Diagnosing Alzheimer's Disease

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ABSTRACT

Alzheimer's is the most common type of dementia, which results in a restriction of daily activities. There are many attempts been made to provide an accurate diagnosis; however, most of them are less relevant for Sri Lankan context and are expensive to be used by the general public. According to Lanka Alzheimer's Foundation most of the victims are elderly and is less conversant in English. Since this disease effects the functioning of the brain, coming up with an early diagnosis process will be beneficial to the community. This research focuses on proposing diagnosis tool for Alzheimer's at the early stages and specifically designed to be used in Sri Lankan context as a low cost solution. The proposed application is a web-based tool capable of navigating using local languages such as Sinhala and Tamil. In order to increase the accuracy of the application the diagnosis process focuses on four types of Alzheimer's disease. Namely; Agnosia, Apraxia, Amnesia and Aphasia. System is able to determine the type of Alzheimer's suffered by the individual with the severity of the disease and assist the doctor in the treatment plans proposed. This research will be a stepping stone for delaying the progression of the disease.

Keywords

Diagnosing Alzheimer's, Memory disease, Health informatics, Dementia, Brain degeneration

1. INTRODUCTION

Alzheimer's is a type of dementia which causes problems with memory, thinking and behavior. Symptoms usually develop slowly and get worse over time, becoming severe enough to interfere with daily tasks. Anyone can get a mental illness, irrespective of their gender, education level or economic status [1], [2]. Alzheimer's disease is the most common cause of dementia and accounts for 50% to 75% of all cases [3].

Statistics show that the likelihood of developing dementia increases with age, this being one of the highest risk factors so far identified [1], [2]. Despite the above and although uncommon, dementia can also affect those under the age of 60, and across the world several cases have been reported of individuals in their 50s, 40s and even 30s developing signs of cognitive impairment and consequent dementia [4].

According to the Alzheimer's disease International (ADI) at present there is an estimated 35 million people in world suffering from Alzheimer's and dementia related diseases. This figure is expected to rise up to 115 million by year 2050. Although the formal research studies are minimal in Sri Lanka, experts suggest that approximately 150,000 people may be currently suffering from dementia in the country. By 2050 as the island's population ages this figure is predicted to pass the half million mark [4].

There are have been many attempts made in detection and treatments of Alzheimer's disease in recent years. A typical evaluation to diagnose, consists of several parts such as; evaluating the recent history of mental and behavioral symptoms, a physical examination and neuropsychological tests. In nearly 75% of cases, Alzheimer's starts with the inability to remember recent events and learning as well as retaining new information. Early stage patients experience memory problems which interfere with daily living that steadily worsens over time [5].

There are some commercially available diagnosing tools in the market. The tools which are on the market such as; DemTalk [6], Virtual Physiological human [7], Nuro Speed, Addenbrooke's Cognitive Examination III [8] and MyLife [9] to name a few. Some of these applications are device dependent (e.g.: Addenbrooke's Cognitive Examination III for iPads) and some applications are stand-alone (e.g.: MyLIfe). Those diagnosing tools are expensive to local patients because and those applications are rarely used for Sri Lankan culture where application is based in English language.

In Sri Lanka experienced doctors will perform diagnostic tests of the patient's memory problem with the symptoms of dementia/ Alzheimer's disease, but less effort is made to identify and understand the severity of the disease. Further, manual counselling sessions are less likely to provide well-developed treatment plans for local patients.

This research is focused on providing a lower cost Alzheimer's diagnosing for Sri Lankan context which requires an automation of the present manual process. Further, this research focuses on monitoring the patients' memory activities for a longer period of time and provide assistance to doctors. This system is designed to support Sri Lankan patients with native language support by providing tests using Sinhala and Tamil languages.

The next section will discuss the literature review covering the background study of the Alzheimer's disease and the prior research carried out by experts followed by the objectives of the study. Section four will cover the methodology in developing the solution following the results and discussion. The article will conclude with a conclusion and future work.

2. LITERATURE REVIEW

Dementia is a general term for a decline in mental ability, which is severe enough to interfere with daily life. Symptoms of Alzheimer's disease are divided into two categories [1], [2]. They are cognitive, or intellectual, and psychiatric. Differentiating between them are important so that behavioural problems that are caused by loss of cognitive functioning are not treated with anti-psychotic or anti-anxiety medications. Cognitive or intellectual symptoms of the

disease are Amnesia, Apraxia, Agnosia and Aphasia which are known as 4 A's Alzheimer's [13].

