A Smart Biomedical Assisted System for Alzheimer Patients

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Abstract: In the last decades the health care developments highly rise the level of ages of world population. This improvement was accompanied by increasing the diseases related with elder like Dementia, which Alzheimer’s disease represent the most common form. The present study aims to design and implementation a medical system for improving the life of Alzheimer’s disease persons and ease the burden of their caregivers. A Smart Biomedical Assistance is an electronic device that provide around the clock monitoring the stability state of the Alzheimer’s patient, showing their location on the map, automatically reminders for medication times, and a call button for an emergency cases that the patient may pass through during the day. The device designed with two units one worn by the patient while the other is an internet of things technology (IoT) platform application used by the caregiver. The wearable unit was implemented by using a motion processing unit sensor, global positioning sensor module (GPS), heart rate sensor with microcontrollers and LCD display. This unit is supported by an (IoT) platform for communication with the patient from anywhere by the caregiver.

Keywords: Alzheimer, Biomedical assistance, IoT, Monitoring, Reminder

1. INTRODUCTION

The health care services are widely Improved in the preceding century; this participate to make individuals lives extended. This rises the ageing level of the world’s population, this has also led to an increasing in the number of persons living with ageing disorders, like dementia [1]. Dementia is defined as the considerable loss of cognitive capability causing interfering the patient’s life activities. It’s not a normal part of ageing. Alzheimer’s disease (AD), is the most popular kind of dementia, it is a progressive disease of the brain that results into memory loss. The most common symptom manner begins with progressively worsening difficulty in remembering newly learned information. This symptom is most common because studies showed that the brain cells disruption generally begins in the brain regions responsible for forming new memories. As damage propagated, individuals experience more mental and physical obstacles. Alzheimer’s is a degenerative disorder, where dementia symptoms worsen day after day [2]. In the early onset of the disease, the forgetfulness is moderate, but with late-stage Alzheimer’s, individuals lose the capability to communicate with people around him or respond to their environment. The number of people suffering from dementia is rapidly rise around the worldwide, approximately there will be 20 new case of it every minute. About 50 million people worldwide are suffering from this disease in 2018. This counting expected to be more than three times, about 152 million by 2050. [3] Caring for Alzheimer’s disease patient or other types of dementia persons is a difficult task, and many family experiences high levels of emotional depression and stress. Caregiving also has a bad influence on the health, employment and income of many caregivers.
Assistive technology has been proposed as a means to compensate for specific physical and cognitive deficits of people with dementia and to lessen caregiver burden. An assistive technology is known as “any piece of kit, or system, has been customized, and used to sustain, or enhance the abilities of subjects with deficits.” [4] Alzheimer patient’s assistive wearable device can provide that in an easy way to use, light weight, low cost. Which can meet an individual’s timing reminder needs for medication and physical or mental exercises with a real time and date watch. Also have the Wi-Fi capability to help the caregiver to follow the patient’s status, locating the patient position for outdoor monitoring and by the help of pulse sensor the caregiver knows if the patient wearing the devise or not, also receiving alarms in the emergency cases that the patients can pass through daily.

2. LITRATURE REVIEW
In the past years, many biomedical assistive systems had been developed. These systems are generally implemented in many forms such as: monitoring, tracking, and locating systems. All of it aims to provide a more convenient life and help patients and ease the caregivers burden.

E. Bantry, and et al. [5] Studied the possibility of using electronic tracking to help people suffering from dementia. The method followed for tracking is by a website showing the location of each tracking device. The website could be accessed either by computer or smartphone. The tracking process starts by sending request via a network (GPRS or SMS) to the device. The device determines the location using (GPS) and sends back to the website so the location appears on the website map within (2) minutes. Ten participants carried out the system test and the study found that the decision to use tracking was informed by the carer’s informal assessment of safety.

S. Pavia and C. Abreu [6] Presented a new proposal for Alzheimer patients tracking system by the use of (GPS). The design is based on mobile phone with (GPS) functionality carried by the patient. And an application was developed used by the caregiver where he has an access account on the web to the project’s application. This makes the caregiver and health care professionals able to track patient anytime from anywhere to locate patient position at current moments or to check the past locations the patient visited. This system represents a solo equipment system that mainly relies on the mobile phone which reflect the low-cost benefit.

