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SYSTEM DESIGN OF SYMPTOM DETECTION OF MILD COGNITIVE IMPAIRMENT WITH OBSERVATIONAL ROBOT

[1]GO-EUM CHA, [2]DO-EUN KIM, [3]KANG-HEE LEE

[1]Soongsil University, School of Computer Science & Engineering, Seoul, Korea

[2]Soongsil University, Global School of Media, Seoul, Korea

[3]Soongsil University, Global School of Media, Seoul, Korea

E-mail: [1]goeum.cha@gmail.com, [2]stellaeunjinkim@gmail.com, [3*]kanghee.lee@ssu.ac.kr

ABSTRACT

This paper proposes a robot observation system that enables users to recognize mild cognitive impairment and early dementia. The behavior of users will be recognized by a household robot to accumulate behavioral data which are forgetfulness, wandering and sleep disorder that is suspicious of dementia symptoms. DemTect, which is a sensitive examination tool of cognitive impairment for early dementia, can check symptoms of dementia immediately by data. This process proceeds continuously. If the user is evaluated to be below the normal range after the DemTect evaluation, this system notifies the caregiver that user should be needed professional inspection, which proceeds continuously. This system has the purpose not only to recognize signs but also to respond promptly to early dementia.

Keywords: *Robot System Design, Mild Cognitive Impairment, Diagnostic System, Mobile Application, Web Application*

1. INTRODUCTION

1.1 Background

In 2017, there are an estimated 962 million people aged 60 or over in the world, comprising 13 percent of the global population. The population aged 60 or above is growing at a rate of about 3 percent per year. Rapid ageing will occur in other parts of the world as well so that by 2050 all regions of the world except Africa will have nearly a quarter or more of their populations at ages 60 and above [1].

According to the OECD survey in 2014, 17 of the 37 nations were an aged society with an elderly population of more than 17%[2]. This means that many countries have entered the aging society, and therefore there is an urgent need to study and care for the elderly and geriatric diseases. In addition, current people want a healthy old age life as their life expectancy. However, due to an increase in life expectancy, cerebral-related degenerative diseases such as vascular dementia and Alzheimer's dementia have been increased and the cause has not been clarified yet. Therefore, the attention of these diseases will be needed [3].

Dementia is a major disease that occurs in the elderly, and it is a major disease that increases the burden on the national healthcare finances as the early detection and treatment of dementia are delayed. According to a report by Alzheimer's Disease International (ADI) in 2015, the number of people with dementia is expected to double every 20 years [5]. The increase in the number of people with dementia is a global problem, and the World Health Organization recognized it as a major public health problem [6]. However, since the current dementia does not have the complete remedy through elimination of the causative factor, but it is at the level of alleviation of the symptom. Therefore, it is important to treat dementia in early stage to minimize the quality of life and loss of medical expenses [7].

Early diagnosis of dementia is important to distinguish cognitive changes due to normal aging and mild cognitive impairment (MCI), which refers to a transient state between dementia both. It has been reported that MCI is perceived as a high-risk condition in Alzheimer's disease and about 10% of MCI progress to dementia [8]. Cognitive screening is one effective way to diagnose MCI. It is a cost-effective assessment tool that can be quickly identified in small amount of time. This screening

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helps identify neuropsychological dysfunction, MCI, and dementia [9]. Moreover, individual and continuous observation based on understanding of disease as well as cognitive screening is important for the diagnosis of MCI [10]. However, due to the need for individual observations tailored to the characteristics of the patient, continuous observation by the experts has two drawbacks. First, it requires a tremendous amount of human resources. Second, the final judgment may not reflect the current state of patient [11]. Therefore, it is necessary to introduce an automated robot system in order to efficiently perform individualization and accurate observation of patients.

1.2 Goals

The system in this paper is a new diagnostic-social robotic system, driven by a growing number of attempts to integrate artificial intelligence into robots. Unlike a robot, a caregiver cannot keep eyes on a subject that they want to observe for every time, and it is difficult to notice the details. Therefore, the purpose of the system we develop is two points. One is to help the caregivers protect the target users through the observation robot. Another one is that, by implementing a structure for diagnosing mental disorder in the observed target, additionally gathered information enables continuous care of the potential patients. This system presents the possibility of the diagnostic-social robot system.

We propose a cognitive test system to identify the individual cognitive state of the patient and an early dementia recognition robot system that implements the behavior recognition algorithm based on the symptoms of mild cognitive impairment. The specific objectives are as follows.

- To build a cognitive screening test that is optimized for the diagnosis of mild cognitive impairment.
- To identify the behavioral characteristics of mild cognitive impairment and design a behavioral recognition algorithm.
- To design a system that reports the results of the above system to caregivers or experts.

1.3 Terminology

First of all, target user refers to the person who directly takes the test. The user can be observed by a robot in daily use to recognize their abnormal behavior. This user group is mainly in their 50s or older who are likely to suffer from dementia. The user may be living with the family, but the elderly living alone can be also be targeted. This user group may refer to a patient already suffering from mild cognitive impairment.

The expert refers to those who have expertise in mild cognitive impairment and can make a medical diagnosis. They can monitor and diagnose the user's symptoms through information in the diagnostic system, if necessary, by combining the patient's information and the caregiver's survey can contact the caregivers for professional treatment.

Caregivers can be referred to the guardians of target user group. They may live in the same residential environment with target user but may not be living together. They conduct surveys from experts about target user.

