

# An Intelligent Assistive Tool for Alzheimer's Patient

Kazi Shahrukh Omar<sup>1</sup>, Afia Anjum<sup>2</sup>, Tahrima Oannahary, Md. Rezaul Karim Rizvi, Diana Shahrin, Tasmiah Tamzid Anannya, Sanjida Nasreen Tumpa, Md Mahboob Karim, Muhammad Nazrul Islam, Md Fazle Rabbi

Department of Computer Science and Engineering, Military Institute of Science and Technology (MIST), Dhaka-1216, Bangladesh  
Email: {<sup>1</sup>qshahrukh41, <sup>2</sup>afia.anjum70}@gmail.com

**Abstract**—Alzheimer's Disease (AD) is a chronic neurodegenerative disease that causes to develop dementia. Alzheimer's patients find it hard to remember recent events, reason and even to recognize people they know. As the disease advances, symptoms can include difficulty with language, disorientation including getting lost, mood swings, loss of motivation, lack of self-awareness and overall behavior. Though a limited number of IT based solutions exist to provide support for Alzheimer's patients, but most of these provide very isolated services either for the patients or for the caregivers. The objective of this research is to propose an assistive tool for Alzheimer's patients and their caregivers to provide support like health monitoring, assist to find lost items, provide reminder to take medicine and assist to monitor patient's location. A light-weighted evaluation study was carried out with 15 participants. The evaluation study showed that the proposed system was effective and usable for the patients and their caregivers.

**Keywords**—Alzheimer, mobile application, heart rate, assistive tool, intelligent system, sensors.

## I. INTRODUCTION

Alzheimer's disease is a progressive disease in which the destruction of memory cells causes slow depreciation in memory, thinking and reasoning skills. A great deal of difficulties are faced by an Alzheimer's patient including short term memory loss, aggression, loss of communication skill, repetitive behaviour, anxiety, agitation etc [1].

According to [2], 24.3 million people have Alzheimer's disease today, with 4.6 million new cases every year (one new case every 7 seconds). The number of people affected will get doubled every 20 years to 81.1 million by 2040. The increasing rate of Alzheimer's patient is not uniform for all over the world. The experts have forecast the increasing rate by 100% between 2001 and 2040 for the developing countries whereas the rate is more than 300% for India, China, and their south Asian and western Pacific neighbors. The number of patients facing dementia caused by Alzheimer's Disease is increasing in the entire world including Asian subcontinent [3].

With the advancement of technology, it is seen that, technology plays a vital role as caregivers for those people who cannot take care of themselves [4], [5]. Therefore, the objective of this research is to develop an intelligent assistive tool for Alzheimer's patients to ease their daily life by measuring their heart rate, locate their personal belongings, monitor

medication taking status and find their current location, while these necessary states of patients will be delivered to their family members and caretakers through a mobile application.

The rest of the paper is organized as follows. Section II discusses the related researches previously done in this area. Section III presents the conceptual framework of the system. The detail implementation of the proposed system is discussed in Section IV followed by the evaluation of the system in section V. Finally, section VI concludes the article.

## II. LITERATURE REVIEW

A significant number of research has been carried on the design, development and evaluation of the assistive tool for the special need people, blind persons, aging population, and for the Alzheimer's patients [6]–[9]. This section will briefly introduce some work focusing to the development of assistive tool for Alzheimer's patients.

A limited number of papers were conducted focusing to mobile applications and software systems. In [10], Yamagat et al. showed that tablets and iPads could be utilized with Alzheimer's patients portraying favorite music and family photographs, as it helped them remember. In another study, Armstrong et al. [11] highlighted the potential explicit and implicit interaction techniques for Alzheimer's patients to receive care using smart phone buttons, touch screens, motion sensing and voice recognition. Similarly, in [9], Donnelly et al. developed a mobile application to provide a virtual caregiver which would give frequent memory cues through video reminders for mild AD patients. A medicine dispensing system is proposed in [12] that reminded the user to take medicine at the predetermined time interval and informed caregiver if they had taken the medicine or not. Some other studies [13]–[15] discussed the smart medication systems that would help patients who require medications several times a day. These devices would deliver medication in the proper chronological order and at correct time intervals.