W. Bourennane, and et al. [7] designed an intelligence ambient aimed to allow the seniors people that live in an independent living situation to be continuously monitored by their health care centers and own caregivers. The study proposes the use of multisensory system including motion infrared sensors installed in the ceiling, presence sensors in bed and zig bee tags embedded in the persons. The design uses two units; the locate unit and remote unit. The first one is responsible to collect the displacement data in real time and store them in data base. The second unit recovers files containing the location data. Analysis and decision algorithms provide the functionality to choose actions in order to alert surveillance team and help them by providing historical events record. This system is tested on confused people unit in (Caussade hospital) in France and it is considered a complete monitoring system to allow patients and medical staff living in a more secure and safe environment for retired seniors.

S. Saranya, and P. Jesujayarin [8] Designed a tracking device for Alzheimer’s disease patients using microchip wireless (MIWI). The proposed system has patient module, guardian module, notification and social network. The patient module consists of (MIWI) transmitter, (GPS) and (GSM). If the Alzheimer patient goes out of each 100 meters’ range, immediately the latitude and longitude values are sent to the caretaker’s mobile number. Microcontroller is used to control all the devices in the patient node. The (MIWI) Device is used to establish the wireless communication between the patient node and caretaker node. Overall performance of the project is finding out by comparing it with existing systems, it’s proved a better and easily adaptable technology to help the care takers of Alzheimer patients.

3. THEORY
Alzheimer’s disease is progressive, degenerative brain disease that destroying memory and other major abilities of the brain slowly and, occasionally, the capability of implementing the simplest jobs. The disease is first discovering and named by the German scientist Dr. Alois Alzheimer. In 1906, Dr. Alzheimer studied the abnormal change in the brain structure of a woman who had died of an uncommon mental problems. Her symptoms was forgetfulness, unstable memory, communication problems, language difficulties, and exceptional behavior [9]. From the physiological point of view (AD) is related with a diversity of factors, such as the deposition of extracellular beta-amyloid (Ab) protein which also known as plaques, accumulation of intracellular neurofibrillary tangles, oxidative neuronal damage, and inflammations. It is widely trusted that, ingredient of amyloid plaques, is mainly increase the production of the (Ab) protein, the major pathogenesis of the disease. Neuropeptides are molecules or neuronal signaling agents that function in central nervous system (CNS) as transporters hormones, as a neurotransmitters or neuromodulators and acting an important role in behavioral functions. (AD) is a neuro disease depicted by progressive decay of cognition, and function that weaken the daily life activities. The disease is mainly specified by brain shrinking and by increase cerebral ventricles. The main defiant finding in diagnosis is a deficit of the cholinergic system, drop in the levels of choline acetyltransferase, and other cholinergic indications. (AD) is also specified by extracellular deposits proteins, which is called cerebral plaques, formed from a dense protein accumulation include the (Ab) peptide surrounded by damaged and dead nerve cells. The other clear mark of (AD) are the neurofibrillary tangles inside the nerve cells, composed mainly by a filament, hyper phosphorylated type of the microtubule- associated protein. see Figure 1.

![Plaques and Neurofibrillary Tangles](image1)

**Figure 1.** Plaques and Neurofibrillary Tangles

### 4. MATERIAL AND METHODS

The proposed system design uses two units one wearable by the patient and the other is a platform application installed in the caregiver smartphone. The wearable unit was built from four units the sensing unit, the control unit, the display unit, and the power unit. Figure 2 is the block diagram of the system. The sensing unit consist of the Gyroscope and accelerometer sensors which used for provide information about the state of wearable unit if it is stable or not which reflect the state of patient for detecting the fall detection case which is common happening in Alzheimer’s patients. The sensors continuously detect the position and tilting angles by measuring the angular velocity and acceleration about the three axes.
Gyroscope defined as the rate of rotation or the angular velocity that measured in (mV/deg/s) about the three axes. The gyroscope also senses the angular velocity, which is the change in the angle of rotation per time unit, measured in degrees per second, see Figure 3. The gyroscope is classified as a type of microelectromechanical system of sensors (MEMS). It combines the electrical and mechanical components into delicate structures in the scale of a micrometer. The accelerometer is also a (MEMS) type sensor but it differs from the gyroscope in measuring the linear acceleration along one or more axes. If both sensors are combined in one board will detect any motion accurately. [10] The gyroscope module has four Pins (Vcc, GND, SCL, SDA). Vcc pin is connected to a 5V GND to GND, SDL connected to the analog pin of the microcontroller. SDA must be connected to the analog pin of the microcontroller. MPU6050 module is 6-axis Motion Tracking Sensor. It contains three-axis Gyroscope, three-axis Accelerometer and Digital Motion Processor. When the gyros are rotated about any of the three axes, the Coriolis Effect causes a vibration that is sensed by a micro electromechanical unit (MEM) inside MPU6050. That produce a signal which is pass through processing stages as follows; first amplifying the signal, and demodulating it, after that a filter are applied in order to produce an output voltage that is proportional to the angular velocity.

