

# Advanced Technology Devices for Alzheimer's Assistance: A Review

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**Abstract**— The existing scenario of the patients suffering from Dementia or Alzheimer disease (AD) indicate that the percentage of people suffering AD is increasing drastically and alarming the health organizations as well as society. It has been reported that by 2050, 1 in 85 old age people (age above 65) will be suffering from this disease and this proportion will double in the next 20 years. As AD is a chronic neurodegenerative disease, it affects the memorization functions of the patient making them difficult to do simple daily activities and further degradation occurs as time passes. In view of this, many researchers and innovators have developed the assistive technologies (AT) for patients and their caregivers that help AD patients in doing their daily activities and also delays further degeneration of the disease. The field of AT mainly use Information and Communication (ICT) technologies viz. sensors and wireless technologies, wireless communication, the image processing and computer vision techniques, artificial intelligence, Internet of Things (IOT), smart phones and associated technologies, audio-video technologies and software development. The AT is also updating continuously to make the life of AD patient simple and more comfortable. This paper presents the in depth survey of AT devices developed for assistance of AD patients as well as their caregivers. It also discusses the problems faced by AD patients while using assistive devices and the challenges for AT development and research.

**Keywords**— Alzheimer's Disease (AD), Artificial Intelligence, Assistive Technology (AT), Image processing, Sensors

## I. INTRODUCTION

Currently the old age people disease called Alzheimer's disease (AD) is demanding the attention of the worldwide health organizations. The main reason behind this is the increasing proportion of older population suffering AD and the situation is alarming. The Alzheimer's Association has estimated that in 2017, 5.5 million US people of age 65 and above will have AD and this percentage will increase with age. Further they reported that women are more susceptible to AD than men. In India, more than 4 million people are suffering from AD and worldwide 44 million [1]. The important fact is that the life of person diagnosed with AD is really difficult and challenging to his family members and society. They need support from close friends, family and society to live peacefully. Therefore the problem of AD patients needs to be addressed and attended by various health organizations and society.

Alzheimer patients depending upon their level of disease need assistance in different forms that help them to do their routine work or other activities. The assistants who offer assistance at different levels are referred to as caregivers. There are different categories of AD patients and hence depending upon the requirement, AD patients can be

graded as early stage, moderate stage and severe stage. Some patients at early stage, depending upon their disease level can manage their routine and day to day life on their own with the help of few simple AT devices and hence they do not need help from caregivers.

Moderate and severe stage patients need support from caregivers. But the cost of these caregivers is not affordable to most of the patients. In addition, caregivers also need AT devices to help and monitor their AD patients. Therefore AT is to support both AD patients as well as for their caregivers.

AT mainly comprises of sensors, hardware and software development by integrating various technologies and ICT. Since last few decades the AT has been in development for the AD patients as well as their caregivers. This paper reviews in depth AT developed in the past for the assistance of AD patients as well as presents the existing scenario. It also discusses limitations of the existing AT devices and also presents the future challenges in this field.

## II. LITERATURE REVIEW

It is well known that AT devices help AD patients in number of ways so as to make their life simple and happy. Some of these widely used AT devices offering support at different levels are described below in short. These mainly include assistance in memorization if the memory loss is up to certain extent, tracking and monitoring activities, identity retention, security, reminders for various things viz. medication, lunch/dinner, tea etc. Besides this, AT devices were also developed to train and guide for body and mental exercise. As AD patients have more risk while operating some home and other appliances, many safety devices were also developed for their security. These safety devices used sensor technology and are called as smart home devices. The memory reminders viz. multimedia DVDs, picture phones, smart phones and associated devices were developed on large scale. For improving cognitive functions, recreational activities such as interesting games and puzzles were designed. It has been observed that in some AD patients at severe stage, the disease is degraded to such extent that they are not able to communicate with family and ultimately society. Memory loss affects the verbal and written communication that is really dangerous for social life. For such severe stage patients, the varieties of communication aids were developed.

Using the basic technologies and their integration, many researchers and scientists have invented large number of AT devices. Many researchers are working in this field to help and enhance the quality of life for AD society. The detail survey of existing AT devices is carried out and presented below as per AT device category.

### A. Memory Reminders

Memory reminding devices were developed in various types viz. DVDs, TV based prompt systems, digital clocks, cell phones, and smart phone based devices, picture phones. Multimedia DVDs are developed to assist patients in remembering various things/events and help in improving cognitive functions [2]. The DVD records the biography of patient and this DVD is played and displayed to that patient again & again to remind his family members, relatives, friends and colleagues. This activity of playing DVDs is done frequently and regularly to help AD patients in better reminding. This helps them to easily do their routine activities. Such DVDs are useful to patients as well as their caregivers. But there are few problems in the overall making of DVD such as which incidences to record, how many relatives & close friends to include etc.