Again some studies were conducted focusing on hardware systems. For example, an IOT based wearable ECG wireless sensor system was proposed in [16] which monitors whereabouts of Alzheimer's patients and triggers alarms to caretakers in case of emergencies. The use of pervasive computing technology to provide better live-at home facility

TABLE I  
SUMMARY OF PREVIOUS WORKS

<i>References</i>	<i>Technology</i>	<i>Objective</i>
[9]	Internet based technology	To give video reminder about daily activities to the patient
[12]	Real time clock, timer, sensor to detect presence of bottle, audible alert	To work as a medication reminder and overdose safeguard
[13]	Computer controlled medication dispensing system	To ensure the proper medication and timing
[15]	Mechanical technology	To indicate the number of pills that has been taken
[16]	IOT based wearable ECG wireless sensor	To monitor whereabouts of Alzheimer's patients and trigger alarm in case of emergencies
[17]	Voice interface, smart phone, ultrasonic location interface	To make the patient do their daily works and taking care of patient's medication
[19]	Multi-agent systems together with the use of RFID technology	To guarantee that patient is getting the right care from the assigned nurse and doctor
[20]	Electronic pedometer	To monitor a person's movement and show heart rate
[21]	Sensors, wireless communication	To record the patient's movement and daily behavior
[22]	GPS and GSM technology	To track the location of patient
[23]	Microchip Wireless Technology	Tracks patient in a range

for the elderly citizens are discussed in [17] and [18]. However, their system neglected the possibility of the outdoor experience and specific cases of visiting outdoor by the old people. In [19], researchers presented an autonomous intelligent agent for monitoring Alzheimer's patient's health properly. In [20], a fitness monitoring device was proposed that included a wireless heart rate monitor which was coupled to the electronic pedometer without any wiring. The wireless heart rate monitor provided a heartbeat signal indicative of an exertion level of the user, while a visual display was provided to display the pedometer functions and the heart rate signal. In [21], a device was described, which was attached to the patient's body, monitoring the movement and behaviour of the patient and informing the caregivers whenever unexpected or alarming incidents occurred. According to [22], real-time GPS-GSM tracking could be helpful for dementia patients to ensure their safety when they go outside of their house. In [23], authors emphasized on memory loss of an Alzheimer's patient who tends to forget things and came up with the solution of Wifi and wearable technologies. Google map-based tracking system and notification to caretaker was an efficient way to help these people.

A summary of the previous works is shown in Table I. In sum, the previous studies suggested separate modules to assist the patients from different angles. It is certain that no collaborative system was developed to help the patients integrated with physical health monitoring, smart medication system, smart tracker for lost items and locating patient both inside and outside home. In addition, inclusion of caregiver and smart phones were also missing parts of the puzzle. Thus, this research aimed to develop an autonomous system integrating all necessary features (constant monitoring, reminder for taking medicine, monitoring heart condition and finding lost items) including relatives and caregiver to make Alzheimer's patient's life easier.

### III. CONCEPTUAL FRAMEWORK

A conceptual framework was proposed to develop an intelligent assistive tool for Alzheimer's patients as shown in Fig. 1. The framework consists of four modules: heart rate monitoring, lost item finder, smart medicine box and lost patient locator. The functionalities of these modules can be accessed/used from a single mobile application that can be used by the patient's caregiver or nurse. Each of these modules will perform independently to help Alzheimer's patients.

#### A. Heart Rate Monitoring

The heart monitoring device allows to monitor the heart rate of the patient and notify the concerned person in case of irregular heart rate. If the heart rate of the patient rises above a threshold value, the nurse/concerned person will be informed about the patient's condition. Based on the situation the nurse will take first aid measures and call on doctor in case of emergency (see Fig. 2).

#### B. Lost Items Finder

It is hard for Alzheimer's patients to keep track of their important things like spectacles, keys, wallet. So, a tracker is attached to their important accessories so that whenever they lose something, they can find it using a mobile application which will buzz an alert to that accessory (see Fig. 3).

