Wearable Tracking Device for Alzheimer's Patients: A Survey

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***Abstract*- Alzheimer's disease is a degenerative mental illness that usually affects the elderly. Since the patient requires round-the-clock care, it also deeply affects the lives of the caregivers who have to give up their means of livelihood to personally care for the patient. Modern day technology aims to provide a more convenient way to monitor and track patients using sensing devices and wearable technology. This paper elaborates on the various tracking mechanisms available today with their strengths and flaws, and proposes an alternative technique which uses a combination of existing indoor and outdoor tracking systems.**

***Keywords*- Alzheimer's disease, sensors, wearable technology, indoor tracking, outdoor tracking.**

1. INTRODUCTION

Alzheimer's disease accounts for 60% to 70% of cases of dementia, a general term for memory loss and other intellectual abilities. Majority of the people with Alzheimer's are 65 years and older. It is a progressive disease which worsens over time. It has been found that 30 million individuals in the world are suffering from autism (nervous breakdown), dementia (short term and long term memory loss), and Alzheimer (loss of brain function).

In the early stages of the disease, the patient will have difficulty remembering names of friends and family members, along with increased forgetfulness. The middle stage involves finding it difficult to remember recently learned information and problems with sleep. Language problems arise because of shrinking vocabulary. As the disease progresses to an advanced stage the patient becomes increasingly paranoid. There is complete loss of speech, with an increased sense of disorientation and confusion, as well as a propensity to respond poorly to attempts by the caretaker to communicate and provide needful care.

Evidently, the disease is a heavy burden on the patient as well as the caregiver as round the clock care of the patients is required. In most cases, the caregiver has to give up a profession or means of livelihood in order to take care of patients, leading to heavy financial problems.

Since the disease has no cure at this point in time, efforts from a technological perspective have been focused on provided convenient methods of tracking the patients remotely. A wearable smart locator helps to keep an eye on our beloved ones [4].

With advent of wearable technology and microprocessor-based devices, there exist a few devices for this purpose, but most are interactive rather than responsive, are on the expensive side and pay little to no attention to indoor tracking. Also, battery back-up and device size are causes for concern.

Today's devices largely focus on tracking the patient using Global Positioning System(GPS) modules that alert the caregiver when the patient crosses a particular boundary outside his confines. The device would send the location coordinates of the patient to the caregiver. These kinds of trackers are feasible as long as the tracking takes place in outdoor settings. While indoors, GPS systems are not very accurate in determining the precise location of the patient.

A more sophisticated system would be one which combines a different indoor tracking mechanism to track the patient more effectively in enclosed environments, particularly hospitals. Current indoor tracking systems in use are based on light sensors, or through Wi-Fi technology.

A device that is used to combine the inputs of both indoor and outdoor tracking systems would be a more complete solution to the tracking problem.

A central monitoring system, such as a web server, can intercept distress signals from each device-wearer. Identification and contact details for each patient can be maintained inside a database, which will be looked-up upon receipt of a distress signal. The responsiveness of the application would allow instant location of the patient and immediate dispatch of help, be it by notification to the caretaker of the patient or by alerting the authorities.

This Literature Survey Paper intends to shed light on some of the tracking techniques and their drawbacks. It also discusses a combined indoor and outdoor tracking device as an alternative and explores the existing mechanisms.

2. LITERATURE SURVEY

In the past years, various tracking/monitoring systems had been designed and these systems are generally implemented in the form of children or vehicle tracking systems.

One of the earliest instances of tracking devices involved a method which allows a parent to alert other people who are present in a fixed radius [1].

An attack warning for vehicle and location scheme was designed. Emergency vehicles will get to a destination by travelling quickly and safely and are indicated along the map with an icon with different visual characteristics with respect to the position of the vehicle [2].

Another proposed method involved locating wireless devices and determining whether a device has entered or exited a pre-provisioned 2-dimensional or 3-D dimensional

geographic zone and alerting the caregiver whenever they are outside the geo fenced area [3].