AD patients who frequently watch digital Television can get help in the form of prompts for reminding certain things [2]. This type of TV prompting reduces the burden on the caregivers. The prompting is for reminding medication, tea, meal etc. This prompting may be implemented in different forms such as displaying relevant images, displaying messages etc. But the requirement is that the prompting should be in the appropriate and simple form. The complete system should be simple to use and flexible. For this, it is necessary to design and use control interface.

Many AD patients are not able to keep track of time and hence their day schedule gets disturbed. They are even unable to distinguish between day and night. For this, innovators designed the special digital clocks helpful for AD patients [3]. These clocks have large fonts and easier to read. Besides numerical time, they display extra information viz. month, day, week, morning, afternoon, night.

The novel concept of picture phones was specially developed for AD patients [4]. In this, picture of a person familiar to AD is displayed and if AD wants to call that person, then he just clicks on that picture. This is useful when AD forgets the phone numbers. For majority of AD patients, it becomes difficult to remember phone numbers of the family members and close friend. Besides this, they are not capable of using the smart phone features and facilities. Hence the simple to use picture phone is definitely helpful device.

Cell phone is a common technology device used as a reminding aid for AD patients [2]. The short video messages may be recorded in cell phone and depending on the patients requirement, the messages will be delivered at required times. Besides this, electronic prompt services such as text or reminders can be set up in cell phone's calendar.

In 2009, Mei-Ying Wang et al designed and developed a smart phone application named Wedjat [5]. This application is used as a reminder for medicine and food. It can reschedule the dose of tablets in case if patient forgets to take particular tablet. This application is designed with user friendly interface so that AD patient can identify and recognize his medicine and get the proper instructions for its intake.

At home, few AD patients forget the room light switches and their functions. For this, innovators have developed motion sensor lights which sense the motion of AD patients and illuminate the room [3]. This system helps in the prevention of patients fall at dark.

Similarly AD patients need lot of support in doing Kitchen work such as finding utensils and items, sequencing in food preparation. Due to memory loss, certain steps will be missed or repeated. Therefore RFID technology and computer vision techniques are integrated to solve this type of problem [6].

Later using advanced technology, memory aids were developed to improve cognitive functions. Typical memory aid used was memory glasses that use artificial intelligence techniques and reminds on the basis of context awareness instead of predefined reminders [7]. Similarly wearable memory aids for cognition viz. Memoclip, Friedman, ISSAC, Autominder, Wearable digital camera SenseCam were developed. Prototypes of these memory aids were tested on healthy patients. ISSAC needs user training and it is difficult to do it on AD patients.

### B. Tracking and Monitoring Systems

The most common problem faced with AD patients is the wandering and it is very serious problem observed in society. AD patients frequently go out of home, wander and hence unable to come back home as they do not remember path or home address/contact. It becomes very difficult for caregivers also to keep track of them. In view of this the number of tracking devices were developed such as shoes embedded with tracking sensor and associated system, RFID based tracking system, socks integrated with sensors and associated mobile application for intimation. Pressure mats based on pressure sensitive technology were developed which alert a caregiver when patient steps on mat and is on the way to exit home. The security system called CareWatch was developed to monitor unattended exit from home at night [7]. This is tested for a period of more than 200 months on AD patients at home. The result was positive but also needs to test other parameters for proper evaluation of this security system. The typically used system is Global Positioning Services (GPS) tracking to find location of wandering patient.

Live systems based on video monitoring and associated verbal systems have been developed to monitor and track AD patients while doing specific tasks [2]. The most common problem in the case of AD patients is the reminder to do simple task of hand wash. Simultaneously verbal systems help patients reminding the specific work if they forget while doing. The development of software for monitoring and tracking is a difficult task.

Another video based technology has been developed for assisting in the body exercise for patients [2]. The videos show the steps and sequence for the particular exercise and patients follow it to do the same. When the patient does exercise, its complete exercising activity is monitored and observed for correctness and accordingly actions are taken. For checking correctness, the computerized model and the use of image segmentation algorithms are used.

The technique for monitoring and measuring the brain activity of AD patients is under development [2]. These techniques use noninvasive technique and associative systems are called electroencephalogram (EEG) systems. These techniques are useful for cognitive training of patients.