#### C. Smart Medicine Box

Alzheimer's patients might forget to take their medicines on time. Thus, continuous monitoring of patient's medication is another vital thing. Whenever the patient will take medication, smart medicine box will activate a WiFi module and send data of medicine intake to server. If the patient does not take medication on time, then a text alert will be sent to the concerned person/nurse (see Fig. 4).

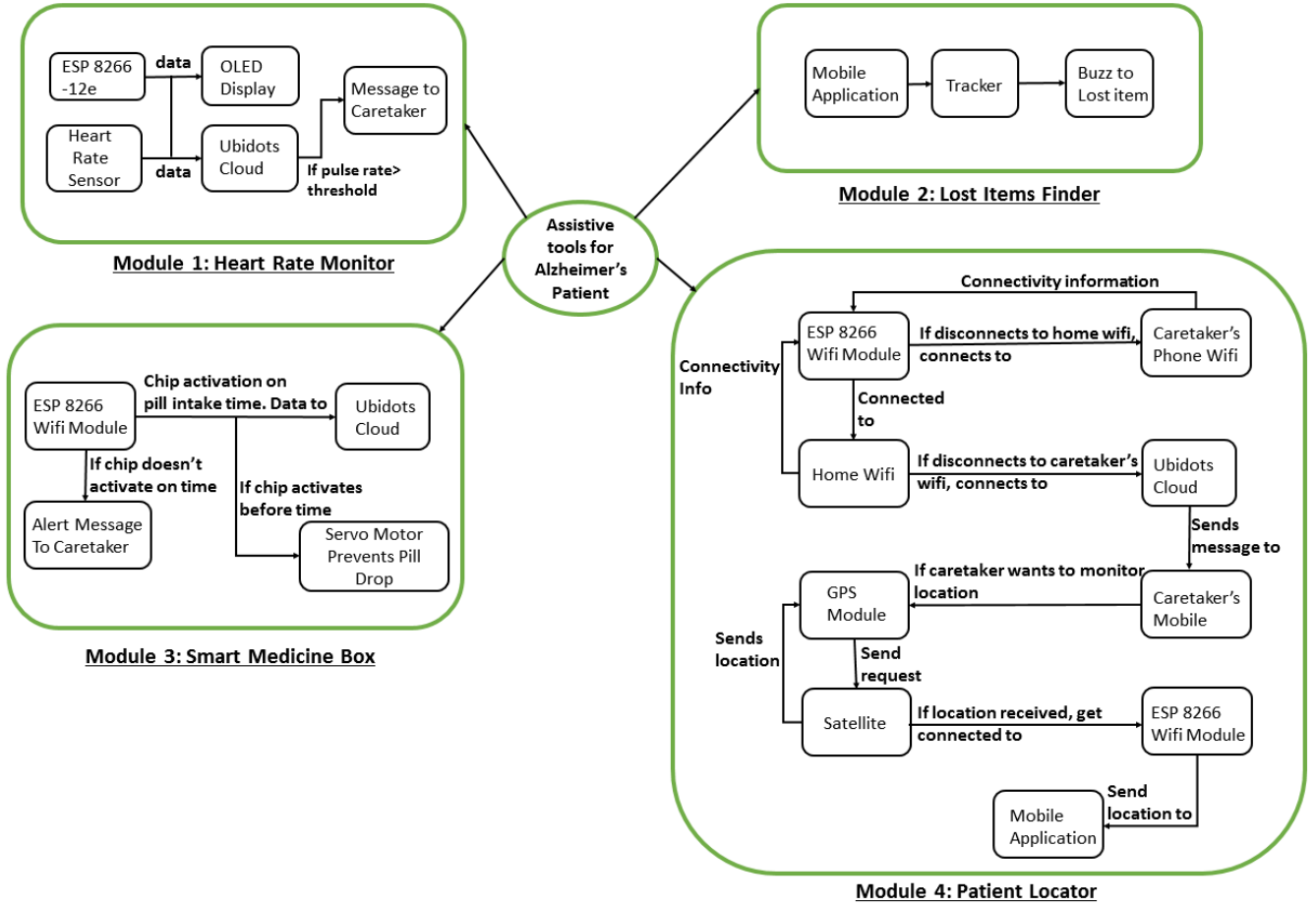


Fig. 1. Conceptual framework of the proposed assistive tool.

