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An Alzheimer's Intelligence Care System (AICS) to Assist Alzheimer's Patients: Design and Development of Application

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ABSTRACT

Introduction: Alzheimer's disease (AD) and cognitive impairment are age-related disorders. Nonetheless, it is possible to maintain Alzheimer's patients' quality of life by meeting their needs and reducing the unfavorable consequences. This study introduces an Alzheimer's Intelligence Care System (AICS), which can meet various needs of such patients while adapting itself to the disease progression.

Material and Methods: Mini-mental state examination (MMSE) was administered to measure the patients' cognitive abilities. The system, then, assigned the patients to level one or two, depending on the severity of their conditions. Afterwards, medicinal, nutritional and athletic schedules as well as a daily routine schedule were given to the patients to follow on three domains as follows: (a) improving the patients' memory through such activities as mental massage and play therapy, which all aim at boosting cognitive abilities, (b) reminding the patients to do their necessary daily jobs, and (c) tracking the patients' daily activities in order to protect them from probable hazards.

Results: It was predicted that constantly following a rigorous schedule helps to control the progression of Alzheimer's disease (AD) to a large extent, thereby slowing or stopping further decline of cognitive ability. Nonetheless, due to various factors contributing to the disease in the elderly, the effectiveness of the method is contingent upon many external factors.

Conclusion: The proposed system in this article intended to meet the patients' needs in improving their memory (massage therapy, play therapy), reminding them to do their necessary daily jobs, and tracking their daily activities in order to protect them from probable hazards through different stages of the disease with capability of adjusting itself to new needs as they emerge, thereby slowing or stopping further decline of the cognitive ability. Further Research on this subject is recommended.

Key words: Alzheimer's disease (AD), Memory, Cognitive abilities, Artificial intelligence, Machine learning, Intelligent systems.

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INTRODUCTION

Aging is closely associated with age-related physiological and cognitive changes including cognitive disorders and dementia [1]. As one of the commonest neurological diseases, dementia threatens the health in the elderly [2]. Dementia is a chronic progressive brain syndrome causing impairment in cognitive functions and it is the fourth leading cause of death in developed countries [3,4].

Alzheimer's disease accounts for 70 percent of dementia cases. Three percent of people with Alzheimer's disease are about 65-74 years old. This figure reaches 50 percent at the age of 85. It is estimated that 25 million people worldwide are living with Alzheimer's disease currently. In the United States alone, the figure stood at 5 million in 2007 and is expected to rise to 13 million in 2050 [5].

In Iran, as the latest figures show, a new case of dementia is diagnosed every seven minutes, constituting 60

percent of people with dementia in the developing countries [6]. Meanwhile, the elderly population has increased and is expected to continue to rise from five million in 2006 to 11 million in 2019. Alzheimer's disease International (ADI) reports that more that 46 million people worldwide are either suffering from Alzheimer's or other forms of dementia. They predict the figure to rise to 131 million in 2050 [6].

Alzheimer's disease and other forms of dementia can severely restrict the patients' functions and undermine their autonomy, thereby decreasing their quality of life [7]. Early symptoms among the elderly are memory loss, especially short-term memory loss. Later on, Alzheimer's and dementia patients lose their sense of time. The impairments can lead to depression, loss of the ability to talk, reclusiveness, and death. The disease affects the victim's ability to look after himself/herself negatively. Likewise, it affects the ability of the patients' family to look after them [8]. The disease imposes additional load on the family, society, and health service systems. Thus, timely diagnosis of the diseases is of utmost importance. Early diagnosis can prevent the disease to become chronic and prevent the progressive decline in patients' cognition, thereby reducing treatment costs and lengthening life expectancy [9,10].

Trustable and inexpensive memory aids are expected to boost memory and delay dramatic memory decline among Alzheimer's patients. Tools that can predict and delay the memory decline are hard to find, so they are memory gaining tools. Moreover, the few available ones do not cover all aspects of the treatment process. Most of the proposed or invented systems provide the patient with a limited range of capabilities such as preplanned audio or visual warnings (through speech, flasher, or vibration) for vital times or situations such as the time to take medicine, to go bed or wake up, and approaching a hazardous place such as the kitchen [11].

