is the total reading time.

[4] shows the relationship between ADHD and vision impairments. The rate of ADHD diagnosis in visual impaired group is higher than the expected in normal subjects. They conclude that the ADHD patients should

consider the treatment for ocular issues even though the cause-result between visual problems and ADHD is not proved. The medication effects for ADHD patients using eye movements are presented in [5]. They recorded the eye movements of three groups: a group of ADHD patients with the medication(especially methylphenidate drug), a ADHD group without the medication and a controlled group while performing the test of variables of attention(t.o.v.a). The results show that the micro-saccade and blink rates are higher in ADHD group. With the medication, the micro-saccade of ADHD patients is significantly similar with that of the controlled group. [6] proposes the rehabilitation system of cognitive functions in children with ADHD. To do this, they develop the dual system composed of an eye tracker and a hand gesture recognition sensor using the .NET framework. Also, the system usability scale(SUS) questionnaire and the questionnaire for user interaction satisfaction(QUIS) are exploited to measure the effects of the proposed system. The result shows that the high mean scores of the SUS and QUIS are taken and it helps the ADHD children to develop their learning and attention skills.

[7] collects and analyzes the eye movements of subjects using a sequence of images. To do this, they develop and test several data mining schemes for automatic analysis and visualization of eye movements data. The first is the Expectation Maximization to model the distribution of a fixations and classify the likelihood of fixations. The second is the Levenshtein distance method to compare sequences of fixations. The last is the analysis of the transitions frequencies of fixations. The results show that the Levenshtein distance method is the best with the error of the 11.8%. The eye tracking methods are presented in [8]. According to the position of the eye ball, the methods are classified in three classes. The first is the eye trackers based on the contract lens with mirrors. The second is the eye trackers based on the eletrooculogram measuring the bio-potentials of eye balls using electrodes. The last is the trackers based on the video using a video camera to track the position of the eye.

[9] proposes the statistical model to classify the subjects with dyslexia using a Support Vector Machine(SVM) and the eye tracker. To do this, they train the proposed model with a dataset composed of 1,135 readings of Spanish speakers from 11 to 54 years old. The evaluation metric is composed of 8 values: a typeface for dyslexia, a typeface preferred by the participant, the number of visits, the mean of visits, the sum of visits, the mean of fixations, the number of fixations and the sum of fixations. They concluded that the reading time, the mean of fixations and the age of the participants are useful for the assessments. The screening model for dyslexia using the eye tracker is proposed in [10]. The predictive modelling and statistical resampling techniques are exploited to differentiate high risk subjects from low risk subjects with high accuracy. Also, for each type of fixation and saccade, they define parameters measuring the duration, the distance spanning, the average eye position, the standard deviation of the average position, the maximum range between two positions and the accumulated distance over all subsequent positions.

3. The Collection System Of Eye Movements

When a subject watches an object or a location of a screen, a cognitive activity of the brain rises in order to recognize the object or the meaning the location represents. Following the similar mechanism, the eyes of a subject stays a specific location of a text for a while to process the information of a region the eyes are watching. Then, the eyes move to the next location in order to process next information. These patterns are repeated until the subject reads a whole sentence or paragraph. A fixation is the location the eyes almost hold and a saccade is the movements quickly to the next location from the previous location. Generally, since korean texts are aligned from the left to the right, the movement of the eyes starts from the left to the right. However, if the subject has difficulties

to understand the texts he reads, the eyes return to the location the reprocessing is required and re-read the texts. The regression is the repeated reading. To analysze the pattern of eye movements for the diagnosis, the following pattern data are required: a fixation, a saccade, a gaze, a go-past, a number of fixation, etc.