#### D. Lost Patient Locator

If Alzheimer's patient goes out of home unattended, he/she might get lost. The GPS-WiFi tracking system will always keep track of the patient's whereabouts. If the patient goes out of boundary line of the house or is far away from their caretaker, the caretaker will be notified by a text alert and will be able to continuously monitor patient's location through a mobile application (see Fig. 5).

The four individual modules creates such a system environment for the Alzheimer's patients so that their medication and health is on check, they can easily find necessary items if lost and their whereabouts and location can be tracked. It also helps the caretaker of the patient as the system makes sure the patient is always within reach and does not get lost which is a common scenario in case of Alzheimer's patient.

#### IV. DEVELOPING THE ASSISTIVE TOOL

The assistive tool was developed in two parts: hardware (see Fig. 6) and a mobile application. The required hardware components are shown in Table II. The Ubidots cloud platform was used to develop the mobile application. The mobile application holds the monitoring and assistive control of four features that include patient locator, smart medicine box, heart

rate monitor and lost items finder. Fig. 7(a) portrays the home screen of Alzheimer's assistant application.

(a) *Patient locator* - The GPS tracking system was used to keep track of Alzheimer's patient's movements. The tracking system was divided into phases. In the first phase, if the patient goes outside of home with his/her caretaker and gets lost, the caretaker can know the patient's location through a mobile application (see Fig. 7(b)). The GPS module continuously fetches the location of the patient with latitude and longitude and sends the data to caretaker's mobile application via WiFi module.

TABLE II  
REQUIRED COMPONENTS OF THE SYSTEM

Module	Components
Heart Rate Monitor	Esp8266 12e, Pulse sensor, OLED display, Battery, Wires
Smart Pill Box	Esp8266 12e, Servo Motor, Batteries and other power sources, OLED display, Wires
Lost Items Finder	Piezo buzzer, Hc-05 Bluetooth module, Arduino Uno, Battery
Lost Patient Locator	Esp8266 12e, Neo 6m GPS tracker, Battery