2.1 Amnesia

Amnesia can be describes as the inability to use or retain memory which includes short term and long term memory [10]. Short-term memory is programmed in a part of the brain called the temporal lobe, while long-term memory is stored throughout extensive nerve cell networks in the temporal and parietal lobes. In Alzheimer's disease, short-term memory storage is damaged first. There are many different types of amnesia; Anterograde Amnesia where the patient cannot remember new information, Retrograde Amnesia where the patient cannot remember events that occurred before the trauma, Transient global Amnesia where the patient finds it very hard to form new memories, Hysterical Amnesia where the patients forget not only their past, but their very identity and Childhood Amnesia where the patient cannot recall events from early childhood.

2.2 Apraxia

Apraxia is the inability to use or coordinate purposeful muscle movement or coordination. The Definition of apraxia refers to the difficulty to getting your body to do what it needs to do in order to complete a task. A term also used is motor planning. When someone have apraxia, he or she have trouble to figuring out what you need your muscles to do in order to accomplish the task. Apraxia is basically a disconnection between the idea of a task and its execution. There are different types of Apraxia such as Ideomotor Apraxia where the patient have deficits in their ability to plan or complete motor actions that rely on semantic memory, Buccofacial or Orofacial Apraxia where the patient find it difficult to carrying out movements of the face on demand, Constructional Apraxia where the patient is having the inability to draw or construct simple configurations, such as intersecting shapes, Gait Apraxia where the patient loss the ability to have normal function of the lower limbs such as walking, Apraxia of speech where the patient is having difficulty planning and coordinating the movements necessary for speech.

2.3 Agnosia

Agnosia literally means "loss of knowledge" is a loss of ability to recognize objects, persons, sounds, shapes, or smells while the specific sense is not defective nor is there any significant memory loss. The common types of Agnosia are Alexia where the patient is having the inability to recognize text, Alexithymia where the patient is having the deficiency in understanding, processing, or describing emotions common to around 85% of people on the autism spectrum, Anosognosia where the patient is having the inability to gain feedback about one's own condition and can be confused with lack of insight but is caused by problems in the feedback mechanisms in the brain and Apperceptive Agnosia where the patient is unable to distinguish visual shapes and so have trouble recognizing, copying, or discriminating between different visual stimuli [11].

2.4 Aphasia

Aphasia is the inability to use or understand language. This will result having difficulties in communicating with daily activities. This will lead to difficulty of communicating at home, in social situations, or at work. Aphasia comes in different forms such as Wernicke's Aphasia where the patient often say many words that don't make sense and Global Aphasia where the patient is having severe difficulties that prevent them from effectively communicating [12].

3. RESEARCH OBJECTIVES

Present process in diagnosing Alzheimer's in Sri Lanka triggers the need to develop a solution to make the diagnostic process reliable for the patients and healthcare practitioners in Sri Lanka. In order to ensure the accuracy of the diagnosis process this system will provide an automated diagnosing capability for the four major types of Alzheimer's disease; Aphasia, Agnosia, Apraxia and Amnesia.

The main objectives of this research is to develop an automated process to diagnose Alzheimer's symptoms in Sri Lankan context. Which required the achievement of first sub objective to provide a low cost, user friendly diagnosis system to identify the type of disease and identify the severity of the disease. The second sub objective is to collect and store diagnosis history of individual patients which will assist doctors in suggesting treatment plans.

4. RESEARCH METHODOLOGY

Since the solution requires an in-depth understanding of the present diagnosis process followed in Sri Lanka, researchers went through an extensive information gathering phase with the experts in the field attached to Lanka Alzheimer's Foundation. The proposed solution is a web application with cross platform support to provide better and practical approach to diagnose symptoms of Alzheimer's disease. Therefore, the solution is cross platform supported device based on different operating systems. Moreover, web technologies are less expensive compared to sophisticated computing equipment used in commercially available solutions. This prevents restrictions and limitations users have to face when accessing the application. Furthermore, most of the known Alzheimer's patients are senior citizens, therefore the researchers specially focus their attention to come up with a technological solution. The main target group is, those who are in their mid-60's or early 80's. This target group plays a significant importance in the success of this application since the elderly may face difficulties with dealing with the computer applications as well as the computer equipment.