2. RELATED RESEARCHES

2.1 Definition and Behavioral symptoms of Mild Cognitive Impairment

2.1.1 Mild Cognitive Impairment (MCI)

Mild Cognitive Impairment (MCI) is defined as the symptoms of patients that have low scores of verbal recall, visuo-spatial recall, verbal fluency and naming, visual recognition, objective sorting and etc. without dementia symptoms. [11]

2.1.2 Behavioral symptoms of Mild Cognitive Impairment

MCI is classified as a transitional phase between normal aging and Alzheimer's disease, with heterogeneous and diverse symptoms. It is characterized by mild memory impairment and is thought to be a precursor to Alzheimer's disease[12], Symptoms of Alzheimer's disease includes forgetfulness, disorientation, wandering, and sleep disorder. MCI also accompanies these symptoms with memory decay[13].

2.2 Definition and Behavioral symptoms of Mild Cognitive Impairment

2.2.1 DemTect

DemTect, first introduced in Germany in 2000, has the advantage of detecting cognitive dysfunction as well as MCI. This test tool consists of 5 subitems. 10-word list repetition, delayed word list recall, number transcoding, semantic word fluency task, and backward digit span. This is for evaluation of language memory ability, numeric conversion ability, word fluency, and work memory ability [14]. DemTect was also released in English in 2004 and is also recommended as a German national and international guideline as a simple way to detect mild cognitive impairment and early dementia [14,

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15, 16, 17]. The interpretation of the DemTect score is shown in the following table 1.

Table 1: Interpretation of DemTect scores [14]

Total Score	Diagnosis	Recommendation
13-18	Cognitive abilities appropriate for target age	Retry DemTect after 12 months or when symptoms get worse
9-12	Mild cognitive impairment	Retest DemTect after 6 months - Observation course
0-8	Suspected as dementia	Additional diagnostic instructions, start treatment

2.2.2 Reasons for selecting DemTect

A variety of tools such as Mini-Mental State Examination (MMSE), Clock-drawing-test (CDT), PANDA [18], EASY [19], MUSIC [20] and DemTect. However, DemTect is currently recommended as an early screening tool for dementia in the tertiary consensus conference in Canada and The German neuroscience (destscheesellschaftfürneurologie; DGN) and has been translated into several languages, including German, English, French, and Polish [21]. In addition, what is important in cognitive testing tools is the reinforcement of testing according to age and education. The evaluation of DemTect is based on the 12-year-old basic education level, with one additional point on the total score [22]. DemTect was selected as a testing tool for the early diagnosis of dementia by an internationally recognized organization, because of its sensitivity to diagnose MCI.

2.3 Detection-Methods of Behavioral Symptoms of Patient

2.3.1 Inquiry using B-ADL(Bayer Activities of Daily Living)

Patients with dementia have a decline in IADL (Instrumental Activities of Daily Living) due to decreased cognitive function. The evaluation of IADL in dementia patients is important for the following reasons. First, the evaluation of IADL is necessary to diagnose dementia. In order to diagnose dementia, not only the cognitive disorder but also the significant disability of everyday life and social life are required [26]. This suggests that dementia may not be present unless the cognitive decline of the patient has a meaningful impairment in daily life. Therefore, evaluation of daily living ability is necessary. Second, the evaluation of IADL is useful for early diagnosis of dementia [27]. IADL is susceptible to early diagnosis of dementia because it declines from the early stages [28]. Finally, through IADL evaluation, the medical practitioner can get detailed information about the degree of independence of the patient's daily life and refer to the treatment [27]. For IADL evaluation, it is preferable for the medical person to make an evaluation by interviewing the carer and the patient. Therefore, the carer's IADL evaluation paper will give priority to the medical person to evaluate the IADL. Bayer-ADL (B-ADL), which was developed to be used internationally as a collaborative work of the United States, Germany, the United Kingdom, Russia, Greece, will be used as the paperwork tool [29].

2.3.2 Observation of robot

Behavior recognition through the camera of the robot is carried out to recognize and identify the symptoms of dementia such as roaming and sleeping disorder. In addition, in the case of the elderly living alone, it is not easy to catch up with their anomalies because it is difficult for the caregiver's IADL evaluation to be done.

2.4 Technical Approach in Related Studies

Various technical studies have been conducted to determine or alleviate dementia symptoms. There are researches such as a system that recognizes symptoms of dementia by making a communication module with a computer avatar, [23] and a cat robot that alleviates symptoms of dementia through interaction with dementia patients [24]. Studies by Nowak and Biocca (2003) show that images with low anthropomorphism increase coexistence [25], demonstrating that several studies use simplified characters or animal shapes for effective interaction.

The research about CATARO [30], conducted by Hock, Oshima, and Nakayama, concentrate on communication problems that occur between caregiver and patient. Peripheral symptoms, behavioral and psychological symptoms of dementia such as abusive language, violence, insomnia, delusions, the things were stolen, wandering around, highly depend on how other people are treating or talking to a patient. Listening to the conversation between robot and patients, caregiver notice patient's non-critical condition indirectly, also

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caregiver can learn the way of communication to patients.

The analysis of PARO [31], it verifies the patient's positive reaction and intimacy to the robot through the real interaction experiment between dementia patients and PARO. Analyzing the behavior of participants, the average physical and verbal interaction grows linearly. It proves that dementia patients willingly interact with the robot.

Safety care system based on dementia assessment system is also proposed. Using RFID, a caregiver can follow up patients' indoor and outdoor activities and prevent them from the hazardous area. To guide the appropriate safety monitoring system to the caregiver, it offers dementia assessment system by using eXtensible-Markup-Language(XML) technology. Caregiver design the questionnaire from the website so that they can produce assessment systems easily. [32] These two systems make caregivers can quickly identify the patient's safety.