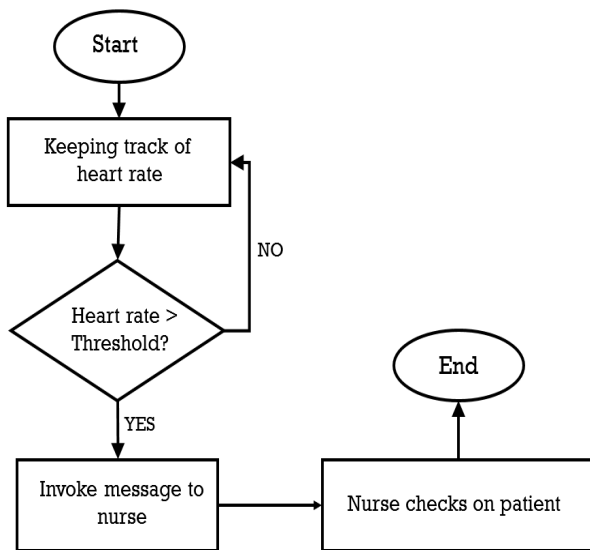


Fig. 2. Heart rate monitor

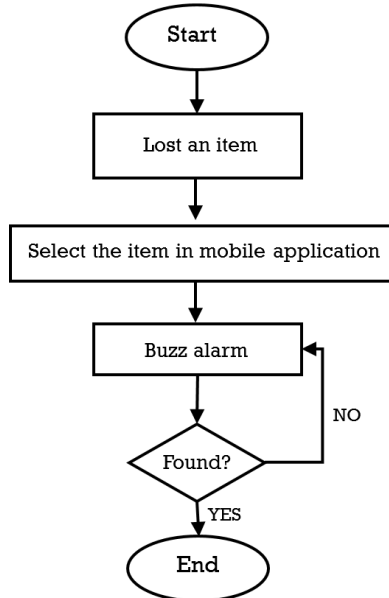


Fig. 3. Lost item finder

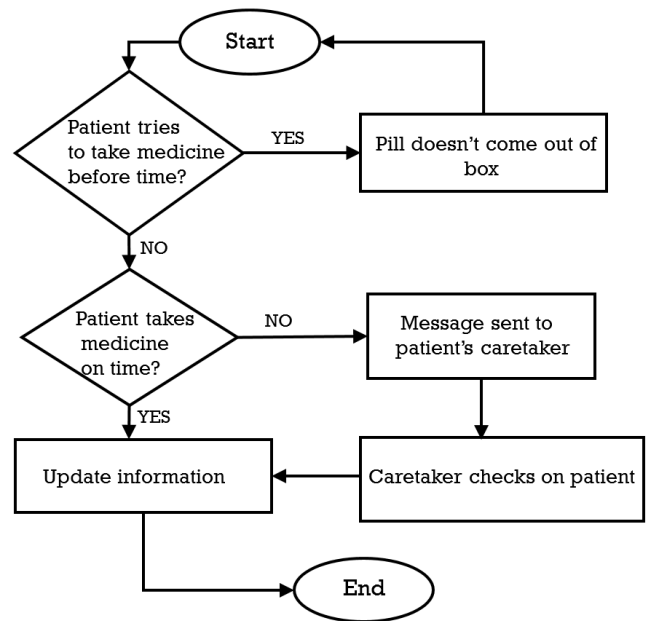


Fig. 4. Smart medicine box

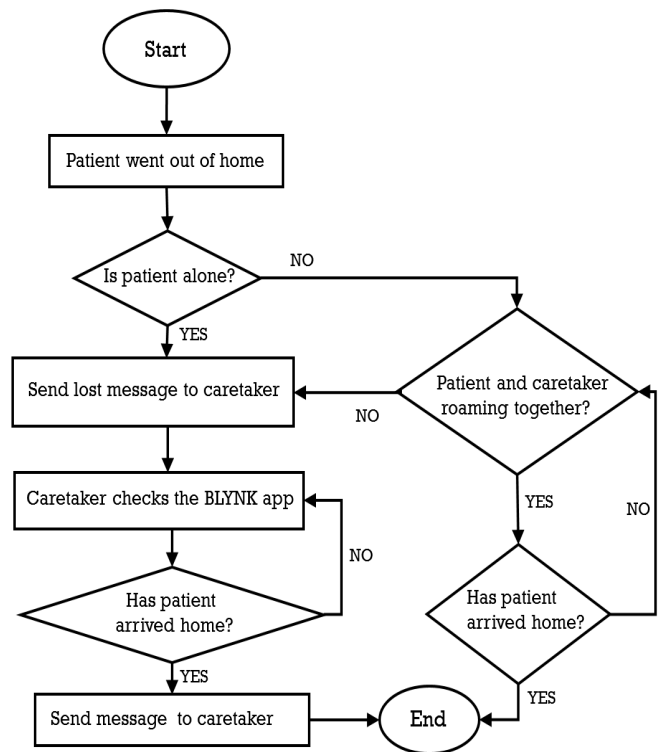


Fig. 5. Lost patient locator

The second phase is that, if the patient goes outside of their home alone, the caretaker will be informed through a text alert and can see the patient's location through the application. This is done by an ESP-12E Wifi module which is also connected to the home Wifi. Whenever the patient steps outside of their home, the Wifi module will try to connect with caretaker's mobile network. If it fails to connect, it assumes that the patient has gone outside alone and so it sends a message to the caretaker's mobile to notify him/her.

