Journal of Engineering and Applied Sciences 13 (1): 242-247, 2018
ISSN: 1816-949X

Smart Technologies for Patients with Alzheimer's Disease: A Review

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Abstract: Smart technologies help people with their daily activities and ease their lives. This study is focused on a review of smart technologies designed for people with dementia, predominantly with Alzheimer's disease. As the population gets older, the number of patients with AD and the burden on the economy will grow. Many modern technologies enable people in the first stages of AD to remain active. In later stages, technology enables them to stay at home longer before hospitalization. Technology also significantly eases the work for caregivers and family.

Key words: Alzheimer's disease, dementia, smart technology, wearable technology, smart home, hospitalization

INTRODUCTION

The population is getting older as shown by the data from Eurostat, the size of the population 80+ is expected to grow by 180% by the year 2050. With increasing age, there is a bigger chance that a person will experience dementia. Dementia is a chronic disease affecting the brain: it decreases the ability to think. About 5% of persons older than 65 and more than 40% of those older than 90 are affected by dementia (Aalten, 2004). The most common cause of dementia is Alzheimer's Disease (AD) (two-thirds of older people and one-third of younger patients 50-65 years old). AD is sometimes called the plague of the 21st century (Aguero *et al*., 2001). Prevention and early diagnosis is very important in AD treatment. There is currently no cure for AD but with the help of modern smart technology there is a bigger chance to delay the onset of the disease. Technology can also help people with a mild stage of disease to live a normal-like life. The use of different technologies enables patients to stay longer in their homes (Bas *et al*., 2008; Beattie *et al*., 2002, 2004) instead of moving to clinical facilities and to be monitored at home by relatives or special workers. There is a significant economic burden because of the care costs. These can be lowered by using modern technologies. Also, caregivers can use various devices and applications to ease their work, save time and thus also lower care costs. It is difficult and expensive to take care of patients in the later stages of AD (Bourennane *et al*., 2013) which also brings with it physical, psychological and social burdens on the caregivers (Brakhus *et al*., 1999; Cummings *et al*., 2008). There are many studies (Curone *et al*., 2007, 2010; Davies *et al*., 2013; Donnelly *et al*., 2008) focusing on the needs of persons with AD. Patients describe their needs mainly as physical, psychological, social and also the lack of information about the disease and the possibilities of treatments. The key problem domains have been introduced by Droes *et al*. (2006), physical and mental health, social contact with family and friends, being useful to others, enjoyment of activities, self-esteem (being respected by others) and self-determination and freedom. Different smart technologies are helping people with Alzheimer's disease to ease the burdens imposed by this dementia. This study is focused on reviewing such technologies. In the next part, the problems of patients with AD are introduced. In the third part of this study, smart technologies and wearable technologies are discussed.

MATERIALS AND METHODS

AD (problems and stages): The first stage of AD starts very slowly and is difficult to identify. Intellectual capabilities are slowly decreasing and memory problems are starting. The first problems are with short term memory and later with the progression of AD also long term memory problems will occur. There is often also anosognosia, i.e., patients are not aware of their disease. Other symptoms are: problems with performing routine household tasks, lowered ability to make judgments, disorders of speech and problems with expression, storing

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things in non-standard places, changes in personality, mood and behavior, problems with abstract thinking, impaired orientation, problems with dressing, loss of initiative and a loss of interest in hobbies and jobs. The literature divides the progress of AD into different numbers of stages, mostly varying from 3-8. In this study, 3 stages based on Eloranta *et al.* (2010) will be described.

The first stage: Occasional difficulty finding words, problems with articulation, decreased fluency of talking, forgetting names, forgetting appointments, difficulties with new situations, difficulties with operating a new device, less attention to dressing standards, avoiding household tasks, difficulties with more complex financial decisions, reduced ability to drive a vehicle, difficulty making decisions, loss of initiative, depressed mood, apathy or aggressive behavior, subjective feeling of forgetfulness.