At last, a software-based on knowledge-base-system obtaining data from microphone or camera provides help to caregiver's or robot's patient care as forms of Graphic User Interface (GUI) or robot system.[33] The purpose is to provide appropriate care to the patient through observation.

3. DESIGN OF SYMPTOM DETECTION OF EARLY DEMENTIA WITH OBSERVATIONAL ROBOT

3.1 Problem Definition

It mainly selects elderly people living with their families or seniors living alone. The robotic system first performs DemTect, which is the cognitive screening test mentioned in 2.2.1, and the expert directly judges whether the dementia is suspected based on the performance results. Based on the derived results, we can observe the daily life of the subject through the robot system so that the behavioral characteristics of the MCI described in 2.1.2 can be found. If behavioral characteristics of MCI or dementia are repeated more than a certain number of times on the basis of continuous behavioral observation, the presence of suspected dementia is confirmed by DemTect test again. IF the DemTect score is less than 12, a notice of suspicion will be sent to the caregiver.

3.2 Overall Architecture

The person who is at risk of developing dementia symptoms is arranged in the interaction environment to transmit the instructions or conduct the test through the graphical interface. The patient's behavior pattern is analyzed through a microphone and sensors around the robot and transmitted to the system. Experts analyze the test results information and behavior pattern information gathered through the system and make input the expected diagnosis results into the managing system. Based on the input diagnosis results, the robot continuously analyzes the behavior pattern, and the caregivers can acquire the condition of the subject based on the given information.

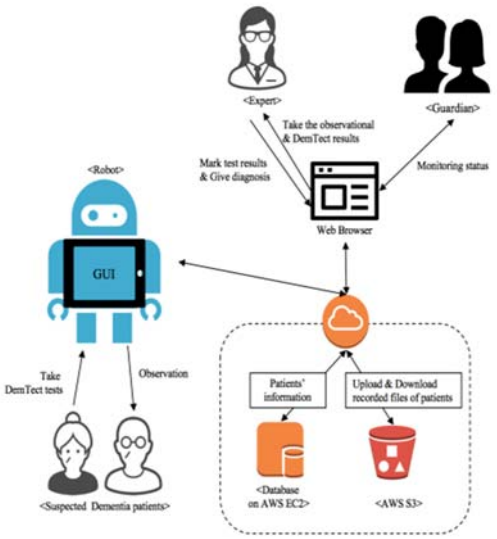

Figure 1: System Design of Interaction between System Users, Robot and Caregiver

3.3 LOCAL: Robot Graphical User Interface

For experiments, a social robot named Q.Bo is used. This robot is based on the raspberry pi that requires small computing power and has low-cost is used to verify this project. Due to this robot that has no visionary aid appliance, an iPad Pro have been used to provide user graphic user interface in front of the robot. The five testing methods in DemTect mentioned in 2.2.1 will be provided in graphical contents and phonetic guides to process cognitive testing. To provide the screening test, an application is implemented and is connected to the robot by simple socket programming to share user information. The robot and iPad are independent computing resource so that the system cannot know which user's information should be processed by each device. The application is based on iOS 11.0 implemented by XCode. The spoken and visual response of DemTect will be temporarily stored at local mobile application then this data will be sent to remote database.

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Figure 2: Experiment robot, Q.bo

3.4 REMOTE: Web Browser

For providing an easy way to manage users' information and to analyze the results of testing and behavior observation, a managing system is presented in web application. This application is executed by Django framework (v1.8) uWSGI on Amazon AWS EC2 instance. The information that the database already has been gathered for this system will be presented by web browser.

3.5 Database

The database that possess every information of each user is created by Django ORM (Object-relational mapping) in MySQL. This database is managed exclusively to other process. If the data is requested by mobile application, it will be shared by calling handmade API which can access database by PHP. In another way, if the web pages request information to be shown, Django framework filters appropriate one.

4. SCENARIO DESIGN

4.1 Integrated Scenario

As shown in Figure 3, we start with the user's basic information registration and proceed with the cognitive impairment test (this) for the first time. The results of the cognitive test and the results observed by the robot are merged so that the expert can remotely check the presence or absence of the dementia of the subject.

Figure 3: Flowchart of Integrated Scenario

4.2 Target Scenario

In the life of the general public, a robot that includes a camera and a microphone is placed, and DemTect, a cognitive screening test, is performed, and the result is used to detect a change in life pattern that may cause early cognitive dysfunction. Changes in life patterns include sleep habits change and wandering. In case of receiving the notification of retry of cognitive screening according to the recommendation in the table of 2.2.1, the test is performed through the graphical interface of the robot. A simple dialogue is provided through the dialogue screen provided in the GUI environment. Daily conversations will be done with robots and nurturing.

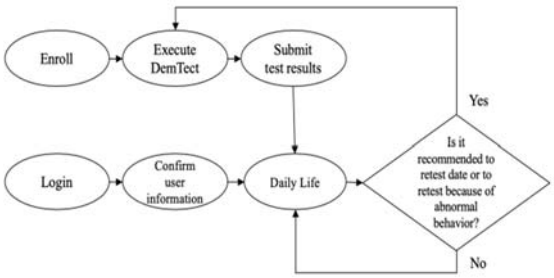

Figure 4: Flowchart of Target Scenario

4.3 Expert Scenario

Experts diagnose symptoms based on observations stored on the server. This system classifies the normal group and the risk group as a result of integrating the DemTect progress received from each patient through the system and the results of the protector survey. And then this system observes the member's behavior observation list and perform continuous observation. If more than the behavior pattern is found more than the cognitive

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screening test, encourage the retest. If the target user has a potential to be a patient, the system will send a request for a request to visit doctor.