**The MPU 6050 main parts:**
1. Gyroscope sensing module.
2. Acceleration module.
3. Temp. sensing module.
4. DMP
MPU 6050 specifications:
1. Acceleration ranges: ±2, ±4, ±8, ±16g.
2. Gyroscope ranges: ± 250, 500, 1000, 2000 °/s.
3. Voltage: 3.3V - 5V [11].

Acceleration defined as the rate of change of velocity in the three axes with respect to the unit of time. The (ADXL335) is an accelerometer or an electromechanical device that used for measuring the acceleration force. Its measurement is according to the gravity force which also knowing as the (g force). Measured in g unit. It is formulated from a surface made from polysilicon and a circuit for signal conditioning that implement acceleration measurement. The analog output signals are proportional to acceleration. This output signal defines the both types of acceleration; the static acceleration (gravity force) in tilt-sensing cases and dynamic acceleration resulting from vibration and motion [12].

The sensor structures are a micro machined polysilicon surface rest on the top of a silicon layer. The springs made from polysilicon support the structure over the surface of the layer for providing a resistance against acceleration forces. The deflection of the systems structure is measured by the use of a differential capacitor that consists of two types of plates one fixed plates (independent) and other are plates attached to the moving mass (dependent). Acceleration causing deflection in the movable mass and distort the capacitor causing the sensor to produce an output its amplitude is depended on the amount of acceleration. After that demodulation techniques with Phase-sensitive are used in order to determine the acceleration’s direction and magnitude. Determining the magnitude and direction of the acceleration can be done through the use of the following equation:

![Figure 3. Gyroscope sensor](image-url)

![Figure 4. accelerometer sensor](image-url)
Where:

- **A\(_{\text{out}}\)**: output acceleration
- **ADC value**: analog to digital conversion of the acceleration
- **V\(_\text{ref}\)**: reference voltage of the circuit (3.3V – 5V)
- **Voltage at 0g**: is the baseline voltage at 0 gravitational acceleration (from datasheet it equal to 1.65)
- **Sensitivity scale factor**: 0.33

\[
A(\text{out}) = \frac{\text{ADC value} \times V_{\text{ref}}}{1024} - \frac{\text{Voltage level at 0g}}{\text{sensativity scale factor}}
\]

The accelerometer used for measuring the angle of tilting means how much the angle of the device is incline from its plan surface as shown in figure 5.

The theta, psi, and phi angles can be calculated as follows:

\[
\theta = \arctan\left( \frac{A_{\text{out}}}{\sqrt{A_{\text{out}}^2 + A_{\text{out}}^2}} \right)
\]

\[
\varphi = \arctan\left( \frac{A_{\text{out}}}{\sqrt{A_{\text{out}}^2 + A_{\text{out}}^2}} \right)
\]

\[
\phi = \arctan\left( \frac{\sqrt{A_{\text{out}}^2 + A_{\text{out}}^2}}{A_{\text{out}}} \right)
\]

**Figure 5.** Angle of inclination

One of the most popular defining symptom of the Alzheimer’s disease is the forgetfulness of the newly learned information in the mild stage of the Alzheimer which this design is built for the patient forget the time to take his medications so a reminder is designed to be programmable by the caregiver to set the time...
of reminding the patient to take his pills by displaying the phrase on the screen and beep sound for attention, so the patient will be depend on himself and would not miss medicine any more.

For monitoring the (AD) patient outdoor a (GPS) module has been added to the wearable unit. The module used is (neo-6m), figure 6 continuously calculates the longitude and latitude for patient’s location and its direction and at which speed (he/she) moves. This information is processed by the microcontroller and displayed real time in the caregiver’s smartphone. To check if the patient wears the unit or not a pulse sensor proposed to sense patient’s heart rate.