The wearable radio frequency (RF) transmitters were designed and developed to record the movement trajectory of AD patient at home [7]. In this system, small wireless network consisting of RF receivers and motion detection devices was developed to test the system. For this, it was necessary to consider the home architecture to remove problems in capturing RF data.

### C. Smart Safety Devices

As mentioned in report [8], the assistive products are developed to offer security to AD patients against injury at home or outside. These products include alerting the patients' caregivers and patients in the form of alarms, indications while patients exit the home.

The automatic assistive devices are developed for providing safety for AD patients while using automobiles [8]. These devices control the car battery with simple cheaper switch. Starting of the car or vehicle is controlled by the switch operated by caregiver. Similarly simple economical alert alarms are developed to alert if any passenger removes the seat belt.

Few devices that calls help for AD patients were developed for those with early stages of the disease [8]. This device is fitted with a button and patient can wear it around neck. When the patient needs help of somebody or caregiver, he presses the button. The range of this device is few hundred feet.

AD patients should be secured while using or operating the various types of appliances especially electrical appliances. The typical cases of this are as below. Similarly patients may forget to close water taps that may cause flooding situations. Some patients may forget to turn off stove burner. Some may be unable to control the room temperature setting.

Therefore various safety devices were developed for different purposes viz. electrical appliance safety, gas stove safety, cooking safety, tracking or path finding, leak detection. These safety devices are based on various sensors and associated embedded development.

Similarly the safety devices comprising the prevention of fall, tracking systems were developed using wireless technology and sensors. Computer vision based automatic fall detector systems were developed and tested [7]. But these devices send only alert to caregivers and still the task of monitoring remains. This does not solve the problem of wandering completely.

### D. Miscellaneous

Besides these common problems, AD patients in moderate to severe phase also get isolated from society due to noticeable memory loss. This further deteriorates their communication with society which again enhances memory loss. This goes into vicious cycle. To prevent this situation, the communication aids that prevent social isolation were developed. Under this, one tool named Social Memory Aid that helps in name and face recognition was used. The use of tool enhanced the communication abilities and also increased the chances of making independent phone calls to family members, relatives and close friends.

New technologies like robots are useful for assistance of AD patients. The term artificial companion stands for robot designed and developed to help AD patients

in doing routine home activities and assistance in self care [6]. This artificial companion improved the overall life quality of AD patients. But it is necessary that robot should be simple and easy to use.

The special assistive technology is developed for normal aged persons to do self cooking [7]. These include VERA (Visually Enhanced Recipe Application) and Cook's Collage. Cook's Collage is a video monitor based reminder system. It guides the cook while implementing multistep recipe by displaying the previous steps performed. VERA is using the text and sound options to help cook by visually displaying instructions. In this, it is possible to customize the visual instructions according to user. In [9], the integration of RFID tags and technology giving audio prompts is used to help aged patients in perform the required steps while cooking especially making a hot drink.

In 2007, Naveen Chilukoti et al. proposed the work to delay the degeneration of cognitive functions in Alzheimer disease [10]. For this, they suggested the need of exercise to patients in the form of both physical and mental. AT is used for giving the exercises to AD patients. The physical exercise is to be carried out using mini stationary bike. For mental exercise, the games are designed that stimulates the brain thinking. This includes the focus on memory, prediction, problem solving capacities, different logics etc. They also used multi-stimulant sensors to give relaxation & fun to AD patients. They suggested that in future, different methods may be used to check and monitor the capacity of doing exercise and exhaust level of AD patients.

In 2008, Shuai Zhang et al proposed the use of AT in smart homes to help Alzheimer patients [11]. The smart home is the integration of various technologies viz. wireless sensors and associated technology, databases and management, machine learning, AI, intelligent decision making. This work uses the collection of data using sensors from AD patients. This data is stored and behavioral patterns of AD patients are observed and predicted. Based on this learning approach, the assistance is provided to AD patients for easily carrying out their daily activities. The analysis of behavioral pattern can be used to provide customized assistance. The future work is required to evaluate the scalability and robustness of this approach.

In 2011-12, Marc A. Kowtko and Jean F. Coppola created and developed open source assistive technology website for the assistance of old aged people with disabilities. Through this website, they created an online community that develops open source assistive software and conducts research in the fields of Web Accessibility and Assistive Technologies.

It has been reported that the assistive technologies that support the recreational and entertainment activities viz. games, art, craft etc. were not developed to a large extent for AD patients [12]. It is necessary to do further development and growth in this era.