4.4 Caregiver Scenario

The robot will be installed outside the behavior radius of the patient or the subject to be observed. Patient registration and then cognitive screening will be progressed. However, it shall be possible for the test subject to carry out the test alone so as not to affect the test at all. They will observe the cognitive screening results of the patients entered by the specialist and follow the behavioral guidelines recommended to the caregiver. At last, caregivers receive alarms related to surveys and conduct surveys on whether or not they live together and observations. (B-ADL)

4.5 Detection System Scenario

Based on the results of cognitive screening conducted by the patient, the normal group and the risk group are classified. If the patient is in group of possible dementia patients, a notification is sent according to the recommended retest period according to the test score. If the retest results show that the patient has symptoms of dementia possibly, the result notification will be sent to the caregiver.

The dialogue with the patient with mild dementia is conducted so that the symptoms do not deteriorate. When conducting the retest, send a survey letter to the guardian. Before the survey is conducted, confirm whether or not you live together. At the time of cohabitation, the guardian will be allowed to conduct surveys. During non-cohabitation, guardians should not conduct surveys and experts should be able to determine the status of the target only as a result of DemTect. If it is not possible to check whether or not the system is alive for a certain period of time on the system, determine the status of the target by DemTect result.

For the possible developed scenario, continuous observation can prevent not only mild cognitive impairment but also other diseases. What's more, when an elderly person is in an emergency, if the elderly person has no movement for a certain period of time (in case of loneliness), he or she can notify the specialist and the guardian so that the first aid or follow-up can be taken.

4.6 Recognition Patient Behavior Scenario

We use a robot to observe problem behaviors that may be associated with dementia in the subjects. If the robot continuously detects an abnormal behavior such as a sleeping disorder or roaming of the subject, it accumulates the number of times and checks DemTect information when it is detected more than 5 times in the system. This abnormal information is collected to help experts to judge whether the user has the possibility of disease.

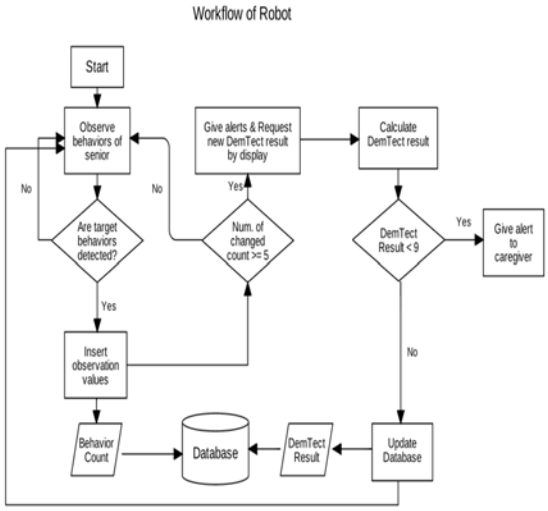

Figure 5: System Design of symptom recognition of patient behavior

4.7 Data Management Scenario

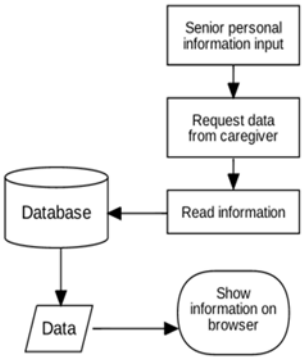

Figure 6: System Design for caregiver to monitor senior

5. Experiments

5.1 Target Scenario

5.1.1 DemTect Test

5.1.1.1 10 words list repetition

The ten-word list iteration is a test that makesa patient to remember given ten words (refer to figures 7 and 8).

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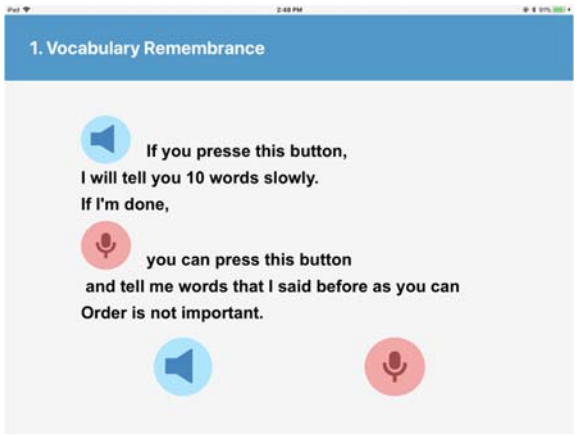

Figure 7: Test process of 'Word List'

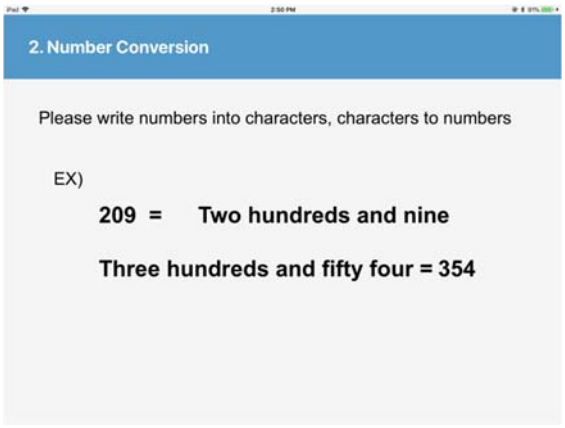

Figure 9: Test example of 'Number Transcoding'