![GPS Module](image)

**Figure 6. GPS Module**

The microcontroller used in the system includes both Nod MCU ESP8266 and the Arduino Nano to control the reading of the motion processing unit sensors to sense the stability state and fall conditions. The (IoT) platform used is the (Blynk) application providing the caregiver 24- hour surveillance with announcement from the patient and notifications from the wearable unit and helping to program the medics times. A report for the work of the device is also recorded for later check if needed. The schematic and circuit of the wearable unit can be seen in figures 7 and 8.

![Schematic Circuit](image)

**Figure 7. Schematic circuit of the wearable unit**
Figure 8. Circuit of the wearable unit

The caregiver uses the smartphone with (IoT) platform application to provide the following tasks:

- Monitor the state of the Alzheimer’s disease patient if he was stable or not.
- Receives notifications if the patient falls on the ground.
- Set the reminder times of medics and display the date and time.
- Receives the call announcement if the patient pass through condition and needs a help.
- If the patient is getting out the WIFI connection zone a turn off notification is received by the caregiver, and from this the caregiver can know if the patient is out the safety zone.
- Locate the patient when goes outdoor and show his position on google map.
- Monitor the patient’s heart rate.
- A report is recorded for the work time of the device.

The continuous sensing of the gyroscope and accelerometer sensors values and continually computing the values of angles and updated to the microcontrollers the state of the patient if he falls on the ground can be detected. The other feature in the wearable unit is the displaying the time and date continuously on the devices screen. As known the Alzheimer’s disease patient being confused about the time of the day so this will help him to know the time and date. This time is programed to be taken from the time and date of the smartphone connected to the device to be accurate in the time zone. The GPS embedded in the system provides an easy way to follow the patient outdoor and monitor their location and speed. The controlling of the system is based on the (IoT) technology which is defined as “A system of communicated devices, mechanical machines and digital, people or objects that are supplied with specific identifiers and have the ability of transporting data across the grid without needing human-to-human or human-to-computer interaction.”

The Internet of Things in fact is a quite simple concept. It aims to make all the things and physical places in the world and link them to the internet. In the (IoT), all the things that are linked to the net can be classified into three categories:

- The things for collecting information and sending it.
The things for receiving information and acting on it.
The things that do both previous jobs.
And all three of these have huge benefits that depends on each other. The (IoT) platform used is the (Blynk) It can be controlling hardware remotely, it can display data of sensor, also can store, visualize it.
The three main components of the (IoT) platform are:
- **Blynk Application** - for creating interfaces for projects by the use of different widgets.
- **Blynk Server** – its task is providing the connection between the smartphone and hardware.
- **Blynk Libraries** - enable the connection with the server and responsible for managing data stream and the incoming and out coming commands.
The connection to the cloud can be achieved through:
- WiFi
- Bluetooth
- Ethernet
- USB (Serial)
- GSM

5. Results and Discussion
The system was tested on a group of elder people were the fall detection recorded and the timing medications was set up by the caregiver also recording of the work of accelerometer was recorded and showed how it read the change in acceleration due to tilting, see figure 9. The test was done indoor and outdoor the outdoor monitoring was relay on the (GPS) and the reading of it display a real location of the system, figure 10. After a questionnaire made to the caregivers for using the device and how it satisfies their needs and how it helped them throughout the times when they were not at the same place with their patients, most of them said its helpful for setting up the medication times in an easy way, and allow them monitor the state of their patients when they were not close to them. They also have notes on the design of the device they said it must be smaller because its size wasn’t appropriate for all of them. The figures 11, 12, 13,14 and 15 shows the systems work.

![Figure 9. Accelerometer measurement](image-url)
Figure 10. locating the unit through the GPS

Figure 11. Date and time display

Figure 12. Reminder message
Figure 13. Caregiver (IoT) platform

Figure 14. Automatical notifications

Figure 15. Setting up the reminder received by the caregiver (days and times)
6. Conclusion

The current study aims to design a smart assistive device for helping Alzheimer’s patients or generally elder people using inexpensive components and make it as easy use as possible. For achieving this purpose, a motion processing unit composed of gyroscope and accelerometer used and showed a really good accuracy in detecting the fall conditions. A (GPS) module prove its accuracy and dependency to provide location information. The reminder showed a little lagging approximately (3-5) sec. due to the delay time between the server and the smartphone. But this don’t represent a problem because the reminding period could be set for any period, so the lagging has no effect. By comparing the device it’s functionality to its cost we can say it fulfill the required job which is built for, by providing: the easy use, low cost, light weight and can be used by large number of people in the society.

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