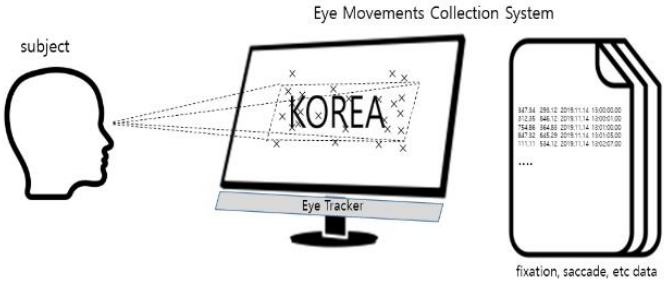


Figure 1. System concept diagram

Figure 1 shows the collection system of eye movements. When a subject watches the texts displayed on the screen, the eye tracker collects the coordinates and the time of the eye movements. Several diffferent texts are displayed continuously in order to collect various eye movements. The collected data are recorded and transformed into a fixation time, a saccade time and etc. for the analysis of ADHD.

To support various sample texts, four kinds of texts are considered. The first is single korean letter composed of one or two consonants and one vowel. If two consonants organize single pronounce, that is considered as single consonant such as a double consonant. The second is a word composed of more than one letter. If a single letter has the meaning, it is considered as a word. The third and the last are a sentence and a paragraph composed of more than several words.

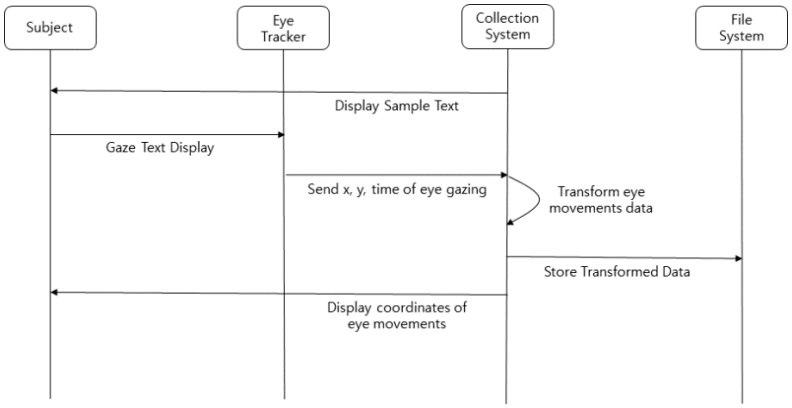


Figure 2. Sequence diagram

The sequence diagram of the proposed collection system is shown in Figure 2. The collection system displays a sample text on the screen of a PC. When a subject gazes the displayed sample text, the eye tracker collects the coordinates of eye and time continuously. After a burden of collected data is sent to the collection system, the collection system transforms the collected data to the pattern data, such as a fixation time, a saccade time, and etc, for a diagnosis. These process are executed repeatedly until the subject watches the whole sample texts. Then, the transformed pattern data are stored on the file system and the collection system displays the coordinates of eye movements on the screen.

4. Design Of Collection System

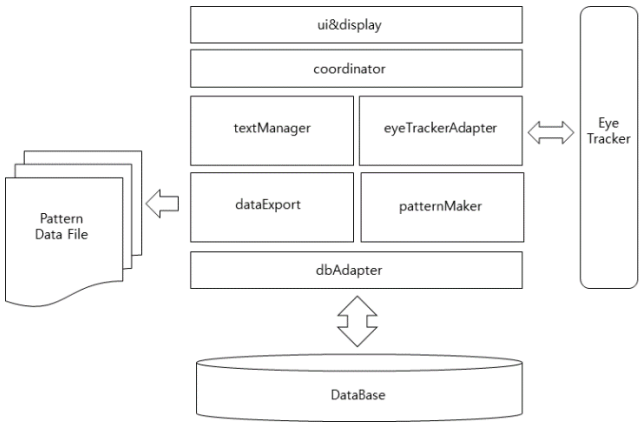


Figure 3. System architecture of collection system

Figure 3 shows the system architecture of the collection system using an eye tracker. The system is composed of seven classes. The first is the ui&display class. This class provides methods to display sample texts and the result coordinates collected by the eye tracker. The coordinator class is a main class to coordinate functions the composed class provide. The eyeTrackerAdpater class manages the eye tracker H/W and collects the raw coordinates and time of eye movements. The textManager class manages four types of sample texts the proposed system supports. It provides basic GRUD functions for sample texts. The patternMaker class transforms the raw coordinates and time data to a supported pattern data, such as a fixation time, a regression time, and etc. the dataExport class exports the transformed pattern data or raw data to a data file. The dbAdpter class provides the GRUD functions based on the Database.