Understanding of the Sri Lankan context triggered the importance of developing a solution supporting local languages such as Sinhala and Tamil. Providing local language support will make the application more user friendly and researchers have identified that the English language interface will require patients to be proficient in English language. Furthermore, the local language support will allow the system to cater to a wider audience in Sri Lanka. Fig 1 shows an activity given to a patient is displayed in Sinhala local language. The question asks the patient to draw the shape displayed on the right on the space provided.

To overcome the language related problems at the initial stage, researchers decided to develop the application interface with three main languages (Sinhala, Tamil and English) which the user can select according to his or her preference. Since the majority of the population use Sinhala in performing activities in day to day, there is a likely high chance in a patient selecting Sinhala as their preferred language. Hence, the researchers focused on developing the system based on Sinhala, Tamil and English languages following the priority requirements.
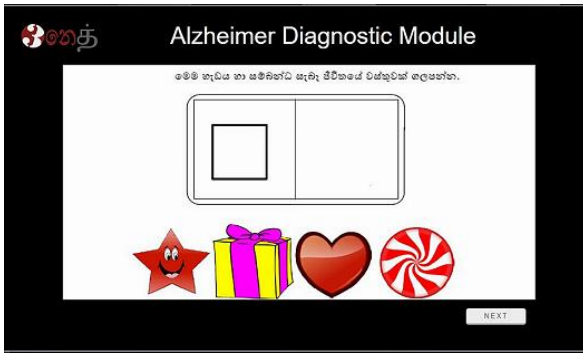
Fig 1: Sinhala language interface

Based on the above requirements the proposed solution will be divided into 3 main areas, namely; diagnosing Alzheimer's disease, introducing treatment activities and tracking individual patient's information.

The development of the each area will be explained in the following sub sections.

4.1 Diagnosing Alzheimer's disease

To develop the application with accuracy in diagnosing the Alzheimer's disease researchers divided the web-based application based on the major types of Alzheimer's disease; Amnesia, Agnosia, Aphasia and Apraxia. Based on those four types researchers moved forward with well-defined individual algorithms in the diagnosis process. Once the patient login to the system patient can access the diagnosing module and conduct his test with the aid of a care giver. Once the test is submitted that record will be updated in the server database according to the scores (patient gain for 4 types of diagnosing methods and for each type marks he obtained for individual question).

Going through the series of phases the final mark of test will be calculated. Those phases are: 1. Retrieval Phase 2. Recognition Phase 3. Scoring Phase 4. Suggestion Phase 5. DAL Going through all the phases and their specifications, 1. Retrieval Phase Gather the all answers, time taken for each answer and patient_id of each patient. 2. Recognition Phase Recognize the answer which the patient given. 3. Scoring Phase Calculate the patient score according to the answer and the answering time which is taken by the patient. 4. Analyze Phase Analyze the scores and identify the disabilities of the patient. 5. Suggestion Phase Suggest the disabilities of the patient to doctor. 6. DAL Add data to the database.

For a type of Alzheimer's diagnosing criteria (just assume agnosia) patient is able to achieve a maximum of 10 marks, if he completes all the questions with correct responses. All four test will carry a cumulative score of 40 (10*4). Then score will be calculated from the average of 30 for analysis purposes and to determine if the individual is Alzheimer's positive. This method is proposed consulting the doctor's current diagnosing process. If the score is above 25, then the patient is Alzheimer's negative and if the score is less than 25 then the patient is recorded as positive with Alzheimer's.

The generated records are submitted for the doctor's review and doctor can visualize the information. These Generated records will be submitted for doctor's review and doctor can visualize the information in detailed graphical ways. The Fig 2 shows a representation of the patient's test results.
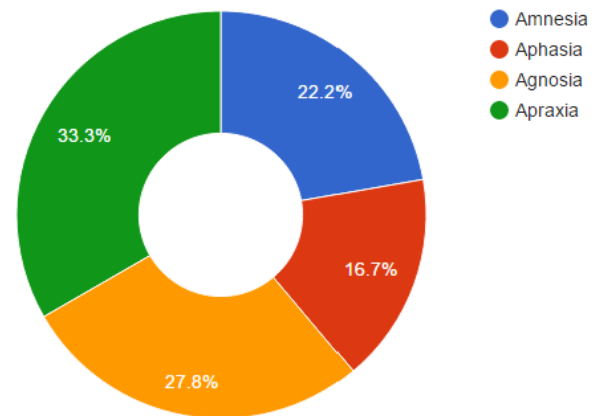
Fig 2: Patient's diagnosing summary

This mechanism is introduced with the structure of four algorithms connected to a backbone main algorithm.

