Alzheimer's Management: A Technical Solution for Neurologists, Patients and Caregivers

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Abstract

Alzheimer's is a memory impairment disorder developed due to multiple cognitive deficits that progressively leads to at least one of the following: apraxia, aphasia, agnosia or a disturbance in executive functioning. As of 2012, more than 5.1 million Americans are affected by Alzheimer's. Caregiving is an important element of an Alzheimer patient's life. Caregiving is a reciprocal relationship where the daily world for both the caregiver and the patient is stressful. We propose a system that aims to lower the stress experienced by that caregiver while taking care of their loved ones. The proposed system would be beneficial for the physicians to analyze and assess the disease progression through neuroimaging, neuropsychological, neurochemical and neurophysiological results collected at different intervals. The data collected from this system could further be used to enhance the medical care provided to Alzheimer patients.

Keywords: Alzheimer's medical care; Reducing need for a caregiver partially; Analyzing neuroimaging; neuropsychological; neurochemical and neurophysiological results for effective assessment; Providing cognitive exercises for Alzheimer patients.

1. Introduction

Alzheimer's early analysis is extremely crucial in providing proper medical care and support for patients suffering from the disease.

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The pathophysiology of the disease is associated with the damage and death of the neurons, originating from the hippocampus of the brain that is associated with learning and memory, then atrophy impacts the whole brain [1]. Though neuropathology is the only assured determinant for Alzheimer's, studies involving other neurological tests can aid in better assessment of the disease.

Once the Alzheimer's stage is assessed using various neurological results and the standards defined by Alzheimer's association in Table 1, the ability of a patient to manage daily activities with partial caregiving could be determined.

The progression of symptoms can be slowed with proper cognitive exercises like listening to music, viewing photos and videos related to the past.

The paper discusses the following problems and how the system can help overcome these problems:

- How do we integrate neuroimaging, neuropsychological, neurochemical and neurophysiological results for effective disease assessment?
- How do we reduce the need for a caregiver partially?
- What are the effective ways to improve cognitive abilities of the patients to slow down the disease progression?

1.1. Objectives of this scientific paper

- Integrate neurological results for better analysis and assessment

- Devise a system to monitor daily activities of a patient remotely

- Provide effective means to reduce symptoms and lower depression

2. Integrating neurological test results

The system will consider every criterion mentioned by National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's disease and Related Disorders Association (NINCDS-ADRDA) except the neuropathological test results for the clinical diagnosis of Alzheimer's in a patient.

2.1. Neuroimaging Results

The 3D brain data from MRI scans should be normalized to template MNI. Only voxels labeled in AAL (Automated Anatomical Labeling) Atlas as hippocampus are selected. 2D transformation on a slice-by-slice basis can be done by selection sampling and CHF (Circular Harmonic Function) computations [3]. The transformed 2D data can be loaded into database as geometric spatial coordinates for further analysis .

Table 1: Summary of the seven stages of Alzheimer's disease based on the ideas of Dr. Resiberg:

| S no	Categories	Stages	Symptoms
1.	No Impairment	Stage 1	During this stage, Alzheimer's disease is not detectable and no memory problems or other symptoms of dementia are evident.
2.	Very mild decline	Stage 2	A person may notice minor memory problems or lose things around the house, although not to the point where the memory loss can easily be distinguished from normal age-related memory loss. The person will still do well on memory tests and the disease is unlikely to be detected by physicians or loved ones.
3.	Mild decline	Stage 3	Patients in stage 3 will have difficulty in finding the right word during conversations, remembering names of new acquaintances and may also frequently lose personal possessions, including valuables.
4.	Moderate decline	Stage 4	In stage four of Alzheimer's disease, clear-cut symptoms of Alzheimer's disease are apparent. Patients with stage four Alzheimer's disease will have difficulty with simple arithmetic, may forget details about their life histories, have poor short term memory, inability to manage finance and pay bills.
5.	Moderately severe decline	Stage 5	During the fifth stage of Alzheimer's, patients begin to need help with daily activities. People in stage five of the disease may experience the inability to recall simple details about themselves such as their own phone number, difficulty in dressing appropriately. They still know their family members and some detail about their personal histories, especially their childhood.
6.	Severe decline	Stage 6	Patients with the sixth stage of Alzheimer's disease need constant supervision and frequently require professional care. Symptoms include confusion or unawareness of environment and surroundings, major personality changes and potential behavior problems, need for assistance with activities of daily living such as toileting and bathing, inability to recognize faces except closest friends and relatives, inability to remember most details of personal history, loss of bowel and bladder control, wandering.
7.	Very severe decline	Stage 7	Stage seven is the final stage of Alzheimer's disease. Since Alzheimer's disease is a terminal illness, patients in stage seven are nearing death. Patients lose their ability to respond to the environment or communicate with others. While they may still be able to utter words and phrases, they have no insight into their condition and need assistance with all activities of daily living. In the final stages of the illness, patients may lose their ability to swallow.
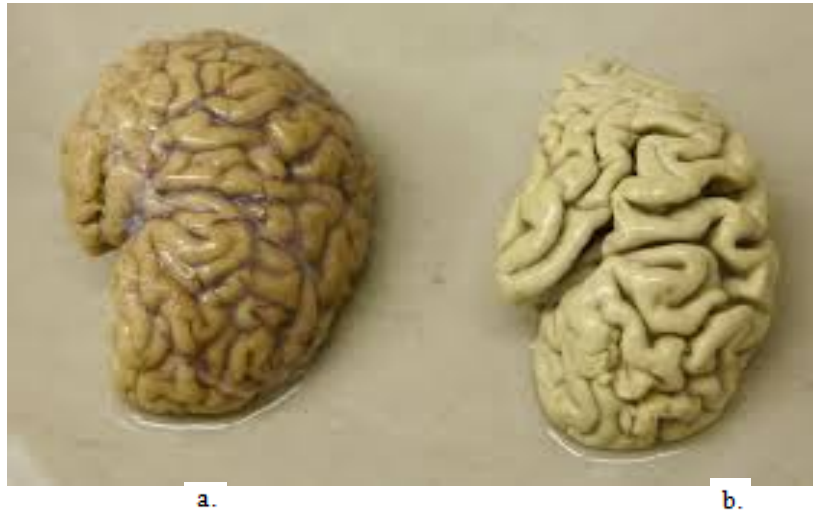
Figure 1: a Normal Brain 1.b Brain (without meningitis) affected with Alzheimer's
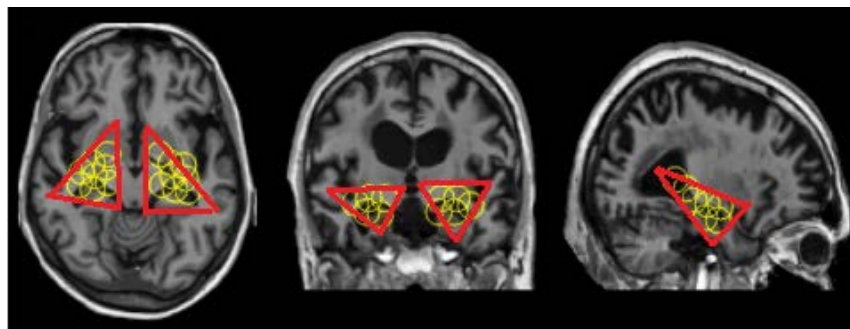

Figure 2: 2D Transformation to fetch hippocampal atrophy

2.2. Neuropsychological results

Physicians usually administer the following neuropsychological tests for Alzheimer's assessment. A direct correlation could be inferred from the results of these tests and atrophy in the hippocampal region.

2.2.1. Mini-mental state exam (MMSE)

Series of questions to determine cognitive impairment is usually administered by a physician for Alzheimer's assessment. Maximum score is 30 points. Patients with Alzheimer's usually score 26 or less [4].

2.2.2. Mini-cog

A person is asked to draw the face of a clock pointing all 12 numbers at right places. Usually, patients with mild to high dementia experience difficulty with this test.

2.3. Neurochemical results

The presence of neurofibrillary tangles and senile plaques in the cerebrospinal fluid of affected person can be

analyzed using Western Blot and Alz50. Progressive neuronal degeneration attributed by Tau aggregation is a biomarker for Alzheimer's. Results obtained can be included in the system for further assessment.

2.4. Neurophysiological results

The results from neurophysiological techniques including electroencephalography (EEG), event-related potentials (ERPs) and transcranial magnetic stimulation provide biomarkers for Alzheimer's assessment.