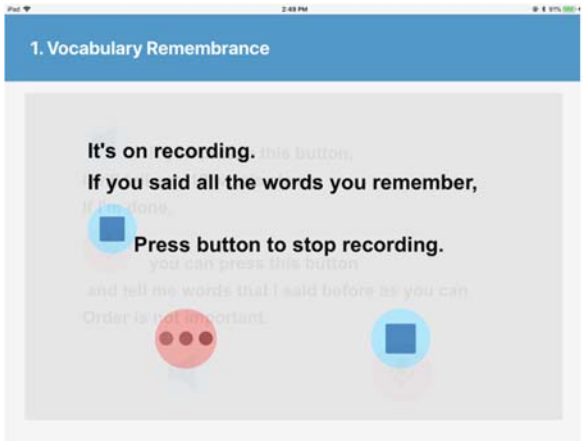

Figure 8: Recording process interacting with a target

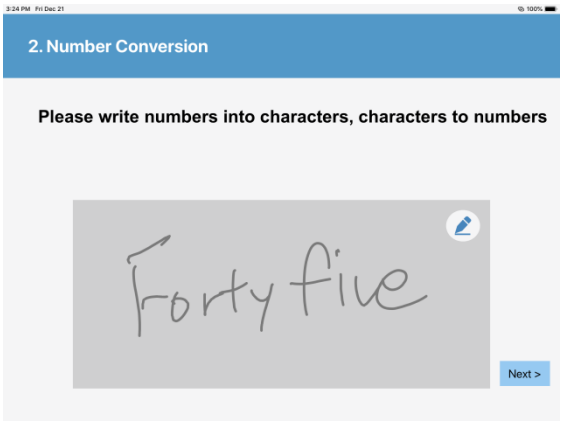

Figure 10: Test Example of 'Number Transcoding'

To accomplish this with a mobile device, a set of 10-word lists is stored in the database. When a patient presses a speaker button to perform this test, one of the 10 sets will randomly speak 10 words through the speaker. Then the patient presses the microphone button to record the 10 memorable words. This will be used as a resource for professional scoring through web services.

5.1.1.2 Number transcoding

Number transcoding is a test converting the format of numbers.

As shown in Figures 9 and 10, given that ordinary cognitive tests are provided to test takers in paper form, we used two methods to make input of correct answer writing on the screen or using the mobile keyboard. Each form of problem is given twice, randomly assigned by the server. This drawn or typed answer is sent to the server and used for each user's DemTect scoring.

5.1.1.3 Semantic word fluency task (Supermarket task)

This is test for users to measure how many words that they can say in limited time period. This test was conducted to record for only one minute and to allow the user to proceed as shown in figure 11.

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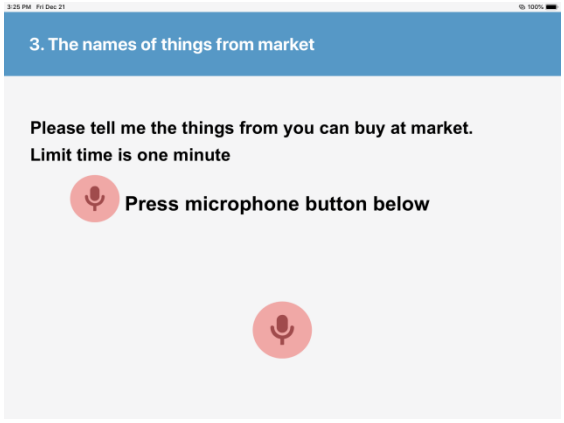

Figure 11: Test example of 'Supermarket Task'

5.1.1.4 Backward digit span

This test consists of two parts, listening to the series of numbers and speaking number series reversely (refer to figure 12).

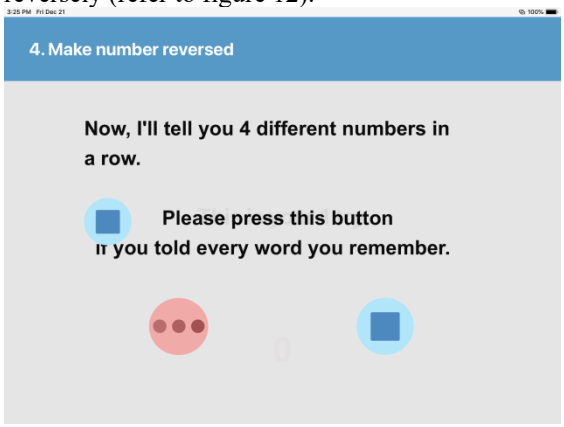

Figure 12: Test example of 'Backward Digit Span' of 4 numbers

A set of this test has random numbers from two random numbers up to six. There are two trials that are performed in this test.

5.1.1.5 Delayed word list recall

This test aims to recall the words mentioned in the 10 words list repetition performed in the previous step (refer to figures 13 and 14).