Other such devices may trace the patient and let other family members know if the patient goes too far away from home. Still others give the patients daily reviewing tasks to slow the memory decline and boost their autobiographic memory [11,12].

Researchers are competing to design easy-to-use tools with multiple purposes. Early and easy detection and treatment of Alzheimer's disease is possible with the help of technologically advanced and widespread systems such as intelligent phones, long distance medical systems, home care systems and social networks [13]. Though all such tools are useful, each alone meets only a portion of the patients' needs. Thus, the present study aims to introduce a system that not only combines the capacities of the present systems, but uses an intelligent mechanism to get regular feedback from each of its modules so as to choose the most efficient treatment scenario. The system adapts itself to new situations as the treatment process progresses.

METHODS

As stated earlier, there is no flawless treatment method, medicinal or otherwise, for Alzheimer's disease. Nonetheless, taking care of the patients and reminding them of the events that beset them or the things that surround them can slow the progression of the disease. Yet, it is often impossible to assign a person to take care of the patient round-the-clock [14]. As such, the aim of Alzheimer's Intelligence Care System (AICS) is to minimize direct human caregiving requirements and reduce the medical costs associated with it.

Design and development

The proposed system aims at helping the patients to improve their life quality and carry out their routine activities while providing the caregiver with a mechanism to follow the patients' activities round-the-clock from his/her own location. Meanwhile, the system sends periodic feedbacks to the patients' doctor, as it is often the case that such patients are unable to remember to visit their doctors or even find their ways to the clinic or the hospital. The feedbacks sent by AICS to the doctor include, among others, such information as how much progress the patients are making in carrying out the games designed for them, and how long it takes for them to answer the system's questions or carry out each of their daily activities. The system is also capable of saving and displaying the photos and names of the patients' relatives and caregivers or other information related to them, thereby helping the patients review or reconstruct their memories. All the information thus displayed and saved is used in the subsequent stages of the treatment process. The caregiver is also capable of making adjustments in the weekly schedule of the patient in such matters as when to take medicine, take a bath, do the games designed for them and enforce them automatically.

Analytic tools

What distinguishes this system from the similar ones is that the proposed system is highly personalized to meet the needs of particular patients on the basis of their treatment scenarios, which are written on the basis of the result of the Mini–Mental State Examination (MMSE). The Mini–Mental State Examination (MMSE) is the most common measure for screening the cognitive ability. It has a maximum score of 30 and considers the age and education level of the test-taker into account when interpreting the results [15]. Table 1 provides a framework for score interpretation.

Once the program is executed, the system first takes MMSE test intelligently. To get the best results, questions are asked both as text and *via* audio sound. The answers too can be provided via microphone in case there is no obligation to do otherwise. Once the data are analyzed, the system chooses a pre-planned treatment scenario to run. The doctors' and the caregivers' approval is needed before implementing the scenario.

Table 1: Progression of cognitive impairment in Alzheimer's diseases

Score	Description	Stage	Duration
26-30	Some cognitive impairment but of questionable significance	Can be normal	-
20-25	Mild cognitive impairment	Elementary	0 to 2 or 3
10-19	Clear moderate cognitive impairment	Intermediate	4 to 7
0-9	Marked severe cognitive impairment	Advanced	7 to 14

Technical development

Figure 1 depicts the system's performance, showing the details of the interactions among the components of the system. Figure 1 shows the graphic interface on the first level of a selected scenario. The interface is quite user-friendly, so that it does not require any technical expertise on the part of the patient or the caregiver. Adaptive Neuro-Fuzzy Inference Systems (ANFIS) is incorporated to feedback and assessment module, which uses Neuro-Fuzzy Inference Systems and soft computations to update the existing scenarios. The overall procedure for this part is explained in Figure 2.