2.5. Integration

All the neurological results obtained for a patient can be integrated and provided to neurologists in a single interface for prompt analysis. Evidence of atrophies in entorhinal cortex and hippocampus will be clearly evident in neuroimaging results. Corresponding evidences such as MMSE scores, changes in electrical activities, and abnormal Tau composition in cerebrospinal fluid (CSF) can be used in assessing the stage of Alzheimer's for a patient. Once this assessment is done, a neurologist can predict the ability of a patient to manage daily activities without dedicated support from a caregiver.
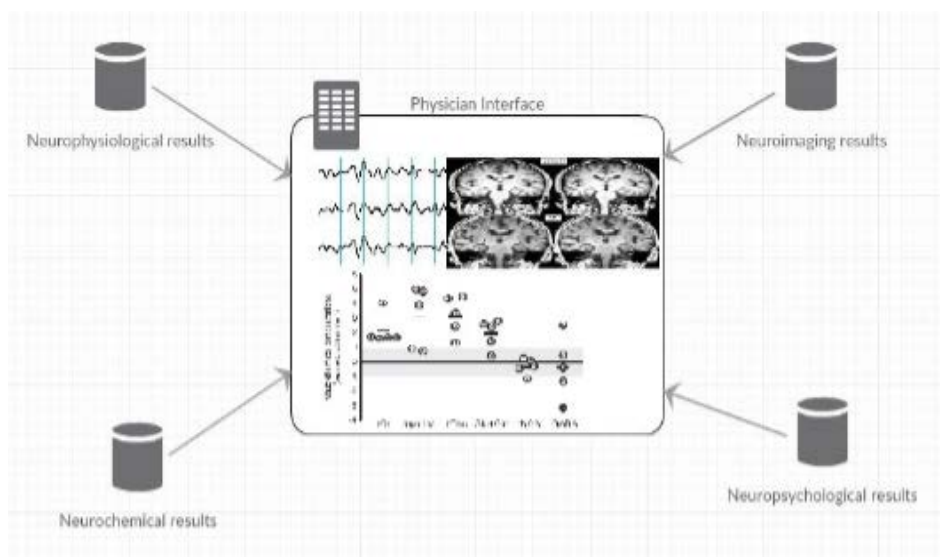

Figure 3: Physician interface to analyze neurological results

3. Reduce the need for caregiver partially

The primary objective of this interface in the system is to reduce the stress of the caregiver who is taking care of the patient affected with Alzheimer. It is important for caregivers to live a normal and stress-free life in the process of taking care of their loved ones.

3.1. Caregiving costs for Alzheimer

In 2014, caregivers of people with Alzheimer and other forms of dementia spent an estimated 17.9 billion hour of informal (unpaid) care, which is approximately 21.9 hours of care per caregiver per week, a contribution of

approximately $217.7 billion (assuming care valued at $12.17 per hour). Caregivers of patients with dementia report significant financial, emotional and physical difficulties. The emotional stress of these caregivers is very high [6].

3.2. Stress experienced by the caregiver

Caregivers report the following health issues

a)   Headaches

b)   Back pain

c)   Sleeping difficulty

d)   Weight gain

e)   Symptoms of Depression

A series of recent studies has found that under few circumstances some caregivers had increased chances of developing cardiovascular diseases and kidney impairment.

Caregivers have been forced to make significant changes to their professional lives as well, to take care of patients affected with Alzheimer. Many caregivers have been forced to quit their jobs or reject good job offers in order to take care of their family members.
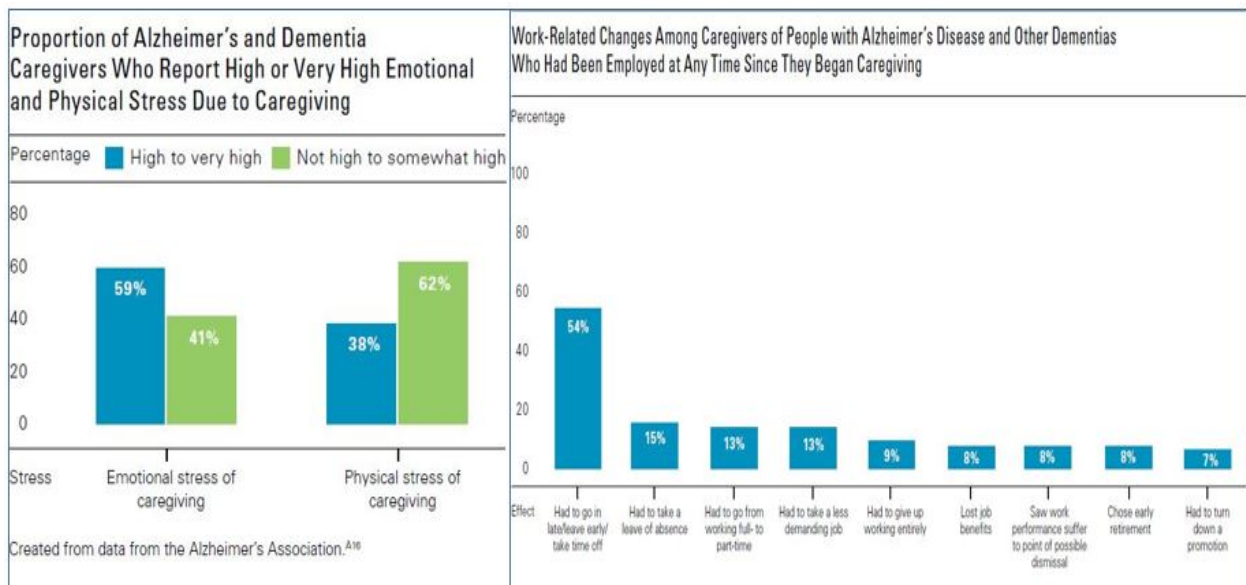