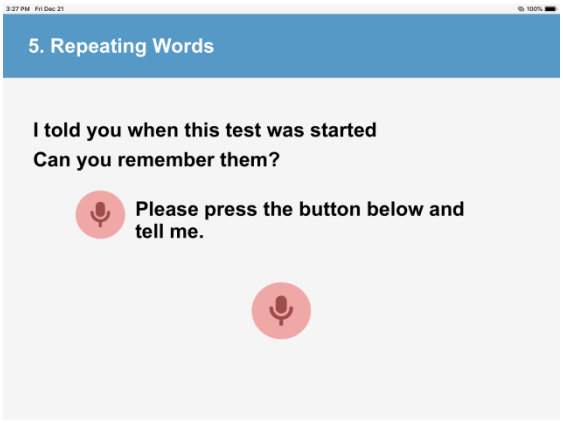

Figure 13: Test example of 'Delayed Word List Recall'

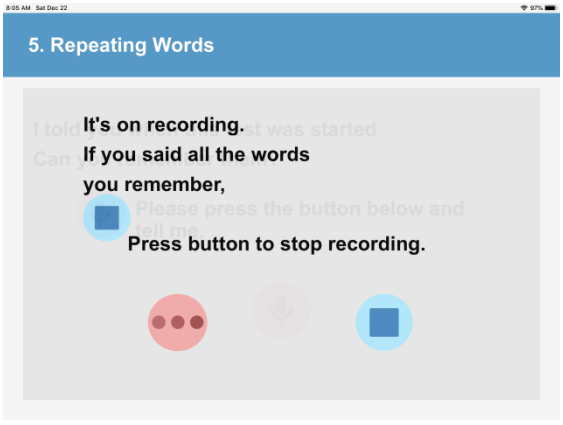

Figure 14: Recording View of 'Delayed Word List Recall'

As shown in Figure 14, when user pressed microphone button, recording will be started, and user can put their answers in audio file after finishing recording.

5.1.2 Detection Sensors

Due to the low capacity of social robot, there was a difficulty in proceeding the human perception by image processing. Therefore, we used sensors as figure 15 to detect the presence of human with two types of sensors. One is passive infrared sensor (PIR sensor) and another one is luminance sensor. Two PIR sensors can cover 240 degree in front of robot that can detect user's existence in figure 15. The luminance sensor is used for detecting sleep disorder.

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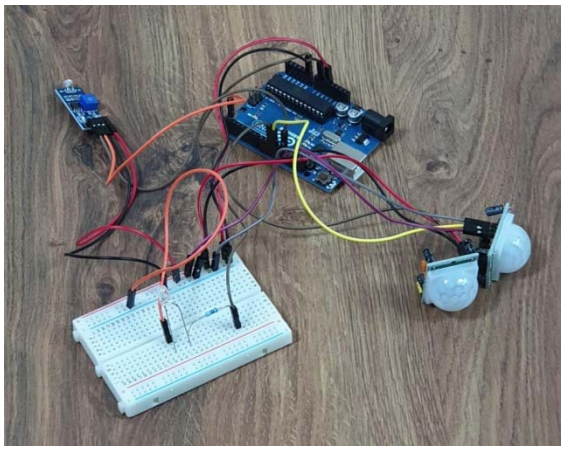

Figure 15: Sensors for Human and Illuminance Detection

5.2 Expert Scenario

5.2.1 Front Page

After logging in on the first page, the expert can check his or her patient information.

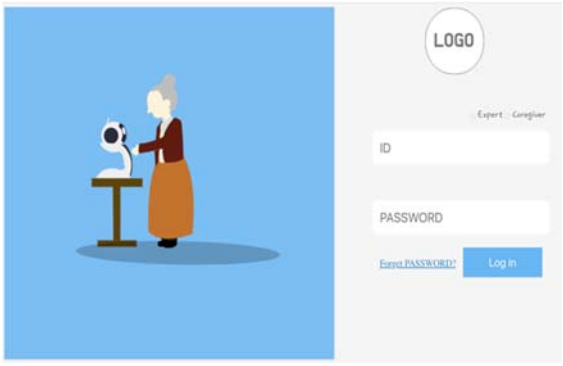

Figure 16: Main Page- Initial screen

To distinguish from caregiver and other professionals for protecting patient's and caregiver's private information, they have to click radio button to verify their status. The radio buttons check ID and grant authority of accessing patient's information (refer to figure 16).

5.2.2 List Page

Through this page, the experts are able to see a list of patients and their caregivers in charge. In this page, the experts can move to the monitoring page of each patient and caregiver. If the experts click the tab composed by HTML button tag and JavaScript code, an additional screen that has images linked to patient report and caregiver report is created.

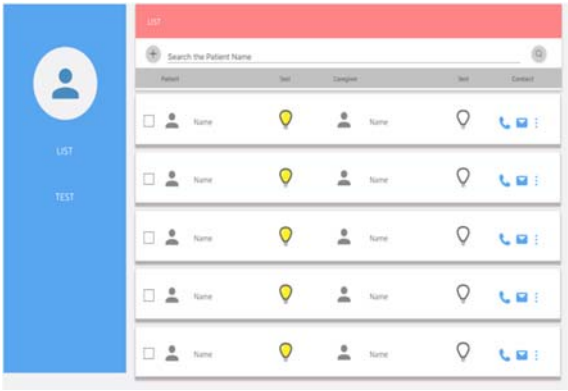

Figure 17: Patient List - Initial screen

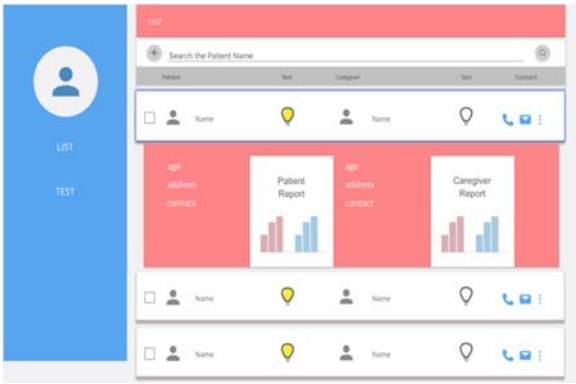

Figure 18: Patient List - additional screen

Clicking the patient report image, experts can move the result monitoring page which they can check the patient's test result and behavior monitoring result. In caregiver report page, the expert can check the result of caregiver's B-ADL inquiry. If there are new patient's test result or caregiver's inquiry result, the image of bulb changes to yellow to alarm the experts (refer to figures 17 and 18).