In 2013, Jean F. Coppola et al reported that the innovative devices such as iPads and Tablets along with mobile applications can be used for the cure and improving the quality of life for AD patients [13]. AD patient's cognitive functions can be recovered by developing mobile apps that allow them to listen their favorite music and frequently view family photographs. But there were many

problems faced by AD patients in operating these mobile applications based innovative devices viz. inconvenient user interface, weight of the device, touch screen problems, difficulty in using the device. The future work is to detect the disease as early as possible and accordingly help patients by giving proper brain exercises and nutrition.

In 2015, S.Mareeswari and Dr. G. Wiselin Jiji have carried out the detail survey about the early detection of AD disease [14]. This survey is essential because the level of treatment differs depending upon the level of disease. At early stage, the problems faced by AD patients are memory loss for certain events, confusion with the timings and location or place etc. The further degradation of these problems may be stopped by making integration of number of ATs and also help from caregivers.

In 2016, a good attempt is made by Er. Zainab Pirani et al. to make the life of AD patients more independent [15]. Most of the AD patients are dependent on their caregivers. To minimize the dependency of AD patient on caregiver, this work has developed the Android based Assistive Toolkit for Alzheimers. This toolkit is designed to track and monitor movements as well as daily activities, proper reminders for medication and food. Besides it also helps to improve memorization abilities by giving AD patients the quiz to solve. But it is necessary to update this toolkit with new technologies to sustain in the market. Also it is required to make the user interface simple and easy.

### III. SUMMARY OF AT LIMITATIONS

It has been observed that varieties of AT devices developed are really useful to AD patients as well as their caregivers. But at the same time there are certain limitations associated with these AT devices. In case of memory aids like TV/Video based prompting systems, only required and simple prompts need to be set otherwise effective utilization of the system reduces. Mobile based applications and smart devices are designed to provide the number of useful features. But aged AD patients find it difficult to use these advanced applications due to complexities and uncomfortable user interfaces. They also find difficulties with the sensitivity of touch screen devices as well as screen glares, audio system. In case of monitoring and tracking systems and also studying behavioral patterns of AD patients, the main hurdle is the privacy and ethical issues which cause limitations in making optimized behavioral model of AD patients. The approximate model may lead to develop faulty or inaccurate decision systems. Artificial helpers like robots are useful but should not incorporate too many complexities. Recreational activities are essential for AD which makes their life energetic and happy. But existing AT based recreational activities viz. games, puzzles, art and craft, are limited and need to be customized according to the requirements of AD patient. Finally the most important is that AT is not cheaper and also the cost of caregivers is also not affordable to considerable AD population especially in developing countries like India. The major impact of this is that AD population is neglected and not attended by society making their life miserable.

### IV. CHALLENGES FOR AT

There are significant challenges in the existing AT field for AD society and thorough research is needed to address some of the issues mentioned below. The development of memory aids demand the simplicity for use and also flexibility. This needs to set and optimize the design parameters of memory aids. Memory aids like Multimedia DVDs record AD patient's biography. But the main challenges are how to make biography that summarizes the life of AD patient, complexity, duration of play etc.

In cellular based AT, though the smart phones, tablets and mobile applications provide most of the functions and full support for AD, the main hurdle is AD population is reluctant to use and operate these devices because of complex user interface and too many functionalities. Practically, the usability of this AT is very low. So the main challenge is to use and develop the complex functions but make the device simple and easy to use.

Artificial companions like robots may use complex functionalities and latest computational technologies and intelligence, but their interaction and interface with AD need to be convenient and simple. Large number of Leisure activities using AT need to be developed in the form of simple to complex games, art and craft activities. These activities stimulate the cognitive functions of AD and help in the overall development of AD. So the challenge is to use the number of heuristic and hybrid algorithms to design the logical games and other activities. The design and development of computational models reflecting the behavioral patterns of AD patients demand thorough study of data collection, analysis, and data mining approaches, classifiers and artificial intelligence techniques.

### V. CONCLUSION

From this study it is concluded that the number of AD patients is increasing at a high rate and hence demanding the development of more useful and affordable AT devices reducing patients' dependency on caregivers. This will attempt to reduce the overall expenditure on AD society. It has been observed that the acceptance of AT devices for real life task implementation is low. With this consideration, future work is needed in this era to make simple and handy to use AT devices. Further efforts are expected to do marketing of AT devices to increase its acceptability. It is also necessary to increase the awareness of AT devices by arranging the awareness programs as some AD patients are familiar with few well known devices and totally unaware about rest of the AT devices.

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