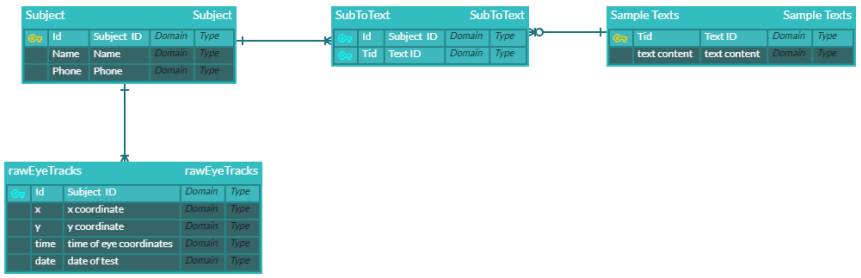


Figure 4. ER diagram of collection system

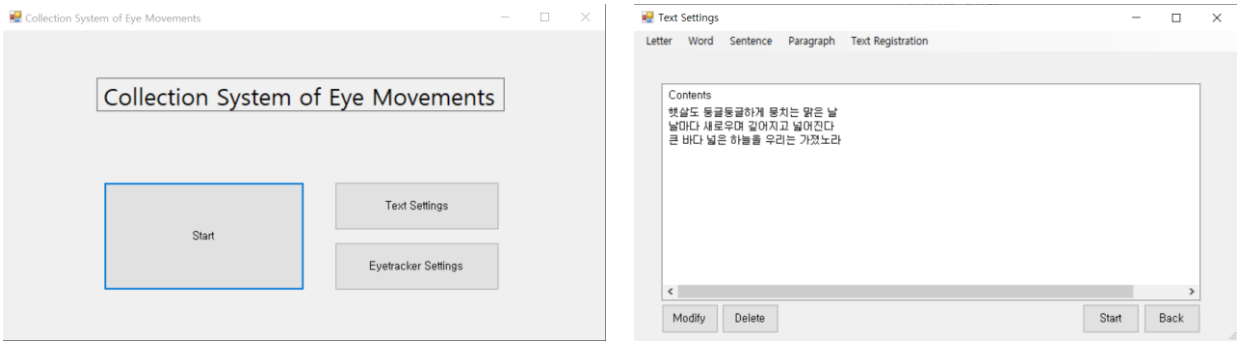
The ER diagram of database is shown in Figure 4. The database is composed of 4 entities. The first is the rawEyeTracks entity which stores x, y coordinates, time and date to be collected. It has one to many relationship with the Subject entity. The Subject stores the basic data of a subject which do the eye tracking test using the provided sample texts. The sample texts are stored in the SampleTexts entity. The SampleTexts entity has zero to many relationship with the Subject entity through the SubToText entity.

5. System Implementation

Table 1 shows the system environments to implement the designed collection system of eye movements.