5.2.3 DemTect Test Checking Page

It is a page where a expert can mark the patient's DemTect Test (refer to figures 19, 20, and 21). The patient's voice and text image data from the test such as 10-word list repetition, number transcoding, semantic word fluency task, and backward digit span can be checked, and the patient can be scored.

When the expert clicks on the speaker image, the expert can listen to the patient's 10-word

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list repetition, semantic word fluency task, and backward digit span. By using checkbox and text input, he can evaluate and record voice data.

In 'Number Transcoding' section, the text image which is written by the patient is showed up, so the experts can check the patient's cognitive status more accurately.

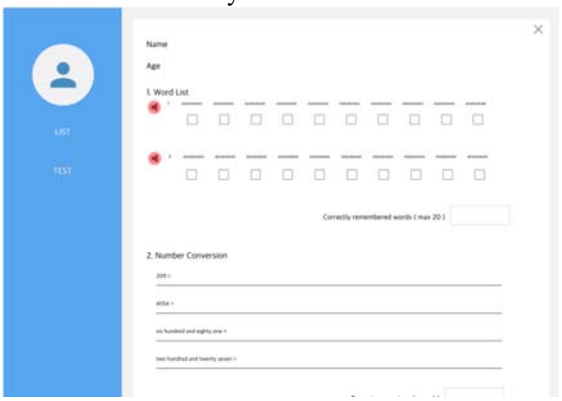

Figure 19: DemTect Checking Page 01

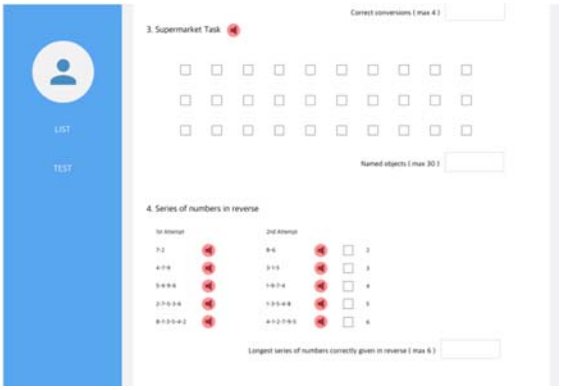

Figure20: DemTect Checking Page 02

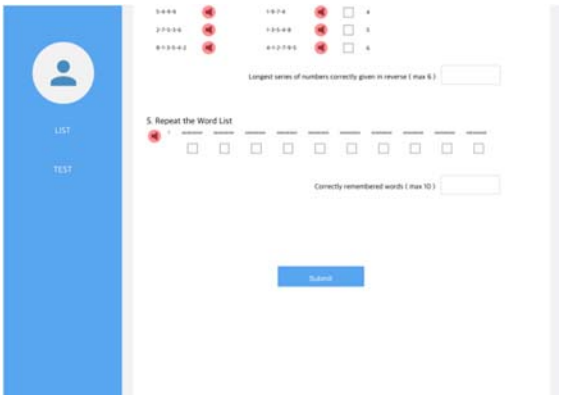

Figure 21: DemTect Checking Page 03

5.2.4 Patient's Result Monitoring Page

This is a page that monitors the DemTect test results and behavior recognition results of each patient. In the first table, you can see the score for each task and the transformed score for converting 18 points to the maximum score.The table below is a reference table and an outline of the score so that the patient can be immediately assessed.

The second table shows the number of sleep disturbances and the number of wandering detected by the robot's camera. The expert can judge these results comprehensively and ask for a visit to the caregiver or the patient himself or ask for a re-diagnosis.

5.2.5 Caregiver Inquiry Monitoring Webpage

This is a page which monitors the results of the protector's survey. The result of the B-ADL survey entered by the caregiver can be confirmed in the same environment as the caregiver. The number and checkbox of the input tag are used to load the numeric data and the checkbox data entered by the protector through the server and display it on the screen. Based on the results of this survey and the DemTect Test performed in 5.1.1, the patient's condition can be evaluated comprehensively.

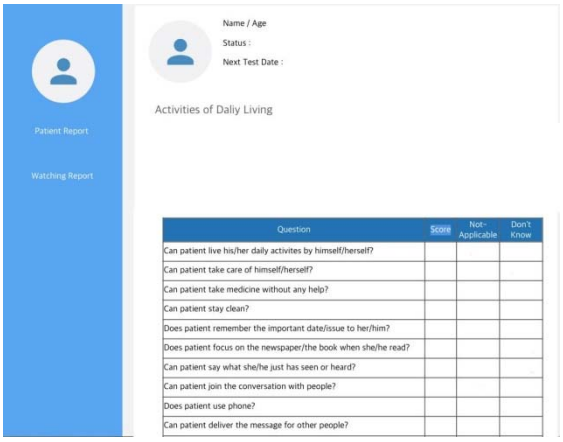

Figure 22: Caregiver Inquiry Monitor Page 01

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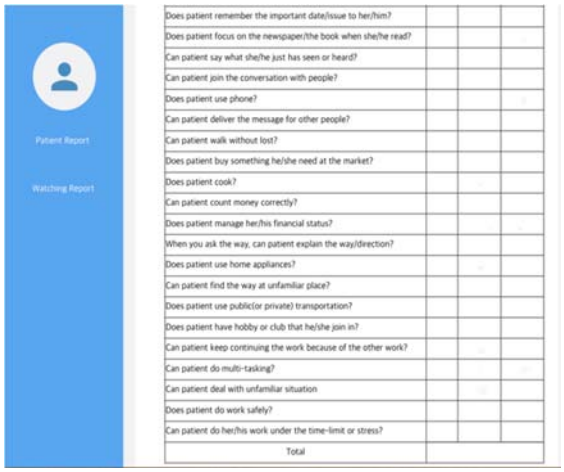