GPS is one of the technologies that are used in a huge number of applications today. We use it to track vehicles along with many other things which we would want to monitor [5]. The calculated co-ordinates are sent to a monitoring application using Global System for Mobile (GSM) technology.

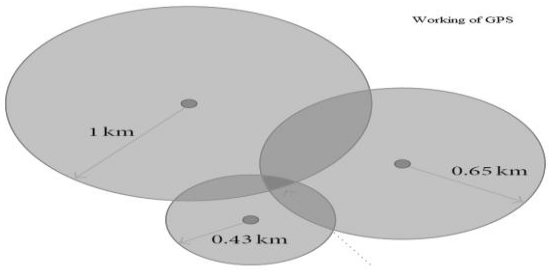

Fig 2.1 –Working of A GPS System

A GPS receiver needs at least three or four satellites to calculate the distance figure out its two dimensions, that is, latitude and longitude, or three dimensions, that is, latitude, longitude and altitude positions.[6]

A low power and cost effective Automobile Localization System using GPS and GSM/GPRS Services [12] is used for locating an automobile and transmitting its position to the owner. It uses GPS technology, a microcontroller and a GSM phone to track adolescents driving the vehicle. A central monitoring center accepts SMS from the device if it is found outside a pre-defined virtual radius. The map coordinates are sent to the caregiver's phone and the exact location is calculated on Google Map application retrieved by the latest latitude and longitudes values sent by the GSM modem [5].

An Android based wearable smart locator band for people with autism, dementia and Alzheimer's disease has been proposed [11]. The architecture of the device consists of an AVR microcontroller, GPS Technology, GSM Technology and a monitoring unit which is an Android based application on a mobile phone. Map coordinates are sent to the monitoring application using Short Messaging Service (SMS). The GSM mobile will receive an SMS which includes the automatic location beacon of the wearer (longitude and latitude) and the virtual radius entering and leaving information [9, 10].

Similarly, the design for implementing a child tracking system on Android mobile terminals [8] was proposed for the safety of children which includes a child module and two receiver modules for getting the information about the child on periodical basis. One device is with child and two other receiving devices are there, one Android mobile device in parent's hand and another as monitoring database in school's control room. The above concept can be very useful in implementing our device in case of Hospitals or health care centers where there can be a central database connected to the devices of all the patients.

An attempt to design, develop and deploy GPS/GSM based vehicle tracking system so that intercity transport companies can track their vehicles in real time and use the alert system to report armed robbery or an accident is described [10]. We can create a much smaller system based on the same concept for Alzheimer's patients to track their moments and alert the authorities if required in real time.

There are many methodologies to design a centralized monitoring center that can receive the distress signals. One of the main purposes for "AASMP - Android Application Server for Mobile Platforms" [9] is to allow deploying Android applications on a server to be accessed by client-side users, not necessarily operating an Android platform, through a browser software without installing any plug-in modules. Using this concept, we can design our portal for smartphones and put in on the android application server so that it can be accessed through smartphones with different OS such as IOS, Windows and Android.

There have also been many devised systems to facilitate indoor tracking. This is especially useful in closed environments such as hospitals.

We can also take into consideration the concept of minimalizing the false alarm caused by GPS inaccuracy. For this, we are embedding light sensors into the device which can detect indoor and outdoor light frequencies and can give the approximate location of the patient.

A recent design effort of a smart tracking prototype, in an attempt to provide real-time, mobile and seamlessly indoor/outdoor location tracking for medical staff, patient or instruments in hospitals by integrating GPS and UWD (Ultra wide Band) has been described [13]. Ultra wide band can locate a person or thing with the accuracy of centimeters. It is envisaged that there might be a possibility of integrating UWD and GPS to give the exact position regardless of the person or thing being indoors or outdoors.

A low-power, high sensitivity, light emitting diode (LED)-based device for intensity-based light measurements[15] describes an approach in which a reverse-biased LED functioning as a photodiode is coupled with a second LED configured in conventional emission mode. With a timer circuit, the time taken for the photocurrent generated on the detector LED to discharge its capacitance from logic 1 (+5 V) to logic 0 (+1.7 V) is measured. The entire instrument provides an inherently digital output of light intensity measurements for a few cents. This device can be combined with other devices and used in our project to detect if the patient moves from one room to another as such it will detect the change in light and then send the alert accordingly.