(b) *Smart medicine box* - A smart medicine box was developed to keep track of the pill intakes by the patient. Whenever it is time for the patient to take medicine, the

medicine box will automatically open. Also, a buzzer will make sound to remind the patient that it is pill intake time. If the patient still does not take medicine, then an alert message will be sent to patient's caregiver. After the patient takes medicine, the box will be closed again. It will again open

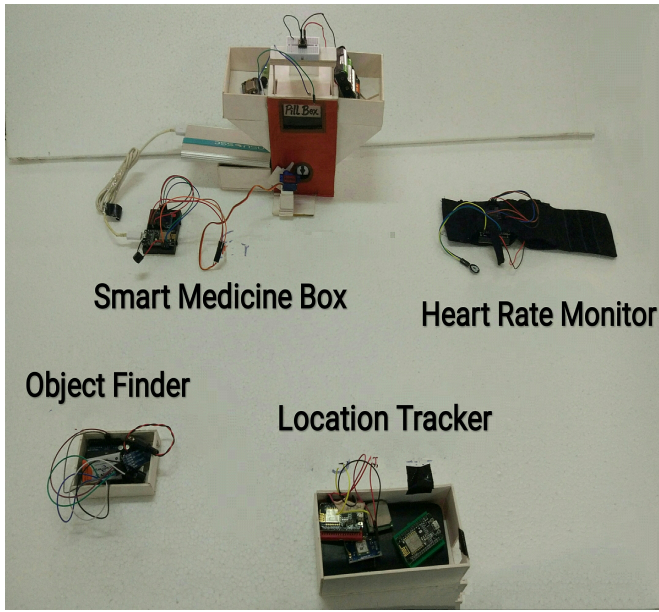


Fig. 6. Hardware parts of the proposed system

when the next pill intake time will come. An OLED display is also attached with the medicine box that displays the time remaining for next pill intake.

(c) *Heart rate monitor* - The heart monitoring system takes the pulse rate of the patient through pulse sensor attached to patient's fingertip. If the Heart rate exceeds a threshold value (e.g. 150 BPM) immediately a message will be sent to the caretaker.

(d) *Lost items finder* - Alzheimer's patient loses their belongings very easily. The object finder helps the patient to find the lost items. If the lost items are at Bluetooth range of their mobile, the application (see Fig. 7(c)) will ring a buzzer.

With the help of the application and by following the sound the lost items can be found.

## V. DEMONSTRATION AND EVALUATION

A Focus Group Discussion (FGD) [24] was carried out to evaluate the performance and usability of the proposed assistive tool. The FGD session was replicated with randomly selected 10 final year under-graduate students and 5 faculty members. During the FGD: firstly, the proposed tool was demonstrated; after that we gave them opportunity to explore and use the tool for 20-30 minutes. At the end, participants were asked to provide their opinion about the system's functionality, usability and usefulness. 13 out of 15 (87%) participants found that the system performs accurately each function, while all of them (100%) were opined that the system was easy-to use. Some of them suggested to include more features related to patient's health, while few other participants suggested to improve the safety of the device by putting the circuits inside a box.

## VI. CONCLUSION

In this paper, an assistive tool was designed and developed for Alzheimer's patients. In respect to the earlier works, this research contributed in two folds: firstly, several features are integrated in a single system, and secondly, a mobile application was developed to utilize those features effectively from a single platform. Thus the proposed system provides an integrated round the clock service to the patients both in home and outdoor. Alzheimer's patients and the caregivers of patients will be greatly benefited from the system, since the system will provide support for constant monitoring, provide assistance for taking medicine, look after the heart condition of the patient, and help to find patient's belongings whenever needed.