The second stage: Loss of interest in hobbies and favorite activities, forgetting faces, inability to use lists, forgetting recent events, failure to adhere to the time of any meeting, difficulty finding words in ordinary conversation, repeating words, difficulties in establishing conversations, significantly impaired ability to carry out household tasks, disorientation in time and space, wandering within known locations, occasional hallucinations, aggressive behavior, inability to concentrate, weight loss, decline of cognitive functions.

The third stage: Failing to recognize family members, inability to express their needs, pathological thinness, urinary and fecal incontinence, inability to dress, inability to eat, failure to adhere to hygiene, often immobile, disorientation, inability to speak, inability to self-service, inability to live independently.

RESULTS AND DISCUSSION

Smart technologies: Smart technologies are now a days part of our lives. They help many people with their daily activities. Some of these devices can be used also to ease the lives of people with dementia. Monitoring the health status of a person (Farbood *et al.*, 2004) from a distance can save significant time for the caregivers and gives the monitored person more freedom. Many projects have focused on technologies which are mainly for elderly people and people with psychological problems.

A complex system for an Alzheimer's care unit is introduced by Fratiglioni *et al.* (1999). A multisensor network is deployed in order to gain information about the monitored persons. A personalized behavioral model consisting of motion deviations, nocturnal activity, falls and mobility can be studied and evaluated. The nursing staff have access to the data through a web application and the system also includes an alert system in case of life threatening situations such as the fall of a person (Hancock *et al.*, 2003). Some of the sensors are attached to the person as part of a plaster. The modern trend uses such plasters (Hayes *et al.*, 2008) containing different sensor technologies, mostly temperature, body position, person localization and fall detection is monitored by this technology. This could be very useful in a situation when there would be a problem in putting bigger devices such as a necklace or bracelet on the body of a monitored person.

Smart wearables: Using smart variables (Janckulik *et al.*, 2008; Kalantarian *et al.*, 2016; Konstantas, 2007) can help patients in all stages of AD. A device containing various sensors can help provide information about the current state of a monitored person. Wearables can communicate with smartphones (Kosse *et al.*, 2013) and using its connection to the Internet can provide real time information about the exact location of the monitored person and their health status. Accelerometers and gyroscopes are embedded in nearly all smart bracelets. Using sophisticated algorithms such a device can monitor the occurrence of life threatening situations such as a person's falling. Modern wearables aim to monitor also other life functions of patients. Monitoring the heart rate is nowadays also one of the widespread features of smart bracelets. Current research is focusing also on measuring the glycogen in the blood and the blood pressure. Using such devices can provide complex information about the health status of a person and significantly lower the effort needed to monitor patients in facilities or family members at home. Sensors are often embedded into a smart wristwatch (Krejcar *et al.*, 2009), smart clothing (Launer and Hofman, 2000) and (Lukowicz *et al.*, 2004), necklaces (Lmberis and Dittmar, 2007) or wristbands (Massimi *et al.*, 2008).

There are different situations where the use of modern technology can significantly help with a given situation or facilitate the appropriate actions. This study has been divided into 3 parts based on the type of help: help with memory, help with routine tasks and help for caregivers.

Help with memory: There are different projects developing technologies helping people with AD to train their memory. Cameras embedded into clothes or necklaces enable monitoring the day's activity of a person (Cann *et al.*, 2011). These recordings can be later used for

reminding the person of his/her day. It trains the memory not only in how to remember different events but also to recognize different people. With face recognition technology, these devices could highlight friends, family and other important people.

The positive results of the testing project SenseCap can be found by Meiland *et al.* (2010). Every day, 1000-1500 snapshots are made by a small portable camera which is worn by the patient. At the end of the day, a short 3 min video can be played in order to remind the person of what they were doing all day long.

Help with routine tasks: As AD progresses, routine tasks start to be problem for individuals. In a mild stage of the disease, it takes longer to do such tasks. In a moderate stage, the completion of tasks with multiple procedures starts to be a problem. Various technologies can help people in these stages with the completion of such tasks.

A complex system for people with AD is COGKNOW (Meiland *et al.*, 2007). This system helps with daily activities, trains the memory, maintains social activities and increases the safety of the person.