Table 1. Implementation Environments

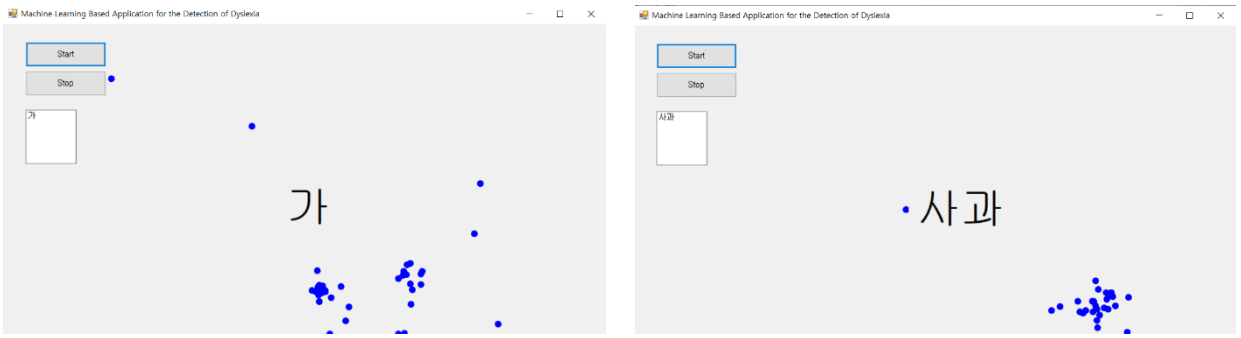
Division	Environment
OS	MS Windows 10
Processor	Intel(R) i5 7200 2.5GHz
RAM	8.0GB
System Type	64bit Operating System
Eye Tracker	Tobii Pro X2-30



(a) Initial screen **(b) GRUD of sample Texts**

Figure 5. Initial and sample texts management

When the implemented collection system is executed, the main menu is displayed as shown in Figure 5(a). The Start button starts the collection of eye movements displaying sample texts. The TextSettings button manages four types of sample texts as shown in Figure 5(b). Basically, the GRUD functions are provided for single letter, single word, single sentence and a paragraph written in korean.

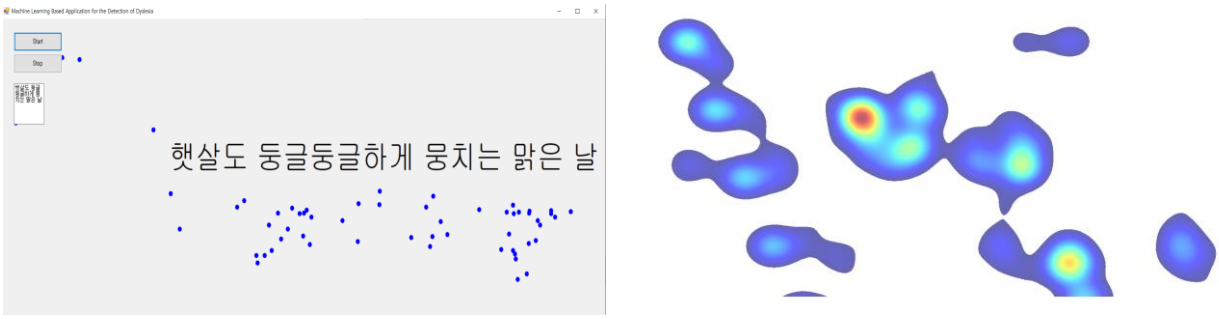


(a) korean word **(b) korean word**

Figure 6. Korean word and sentence

After the subject select the sample text type to collect the eye movements, the registered sample texts are

displayed on the screen as shown in Figure 6. And then, the subject is able to start the collecting using start button. Figure 6 shows the results after a subject watches single letter and a word.



(a) results of a sentence **(b) the number of fixation frequency map**

Figure 7. Collection results of eye movements

Figure 7 shows the data results collecting eye movements using a sentence. The Image map of the number of frequency fixation resulted by Figure 7(a) is shown in Figure 7(b).

6. Conclusion

ADHD is one of the psychological disorder of children showing inattention, impulsiveness and hyperactivity figures. Since the symptoms of ADHD lead to various side effects, such as learning disability, it is important to assess ADHD symptoms and start the treatment in childhood. However, since the assessment questions for ADHD are too professional or the tests require cognitive and activity abilities, the children have the difficulties to understand the questions and show proper responses. To solve this problem, we proposed the collection system of eye movements for ADHD diagnosis. When a subject watches four types of sample texts, the system collects raw coordinates and time of eye movements and transforms them into the pattern data. The further research is the design and development of screening modules for ADHD using the generated pattern data.

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