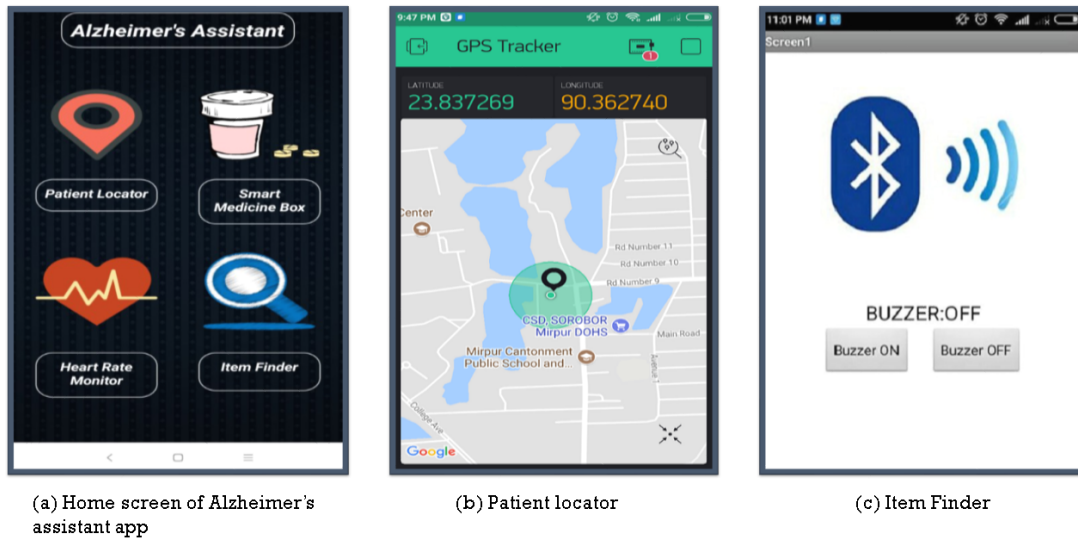


Fig. 7. Alzheimer's assistant app

However, there are still certain limitations of this proposed system. The system was built as a prototype. It was developed in an academic environment and thus no evaluation study with real-users were obtained against it. Also, the smart medicine box module does not work without a Wifi connection. These issues will be addressed in our future work. Apart from these, the system modules can be developed as wearable. Furthermore, few more features can be added to provide more medical/health details of the patient.

#### ACKNOWLEDGEMENT

This research was supported wholeheartedly by faculties of Department of Computer Science and Engineering, MIST. We would like to show our gratitude for their great support. The first two authors of this paper have contributed equally in terms of implementation of the proposed system, while all authors have contributed to literature review, evaluation study and writing of the article.