Figure 3 shows the graphic interface on the first level of a selected scenario. The interface is quite user-friendly, so that it does not require any technical expertise on the part of the patient or the caregiver.

In Figures 3-6 the technical design of the software is present. Figure 3 shows the Application's interface with three domains (Reminder system, Schema therapy to review of specific life events, and Alarm system for drug, health and regular daily living), Figure 4 displays the caregiver web tracking system, Figure 5 presents the total score of patients in application, and finally Figure 6 shows the mobile game for memory improvement.

Briefly, the system starts with the administration of MMSE test to the patients to determine the stage of the disease. It, then, chooses an appropriate scenario on the basis of the environmental and clinical data it is provided with. Afterwards, it runs the selected scenario. Finally, upon receiving feedbacks, the system modifies or changes the scenario (Figures 2-6).

Review of the related studies

Various methods have been used to improve the quality

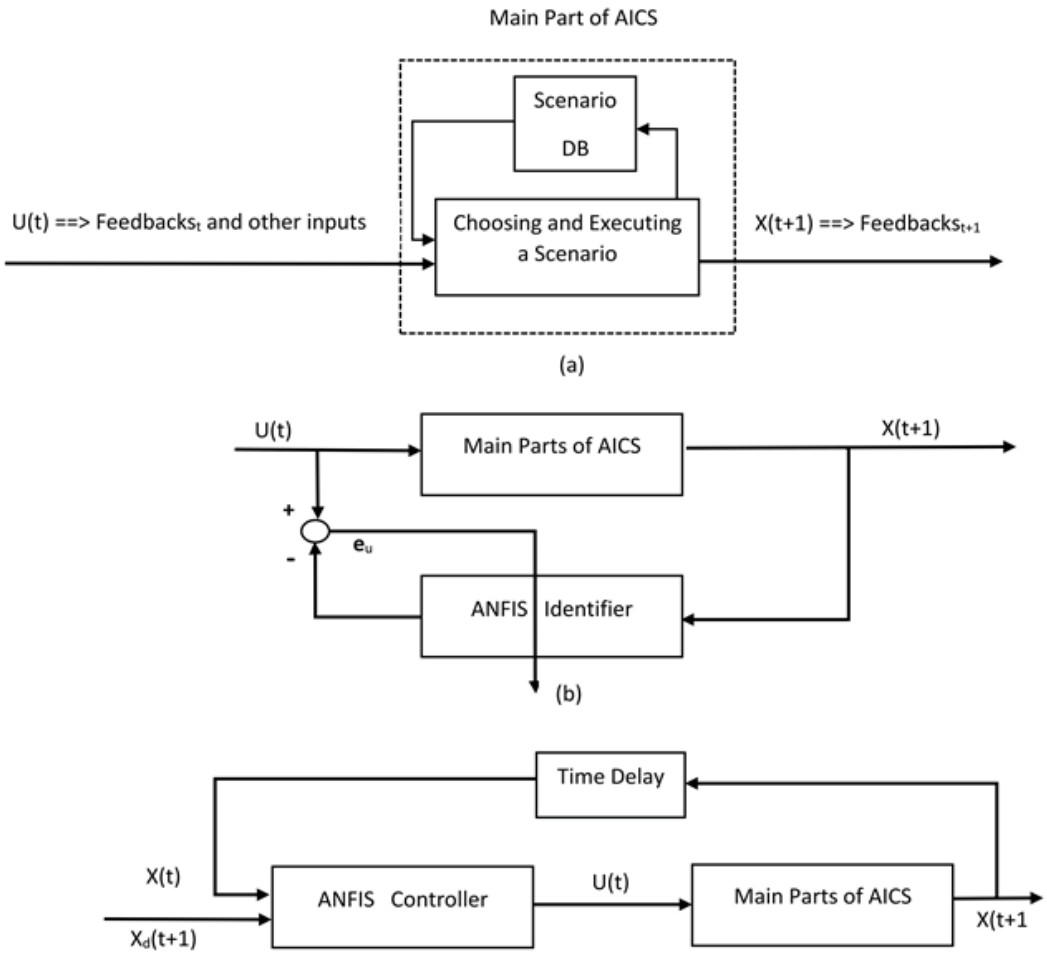

Figure 1: Main parts of Alzheimer's intelligent care system

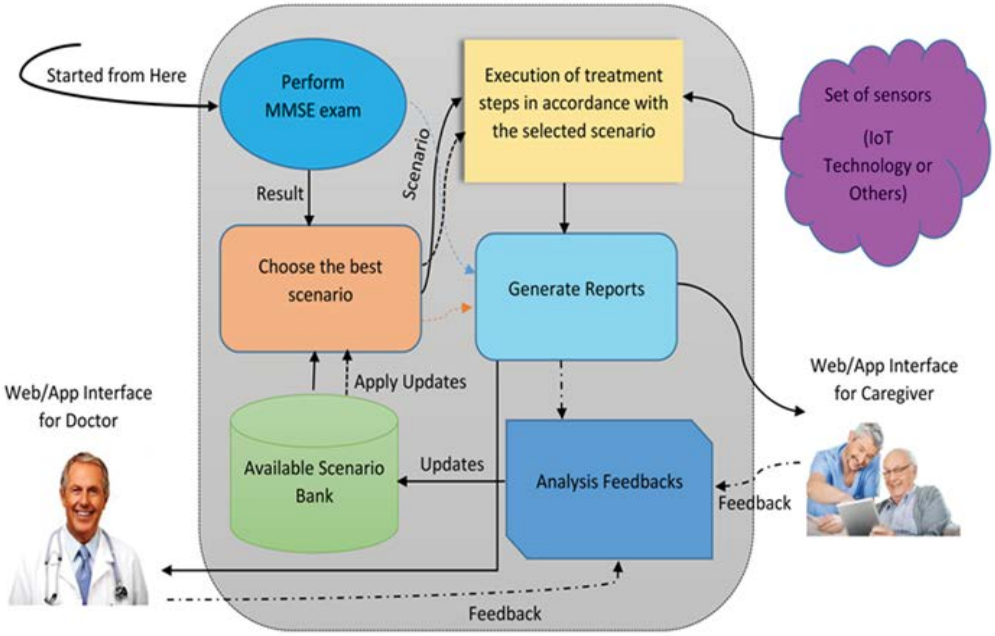

Figure 2: Core of Alzheimer's intelligent care system

Figure 3: The application's interface with three domains (A) Reminder system, (B) Schema therapy to review of specific life events, (C) Alarm system for drug, health and regular daily living

of life among people with Alzheimer's and dementia. Nonetheless, recent research suggests that the situation is far from satisfactory as the new Alzheimer's related technologies, especially those designed specifically for home use, are incapable of meeting various needs of such patients [16,17]; however, such efforts have been able to be of some help to the elderly and people with Alzheimer's. Generally, three types of efforts have been in progress in this field. First, some have focused on designing devices that can improve the memory of people with Alzheimer's. Such efforts stem from the belief that people with Alzheimer's and dementia often fail to carry out their daily routine activities, resulting in even more severe decline of their memory as well as depression and reclusiveness. Second, others have designed tools for monitoring such patients' behavior at home or out of house to detect any unusual or risky behavior. They hope that such devices are capable of detecting symptoms of dementia and Alzheimer's early enough, so that the progression of the disease could come under control. Still others have focused on helping such patients by providing them with mental or memory-related exercises to stop or minimize the decline of their memory.