Figure 4: Caregiver-related issues in taking care of Alzheimer patients [6]

3.3. Proposed solution:

Our system enables the caregiver to monitor the progress of the patient's recovery.

a)   The location of the patient is continuously monitored by the caregiver.

b)   The caregiver will be able to set daily reminders of activities to be performed by the patient.

c)   The caregiver will be able to add videos, photos or other music files that would help trigger the memories of past events, which helps in reducing symptoms of the disease.

4. Effective measures to reduce symptoms and lower depression in Alzheimer patients

As the disease progresses, the patient goes through severe stress and depression. Studies have revealed that listening, recreating, improvising and composing music can help patients to overcome depression and aid in slowing down the disease progression [7]. Studies have also revealed that family photos and videos could help patients in overcoming dementia [8]. The interface primarily includes music contents, family images and scrapbooks to reduce the symptoms in patients and to lower the depression.

4.1. Proposed Solution

The patient interface in the system allows the patient to access the set of reminders or activities assigned to him by a caregiver. Various activities include dieting, medication and common household activities. The interface also allows patients to take up music therapy and cognitive exercises assigned by their caregivers. The interface has a GPS tracker that accurately keeps track of patient's location and loads them to the database in geographical spatial coordinates. The location of the patient can be monitored by the caregiver from a remote location.

5. Conclusion

The system will aid all three primary actors related to Alzheimer's – physicians, caregivers and patients.

Overall benefits achieved from the system include:

Physician - One stop solution to analyze all neurological results for a particular patient and the ability to analyze the level progression for different patients through their results.

Caregiver – Reducing the need for a caregiver partially and decreasing the stress level of a caregiver.

Patient – Accurately tracks the patient location, triggers periodical reminders set for a patient and allows the patient to take up music therapy and cognitive exercises.

6. Future

Neurological results collected from different patients can aid in analyzing possible trends followed by the disease. The trends could further help in research works related to drug enhancements, clinical trials and potential long-term cure for the disease. Neuroimaging captured through geometric spatial coordinates from different patients at different intervals can be used to analyze the effect of drugs prescribed and cognitive exercises suggested for different patient groups. The graph in Figure 5 depicts the percentage change in size observed in two different patients from scans taken at different intervals.
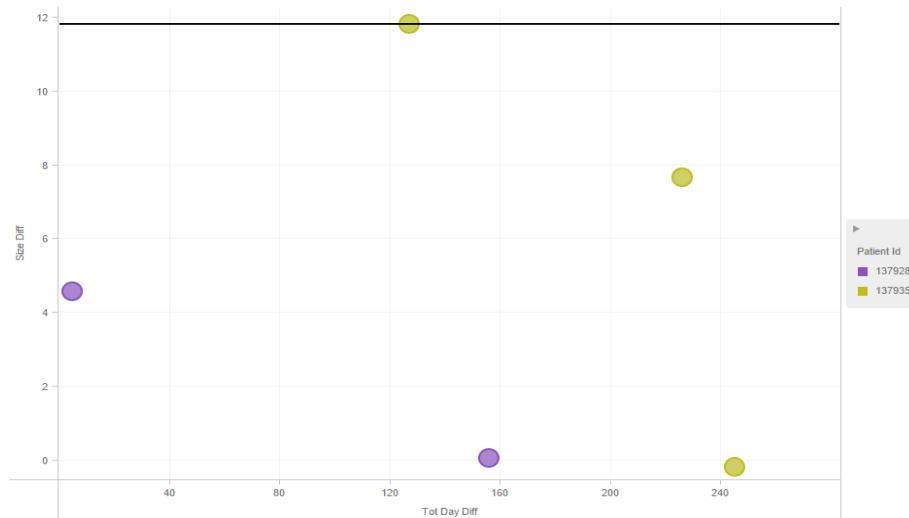
Figure 5: Percentage change in brain size observed from scan details of two different patients

Acknowledgments

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