#### REFERENCES

- [1] J. Paton, K. Johnston, C. Katona, and G. Livingston, "What causes problems in alzheimer's disease: attributions by caregivers. a qualitative study," *International journal of geriatric psychiatry*, vol. 19, no. 6, pp. 527–532, 2004.
- [2] C. P. Ferri, M. Prince, C. Brayne, H. Brodaty, L. Fratiglioni, M. Ganguli, K. Hall, K. Hasegawa, H. Hendrie, Y. Huang *et al.*, "Global prevalence of dementia: a delphi consensus study," *The lancet*, vol. 366, no. 9503, pp. 2112–2117, 2005.
- [3] R. G. Logsdon, L. E. Gibbons, S. M. McCurry, L. Teri *et al.*, "Quality of life in alzheimer's disease: patient and caregiver reports," *Journal of Mental health and Aging*, vol. 5, pp. 21–32, 1999.
- [4] A. Kintsch and R. DePaula, "A framework for the adoption of assistive technology," *SWAAAC 2002: Supporting learning through assistive technology*, pp. 1–10, 2002.
- [5] K. Hawkey, K. M. Inkpen, K. Rockwood, M. McAllister, and J. Slonim, "Requirements gathering with alzheimer's patients and caregivers," in *Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility*. ACM, 2005, pp. 142–149.
- [6] T. Zaki, M. N. Islam, M. S. Uddin, S. N. Tumpa, M. J. Hossain, M. R. Anti, and M. M. Hasan, "Towards developing a learning tool for children with autism," in *2017 6th International Conference on Informatics, Electronics and Vision 2017 7th International Symposium in Computational Medical and Health Technology (ICIEV-ISCMT)*, 2017, pp. 1–6.
- [7] Y. Lee, C. Chiu, L. Jhang, and C. Santiago, "A self-reliance assistive tool for disable people," in *3rd International Conference on Control and Robotics Engineering 2018 (ICCRE)*, 2018, pp. 26–30.
- [8] N. S. Khan, S. Kundu, S. Al Ahsan, M. Sarker, and M. N. Islam, "An assistive system of walking for visually impaired," in *International Conference on Computer, Communication, Chemical, Material and Electronic Engineering 2018 (IC4ME2)*, 2018, pp. 1–4.
- [9] M. Donnelly, C. Nugent, S. McClean, B. Scotney, S. Mason, P. Passmore, and D. Craig, "A mobile multimedia technology to aid those with alzheimer's disease," *IEEE multimedia*, vol. 17, no. 2, pp. 42–51, 2010.
- [10] C. Yamagata, J. F. Coppola, M. Kowtko, and S. Joyce, "Mobile app development and usability research to help dementia and alzheimer patients," in *Systems, Applications and Technology Conference (LISAT), 2013 IEEE Long Island*. IEEE, 2013, pp. 1–6.
- [11] N. Armstrong, C. Nugent, G. Moore, and D. Finlay, "Using smartphones to address the needs of persons with alzheimer's disease," *annals of telecommunications-Annales des télécommunications*, vol. 65, no. 9–10, pp. 485–495, 2010.
- [12] R. B. Sagar, "Bottle-cap medication reminder and overdose safeguard," Aug. 12 2003, uS Patent 6,604,650.
- [13] A. P. Passamante, "Smart automatic medication dispenser," May 19 1998, uS Patent 5,752,621.
- [14] A. Naditz, "Medication compliance—helping patients through technology: modern "smart" pillboxes keep memory-short patients on their medical regimen," *Telemedicine and e-Health*, vol. 14, no. 9, pp. 875–880, 2008.
- [15] E. H. Aiken, "Indicator for pill bottle," Sep. 14 2004, uS Patent 6,789,497.
- [16] M. W. Raad, T. Sheltami, and E. Shakhshuki, "Ubiquitous tele-health system for elderly patients with alzheimer's," *Procedia Computer Science*, vol. 52, pp. 685–689, 2015.
- [17] S. Helal, C. Giraldo, Y. Kaddoura, C. Lee, H. El Zabadani, and W. Mann, "Smart phone based cognitive assistant," in *UbiHealth 2003: The 2nd International Workshop on Ubiquitous Computing for Pervasive Healthcare Applications*, 2003.
- [18] C. Giraldo, S. Helal, and W. Mann, "mpca—a mobile patient care-giving assistant for alzheimer patients," in *First International Workshop on Ubiquitous Computing for Cognitive Aids (UbiCog'02)*, 2002.
- [19] J. M. Corchado, J. Bajo, Y. De Paz, and D. I. Tapia, "Intelligent environment for monitoring alzheimer patients, agent technology for health care," *Decision Support Systems*, vol. 44, no. 2, pp. 382–396, 2008.
- [20] K. Y. Sham and P. L.-K. Wong, "Fitness monitoring device having an electronic pedometer and a wireless heart rate monitor," Apr. 6 1999, uS Patent 5,891,042.
- [21] M. Student, N. Karasikov, D. Tamir, and R. N. Bar-On, "Remote monitoring system for alzheimer patients," Jun. 12 2008, uS Patent App. 11/913,439.
- [22] M. H. Kasliwal and H. Y. Patil, "Smart location tracking system for dementia patients," in *Advances in Computing, Communication and Control (ICAC3), 2017 International Conference on*. IEEE, 2017, pp. 1–6.
- [23] S. Saranya and P. JesuJayarin, "An efficient tracking device for alzheimer patient using miwi," *International Research Journal of Engineering and Technology*, vol. 4, no. 4, pp. 3365–3371, 2017.
- [24] R. A. Krueger and M. A. Casey, "Designing and conducting focus group interviews," [Online; accessed 02-Feb-2018]. [Online]. Available: [http://web.worldbank.org/archive/website01028/WEB/IMAGES/SDP\\_36.PDF#page=10](http://web.worldbank.org/archive/website01028/WEB/IMAGES/SDP_36.PDF#page=10)