The implementation of Aphasia Diagnostic Module, mainly use voice recognition and optical character recognition as technologies. Aphasia Diagnostic Module is done by php and it include series of phases to calculate the score of patient. After gathering all the answers given by the patient, all correct answers, response time taken by the patient for particular test and the patient_id will send to the server and calculate the score. The processing will be happen in server side process.

4.2 Introducing treatment activities

The system consists of a module named as "the activity centre" with simple memory activities. This allows the patient to try out activities as freehand design tools and some brain functioning games. The required target of the activity centre, is assisting to conduct brain functions of the diagnosed patients. This will assist a doctor in potential treatment plans. The system will enrich with the preprogramed memory activity bundle to execute as required. When an individual is identified as an Alzheimer's patient the doctor or physician can allocate suitable brain activity schedule to follow. The development of the patient or the progression of the disease will be assessed and added to the patient's personal records at the backend.

4.3 Tracking individual patient's information

Once patient received login details he/she is able to login, with the assistance of a care giver. Each session is recorded as a new session and system keeps track of the individual patients own information. The record keeping will aid the doctor in understanding the progression of the disease and check the effectiveness of the treatments given for the current diagnosis. The proposed system's design is given below in Fig 3.
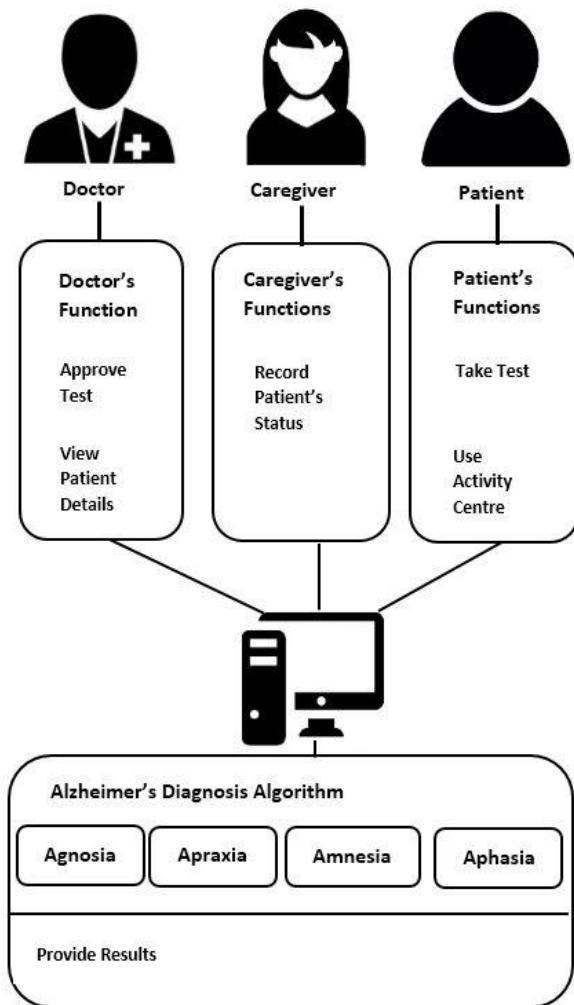
Fig 1. System's Design

5. RESULTS AND DISCUSSION

Prior research and investigations carried out with Lanka Alzheimer's foundation shows that even though there are some technologies currently available for diagnosing Alzheimer's disease, they are expensive and complex. Most of the time these tools require external assistance of a caregiver or guidance for a patient operate it. By considering the above mentioned factors; the researchers proposed a computer-aided application which is user friendly and simple for an elderly person to operate. Therefore a tablet based web application was introduced.

This diagnosis tool is a stepping stone towards an innovative way of detecting the disease where patient needs less assistance in handling the device. The web solution allows mobility and portability.