Figure 23: Caregiver Inquiry Monitor Page 02

5.3 Caregiver Scenario

5.3.1 Front Page

Not only expert but also caregivers should log in to check their patient's cognitive status data. They have to click 'caregiver' radio button to verify their ID and password. After verifying their ID and password, they can access their test and inquiry data.

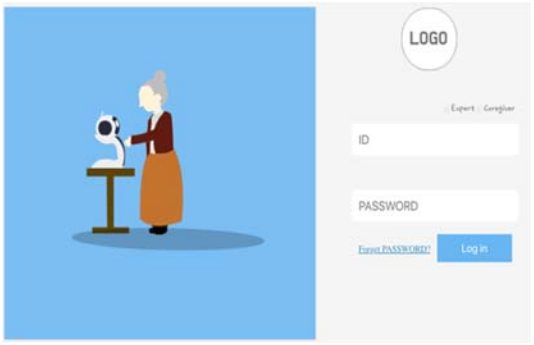

Figure24: Main Page- Initial screen

5.3.2 Patient Monitoring Webpage

This is a page where the caregiver can continuously track and confirm the patient's DemTect Test result and behavioral impairment recognition result. First, the graph shows the patient's DemTect Test results. I wanted to visualize the patient's results using a JavaScript open source based on a canvas tag named Chart.js in figure 25. In addition to this, it is designed to enable continuous observation and tracking by allowing the cumulative number of behavioral disorders to be identified by attaching a behavioral disorder recognition result sheet in figure 26.

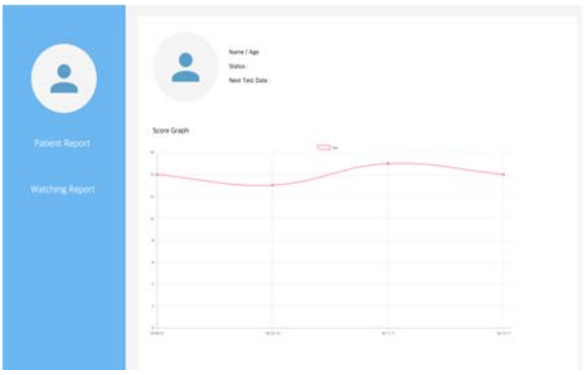

Figure 25: Patient Monitoring Webpage 01

Figure 26: Patient Monitoring Webpage 02

5.3.3 Caregiver's Inquiry of Bayer-Activities of Daily Living Webpage

To check patient's status more correctly and deeply, caregiver not only keeps monitoring the report of screening result but also do inquiry called "Bayer-Activities of Daily Living". For answering the questions of the inquiry, caregiver uses the following table. The caregiver can write numbers from 1 to 10 at the "Score" box depending on the patient's activities' status. If the question does not apply to the patient's situation, the caregiver should check "Not-Applicable" checkbox or if the caregiver doesn't know about the patient's status about following the question, the caregiver should check "Don't Know" checkbox. These data send to the expert to monitor the patient's cognitive status integrated.

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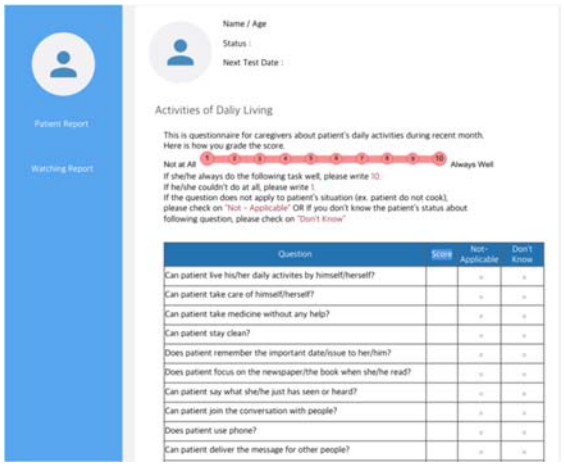

Figure 27: Caregiver's Inquiry of Bayer-Activities of Daily Living Webpage 01

Figure 28: Caregiver's Inquiry of Bayer-Activities of Daily Living Webpage 02

6. Conclusion

We have designed and developed a system of mild cognitive impairment symptoms. We provide an environment using a robotso that can detect and diagnose cognitive impairment.A mobile application and web application are implemented to overcome limitation that robot cannot provide cognitive testing interface and to provide a managing system. In supporting this system, our motivation is to provide diagnosis environment with the advantages of convenient system and inexpensive price of diagnose mild cognitive impairment.

Our current work consists of many potentials for future work. The robot we have used to deliver the system has the potential to be extended into a social robot through the implementation of the chatbot conversation function. If we add the ability to talk to people using this robot, the system can have not only a diagnostic service but also an interactive robot. As a result, target users and their caregivers will continue to receive professional help, not only to respond to their mental changes but also improving their cognitive abilities. Moreover, future research will be extended to a system for dementia patients. It is possible to develop into a patient protection system as well as an integrated residential environmental management system.

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