One of the systems helping people with their daily tasks is the coach (Mihailidis *et al.*, 2008). The first prototype was focused on hand washing. A person's hand locations were monitored by bracelets. The next versions started to use video tracking which is much more comfortable for users.

Older adults have started to be more accustomed to using smart phones. There are various applications for reminding them of their daily tasks. Such a system (Mulvenna *et al.*, 2010) can help prepare messages which will be played at given times. The messages can remind the person to take their medicine have lunch or for example, not to forget to go to a meeting. Reminders to exercise and controlling the training process can help older people with their physical abilities (Murai *et al.*, 2015).

There are also special technologies in AD diagnostics such as music or art therapy using modern technologies providing various interesting diagnostic information (O'brien *et al.*, 2015). For later stages, patients can find music therapy very helpful. Such patients are often not very responsive. Using the application Hyperscope (Perkins *et al.*, 2008) enables the user to compose their own music and so, the patients are encouraged to use their motor control and interact with the application. The aims of current research are to distinguish early AD from other neuropsychological problems, based on information from the patient's music therapy. In addition, art therapy (Pitts *et al.*, 2015; Powell *et al.*, 2008) helps people with AD. A special application (Roest *et al.*, 2005) was developed in order to encourage and support cognitive creativity. Patients are more interested in such activities and can train their brain as well as motor functions and often also increase social contact with others.

Aging and problems related to it are a current problem in Japan. There are several projects concerning the use of modern technology to assist elderly people. One of the first fully automated health monitoring systems for dementia patients was introduced nearly 20 years ago (Rosner *et al.*, 2015): rooms with different sensors were built and data about its inhabitants was collected and evaluated. The same researcher investigates by Sorrell and Sorrell (2008) the possibilities of using robots for caring for elderly people. For severe dementia patients, the robot AIBO is recommended as a technology for increasing social activities.

In Osaka, Japan, a smart home detecting unusual events related to health problems, equipped with 167 different sensors is introduced by Stoukides (2008). A similar project is a smart home equipped with cameras and microphones (Tamura *et al.*, 1998) for monitoring its inhabitants. This direction of research can be controversial because of problems with the inhabitant's privacy. A household object interaction system (Tamura *et al.*, 2004) for recognizing the inhabitant's behavior emphasizes the privacy of the inhabitants while gaining information about their activities.

Help for caregivers: Technologies can help not only improve the lives of patients with AD but also ease the work of their caregivers (Teri, 1997; Valembois *et al.*, 2015). Monitoring and providing information about patients can save a significant amount of the caregiver's time. There can be prompt reactions to life threatening situation that can be noticed by a surveillance system and sent to the personal device of a caregiver (Davies *et al.*, 2013).

Not only people with AD have needs related to the disease. Research by Walters *et al.* (2000) deals also with the needs of caregivers. Systematic reviews focused on technologies helping caregivers can be found by Yamazaki (2006). Research dealing mainly with telecare can be found by Zachos *et al.* (2013). Access to information about the disease, the scientific literature and contact with the rest of the community is very important for caregivers. Modern communication technologies provide all of these. By Teri (1997), a device running an adapted enterprise social media app to support person-centered care is introduced. Caregivers can store information about the behavior of patients and different

events related to their care. The information can be shared among caregivers and the history of the patient's behavior can be monitored.

CONCLUSION

The population is getting older and the number of people with different problems related to age will increase. Research in the field of modern smart technologies is bringing about many devices and applications that help ease the daily tasks of elderly people and remain active longer. Many of these technologies are focused on people with dementia and its most common type, Alzheimer's disease. With the help of such systems, people in the first stages of AD could continue their normal lives. In later stages, smart technologies can monitor the health status of such a person, provide information to family and caregivers and sound an alarm during life threatening situations. In all stages, technology helps to train the memory, increases social contacts and helps with daily tasks.

ACKNOWLEDGEMENT

The support of the Czech Science Foundation GACR #14-02424S is gratefully acknowledged.

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