Abu-Dalbouh et al. [15] designed a cell-phone-based system, which was capable of reminding the patients or their caregivers of when to take drugs, eat, drink, and do other vital affairs. Likewise, many advanced mobile-based tool for reminding the patients about

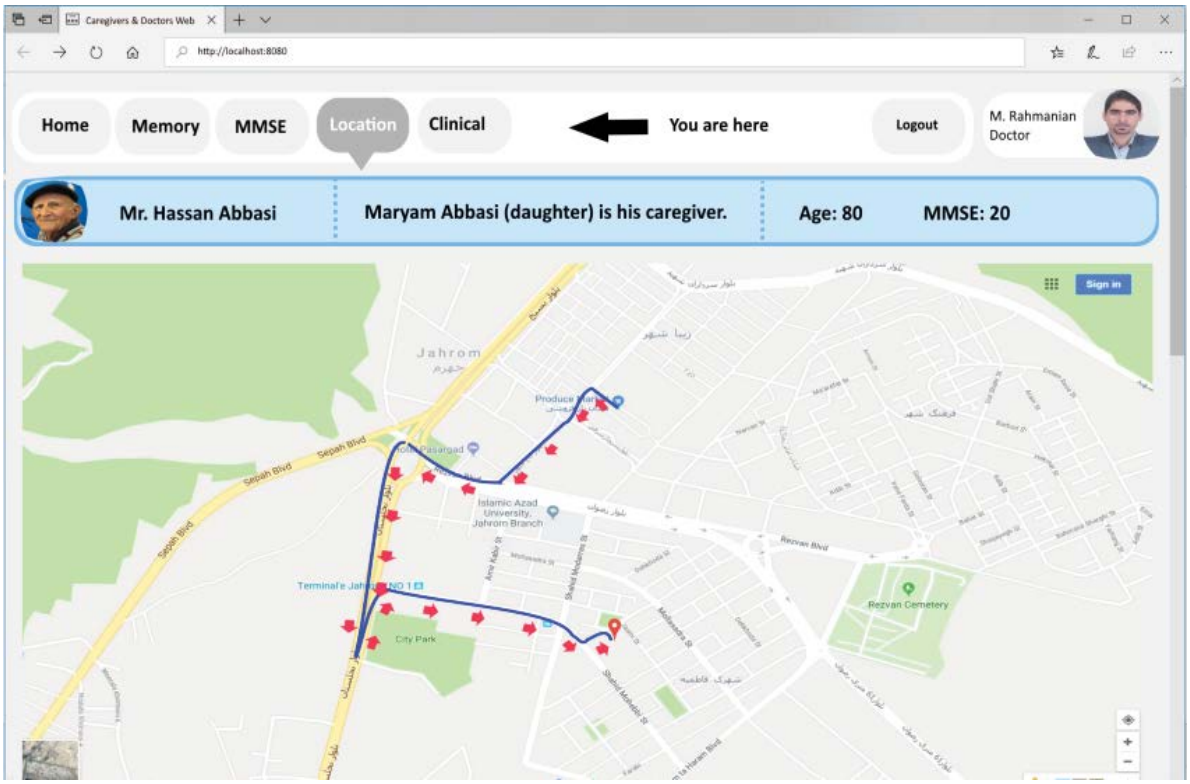

Figure 4: Caregiver web tracking system

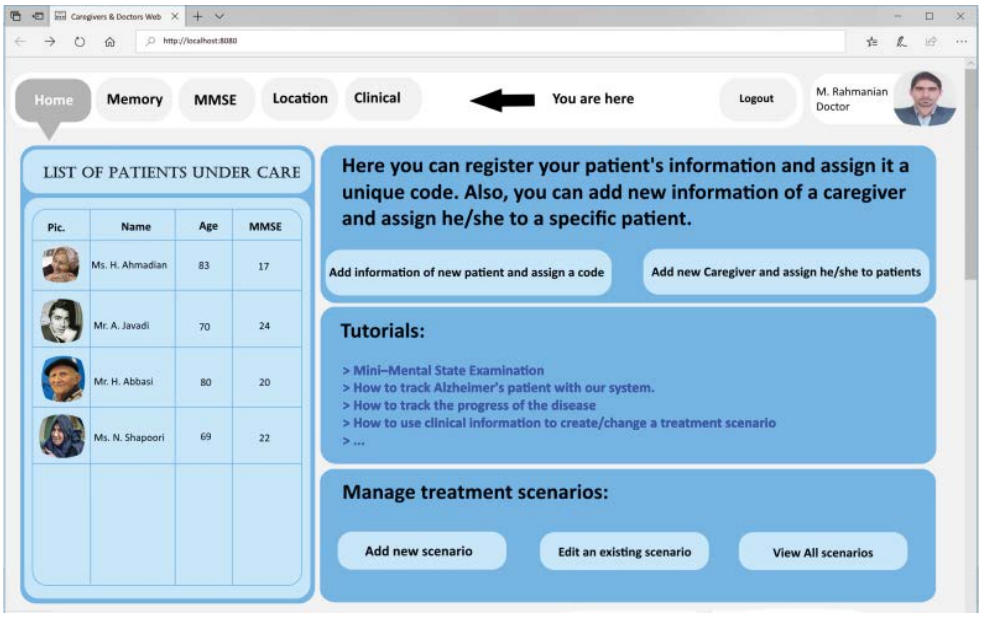

Figure 5: Total score of patients using assisted system for physician tracking system

when and how much drug to take were designed. Other similar applications are MyMedSchedule, MyMeds, and RxmindMe. Donnelly et al. improved the existing tools, which used only sound and text for warning, by adding video to their tool. In their proposed system, the caregiver is to record and upload a video through an internet connection onto a central server. The server, then, sends the videos on pre-planned times to the patients' mobile phones. They believe that they have, thus, simulated a virtual reality caregiver [17].

Some have designed a smart system for tracking the activities of the patients with mild cognitive impairment, using a multiple motion sensor system. The smart system they developed collects data through a multiple motion sensor system. Then, it analyzes the data statistically with the help of a related technology to detect abnormal activity. The information is, then, sent to the patient's doctor through a user system. Similar innovations have been reported in [14,17-21]. Yet, Riboni et al. method is capable of detecting much more complex array of activities [17,18].

Figure 6: Mobile game for cognitive massage

The researchers who have focused on the control of memory decline have designed such tools as Alzheimer's Daily Companion, Alzheimer Caregiver Buddy, and Samsung Memory Recaller. The most comprehensive program, tools and devise are addressed in the site below [14,20-23]. The application is intended to stimulate memory in people with early Alzheimer's symptoms by reminding them of the past experiences through videos and photos shared by people with whom they have had shared experiences, thereby helping them to remember family members, friend, relatives and their surroundings [14,22].