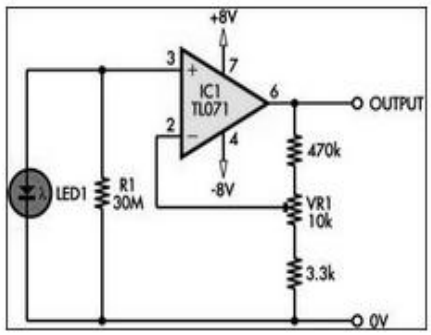

Fig 2.2 –An LED based light sensor

To track a person inexpensive sensors are integrated into a wearable device [14]. 3D accelerometers are used to detect a person's acceleration.3D magnetometers detect the magnetic field. The device also uses fluorescent light detectors and a temperature sensor to completely track indoor navigation. We plan to borrow the concept of magnetic sensors and use photodiodes as light detecting sensors as well as measure cell tower strength to find a person's position indoors. A combination of these 3 can give us a position which the caretaker can use in a hospital environment to verify whether the patient is inside the virtual permissible radius or not.

The significant challenge posed by combining the two mentioned systems of tracking is the switching of the sensors at the appropriate situation.

A microprocessor can act as the coordinating center of this device. Depending on prevalent conditions, the microprocessor can be programmed to switch its input source from GPS tracking system to indoor tracking system (light and cell tower strength).

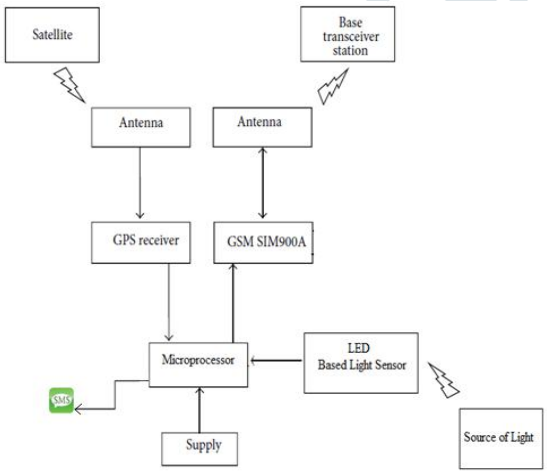

Fig 2.3 –Proposed architecture

The challenge to be addressed here is the programming of the microprocessor. The device is designed keeping in mind the automatic resolution of the input signals to the proper position information.

A software development tool is provided for Texas Instruments Inc. microcontrollers which includes Windows®-based computer forms[16] for editing and initializing registers, which otherwise consumes a lot of time. The computer forms are generated in conjunction with using widely used computer tools including software which is not proprietary to the microcontroller manufacturer. The software development tool is capable of generating computer code of a selected language which is operable to program selected microcontroller registers with predetermined information. This generated computer code can be inserted within a desired location in a main program for programming the microcontroller. Register information is programmed into the microcontroller registers without the use of an emulator. Using this tool for our project will make customization an easy task, it will reduce a lot of programming time and make register initialization easy which in fact in complex.

An investigation of various indoor tracking devices produced a comprehensive study about their advantages and disadvantages [17]. IR, RF and Ultrasonic technologies are used in indoor tracking. Indoor positioning is used to locate people or the required objects in large buildings or in confined areas. From this survey we can borrow the working of the infrared emitter and receiver. A tiny infrared beacon, worn by every person, emits a unique code identifier every 15 seconds. Each location in a building covered with a network of IR sensors which detect these transmissions. A central server collects data from fixes IR sensors around the building and the location of the person can be identified. In our project the patient will be wearing an IR receiver and when the patient goes out of the confined range, the caretaker gets informed.

We have to monitor our daily activities in order to find out if we have any variations [18]. Human behaviour reflects the mental and physical health of the subject. In this study, an unconstrained indoor monitoring system was developed. Human behaviour and activity were monitored by infrared positioning sensors and magnetic sensors. Our project has borrowed the idea of infrared sensors to detect the movement of the patient.