As mentioned above the tool is providing functionalities for two user types. Namely; doctors and patients. Doctors can register new patients to the system and patients perform tests on periodic basis. As patients may actively perform tests; the doctor can monitor and get an overview of the progression of the disease. Doctors can view the entire history records of the patient's diagnosis criteria as required. The registration process is a onetime activity which will allow the patients to use the system. Since the patients are suffering from memory related illness the login process require the assistance of a caregiver. Caregivers are encouraged to update the patient's

present status with the system which will allow doctors to take appropriate actions as required. The diagnosing module will test the patient in several ways to correctly identify the patient's progression of the disease.

The Alzheimer's detection algorithms used in this tool is developed with the consultation of the doctors who are specializing in the field of Alzheimer's diagnosis process in Lanka Alzheimer's foundation and other local hospitals. This is to ensure the validity of the diagnosis process. Further, to increase the accuracy of the detection, the algorithm focuses on the four types of Alzheimer's (i.e.: Agnosia, Apraxia, Amnesia and Aphasia) which is common among most of the patients in Sri Lanka. The tests are based on the local Sri Lankan context which helps the patients to be in a familiar environment. Furthermore, apart from English; the test can be taken in both Sinhala and Tamil languages which are commonly used local languages in Sri Lanka. The patient is able to take voice assistance from the system to aid the test taken. The system is capable in providing voice assistance in the same language selected by the patient at the test initiation stage.

Memory related diseases like Alzheimer's are highly sensitive in nature. The Sri Lankan culture itself has given fewer positive responses towards people suffering from brain related illnesses. Therefore, it's a basic necessity for a patient to directly communicate the doctor when required. The proposed system is designed with the functionality to communicate with the doctor real time. Which is a relief for the patient.

Researchers have identified that the target population of this tool are mostly elderly. The average age of the users are above 60 years. Therefore, one of the primary requirements of the system is that it should be easily navigated with large icons and words to provide instructions. Moreover, upon the doctor's advice the patient is able to perform the tests at home via the web application. This will also assist the patient to be in a familiar environment while attempting the test. Which again is identified as a requirement for memory related illnesses. The doctors explained the need to provide a tablet based interface for patients since handling a mouse to perform a test will be a difficult task for a patient with Alzheimer's. Furthermore, free hand drawing is easier to perform than using a mouse as a tool. Since the patient's memory deteriorates over time; the login process of the web-based interface may be a difficult task for a patient. In that scenario assigned caregiver is given the facility to update the status of the patient and assist the patient in login to the web system to perform the task.

6. CONCLUSION

Alzheimer's disease is a progressive, degenerative disorder that affects the brain cells. There are many attempts been made to provide an accurate diagnosis tools for Alzheimer's. However, most of them ineffective due to language barriers and cost. This research is an attempt to develop a diagnosis tool for Alzheimer's at the early stages and specifically designed to be used in Sri Lankan context as a low cost solution. Since the disease has no known cure present, this research will be a stepping stone for the delaying the progression of the disease.

The functionalities of the application include gathering and analyzing information with patients' previous track records to diagnose the stage of Alzheimer's the patient is currently suffering, supporting native languages (Sinhala and Tamil) with interactive user interfaces and a step by step voice guide in Sinhala or Tamil, easy navigation through the application

and provides a real time communication facility with the doctor and patient and manage information provided by the patient's caregivers and track down routine details time to time with patient's tests and evaluations and supporting cross platform use of the tool.

Information Technology can be used in healthcare service to Speed up the basic diagnosis procedure by automation and make cost electiveness and efficiency of healthcare delivery absolutely high. Since day by day various disease are spreading all over the world. Inadequacy of resource personals, heavy work load of doctors, inability of control consequent deaths and inability of identifying health vulnerabilities. The disease diagnosis system will address above problems through automation the basic diagnosis procedure. Information gathering will be the most important part of methodology since accuracy is very important factor. Gathering information will be done in many ways in several times and will identify most accurate information and most suitable matrices. System designing will be done after careful analysis of information which ensures achieving the objectives.

Main problem faced by the researchers is to develop a user interface that facilitates the disease diagnosing ability. One of the main concerns of the diagnose support module is wiped out the uncertainty of decision taken by the doctor. The system has been evaluated against objectives several times which increased the accuracy of the system.

7. FUTURE WORK

As further developments, researchers are planning to implement a medication management component to improve the system's capabilities. Since the system is focused on four types of Alzheimer's disease researchers are planning to incorporate a comprehensive diagnosis of the types with separate functionality to map the severity of each of the types discussed which will require an update of the knowledge-base used in the diagnostic module.

8. ACKNOWLEDGMENTS

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