CONCLUSION

In spite of all efforts by the researchers in the field of the geriatric studies to use technological tools to cope with aging problems, people with Alzheimer's or dementia still suffer a lot. Most of the technologies introduced in the review of previous studies are unable to provide comprehensive care for such patients. Moreover, they are unable to adjust themselves to changes due to the progression of the disease. The proposed system in this article is intended to meet such patents' needs in improving their memory (massage therapy, play therapy), reminding them to do their necessary daily jobs, and tracking their daily activities in order to protect them from probable hazards through different stages of the disease with capability of adjusting itself to new needs as they emerge, thereby slowing or stopping further decline of cognitive ability. The technology introduced in this article is to be piloted on hospitalized Alzheimer's patients in a true experimental setting in the coming stage.

LIMITATION

This research designed and developed a device to help mild to moderate cognitive impairment in Alzheimer's patients and help them to prevent memory loss in these patients. Despite the fact that the device was designed based on the patients' complication and developed by a new approach to the patients' treatment as a medical and psychological approach, this device is recommended to be evaluated in patients to ensure its efficacy.

This application was submitted in the Copyright Center as a patent with cod of 139550140003005619.

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ETHICAL CONSIDERATIONS

Non applicable.

AUTHORS' CONTRIBUTION

(I) Conception and design: All authors (II) Administrative support: L. Mossalanezhad (III) Provision of the study materials or patients: All authors (IV) Collection and assembly of data: All authors (V) Data analysis and interpretation: M. Rahmanian (VI) Manuscript writing: All authors (VII) Final approval of manuscript: All authors.

CONFLICT OF INTEREST

Authors declare there is no conflict.

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