An object tracking and management system and method using radio-frequency identification tags is disclosed [19]. Objects to be moved between locations are outfitted with RFID tags having information relating to the identities of the objects. The locations are also marked by RFID tags containing information on the locations. A transport vehicle for moving the objects is equipped with an RFID interrogator capable of detecting signals from the RFID tags. We took the concept of using radio frequency to rack an object from this. The patient has a RF transmitter which gets activated once the patient goes outside the room and sends on the buzzer.

A tracking system in which radiofrequency signals [20] emitted by an invasive device such as a catheter are detected and used to measure the position and orientation of the invasive device within a subject. Catheter is used in the human body, it is a tube like structure .We borrowed the idea of using RF waves to detect the patient when they leave the confined premise.

As mobile computing systems and local area wireless networks are growing rapidly, the need for location services is growing too [21]. The paper presents RADAR, a radio-frequency (RF)-based system for locating and tracking users

inside buildings. RADAR operates by recording and processing signal strength information at multiple base stations positioned to provide overlapping coverage in the area of interest. We have borrowed the idea of radio frequency based tracking to track the patients inside the building. Every patient will have an RF transmitter which is connected to the main controller in the hospital.
RADAR, a radio-frequency (RF)-based system is used for locating and tracking users inside buildings [22]. Operated by recording and processing signal strength information at multiple base stations, RADAR combines empirical measurements with signal propagation modeling, hence detemining user location and thereby contributing to related applications. The accuracy of this device is very high. This can be helpful as in our device also we can use RF sensors to track the location of an individual.

The emerging application of device-free localization (DFL) using wireless sensor networks [23], which find people and objects in the environment in which the network is deployed, even in buildings and through wallsThey use RF signals to probe the deplyoyment area. They have described modalities of measurements made by RF sensors, the statistical models which relate a person's position to channel measurements, and describe research progress in that area. This research can be helpful as we also have to use RF sensors to track the location of the patient.

A model of signal dynamics is proposed to allow tracking of transceiver-free objects [24]. Based on radio signal strength indicator (RSSI), they have proposed three tracking algorithms to eliminate noise behaviors and improve accuracy. The midpoint and intersection algorithms can be applied to track a single object without calibration, while the best-cover algorithm has potential to track multiple objects but requires calibration. Their experimental test-bed is a grid sensor array based on MICA2 sensor nodes whose results show that the best side length between sensor nodes in the grid is 2 meters and the best-cover algorithm can reach localization accuracy to 0.99 m. Eliminating the noice is important as such for the device to be highly accurate, there should be no noice.
A real-time patient monitoring system have designed and developed [25] that integrates vital signs sensors, location sensors, ad-hoc networking, electronic patient records, and Web portal technology to allow remote monitoring of patient status. These functions can be added in future to our device for other functionalities. The tracking concept can be improved on accuracy for all geographical location, then this system can be of use for our device.

The scope of the proposed device is huge. This device can be used to confine the patient to a preset safe area. If the patient unknowingly leaves the safe zone or just gets lost, an alert will be sent to the caregiver or the designated civil authorities with the location. It can be used to track the patient in a building, probably a hospital, reducing the man power required and the constant alertness for the caregiver. The location of all patients can be kept under watch through a centralized system. The same technology or device can be used for similar scenarios such as patients with amnesiac disorders or in the monitoring of patients with serious visual impairment.

3. CONCLUSION

In this paper, a detailed analysis of the various tracking systems has been performed, highlighting the technical shortcomings of the present methodology. It was seen how the various tracking systems have their own applications, strengths and also certain fallacies that lead to inaccurate results.

The most optimal situation would involve integration of various components, and switch between different types of sensors to give the most accurate position. Specifically, using a combination of light sensors and cell tower strength to discern the accurate position indoors, and a GPS based module that would give the accurate outdoor position. The distress signals are monitored by a centralized monitoring system, which is responsible for directing location information to the appropriate caregiver.

The possible drawbacks of such an approach would be the size of the device, and also the cost effectiveness of the different components.

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