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Optimized Location Tracking Assistance for Elderly with Cognitive Disorders

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Abstract- Living assistance systems catering to the need of elderly people affected with Alzheimer and suffering with loss of cognitive functioning or dementia, is still a challenge. When such people go out and forget their return path to home, the caretakers should be able to track them, otherwise it may be causing harm to these senior citizens, as well as it could be an anxiety for society. This study addresses the above concerns and is focused on the design of an assistive device (which does not need an operation from the user's end), that supports the aged or physically challenged with memory loss and acts as a relief to their caretakers. This wearable device is designed in such a way that the route travelled by the person with this wearable device/node, can be tracked from any place, with help of the integrated web API using Python Flask or using mobile phone through the associated mobile app. Since the route travelled with map is displayed, any person, even without much technical knowledge can extend supporting hands. The device has coverage across the country as GSM network is used. A Virtual Private Server (VPS) in a cloud provider data centre with a secure network is used in the design. The VPS is used to relay messages from the nodes to core server, data movement is guaranteed and since, no data is stored on the cloud VPS, the issue of data security is also addressed

Keywords— *Alzheimer, Living Assistance Systems, Cloud Computing, GSM network, Virtual Private Server.*

I Introduction

Alzheimer's disease, a serious brain functioning disorder, is the most common type of dementia in the aged population [1]. Alzheimer's affected people show loss of cognitive functioning and behavioral disorder. The symptoms of dementia may be minimal in the initial stage, but the symptoms may worsen as the disease progresses and affects the brain severely. At least 44 million people are living with dementia, making the disease a global health crisis and as per the statistics, in India alone, more than 4 million people have some form of dementia [2]. Predicting the exact time of appearance of dementia in a person, is specific aspect of difficult-to-diagnose clinical condition, and the complexity of impairment observed including neural, cognitive, and social levels is of highly controversial nature [3,18]. One of the authors has witnessed a true incident of unexpected memory loss leading to the drowning of a close relative affected by dementia. The scope of this work is to be highly beneficial to society in reducing the count of accidents and drowning cases in this regard. The work is an attempt towards reducing the stress of family members about their elder relatives with disability/ dementia/ Alzheimer's.

With the growing fashion of nuclear families in society and the caretakers being employed or mostly cannot be at home during daytime, results in forcing elderly people alone at home. This work has produced the prototype of a tracking device, that allows caretakers to keep tract of the activities of patients suffering from Alzheimer, when they go out alone. It enables the consumers of the service to receive real-time data pertaining to the senior citizens with the disability. The software stores and manages details including location, operation, user logs, history, and other information. The proposed system makes good use of popular geo-location technology that combines a phone/ laptop/ Raspberry Pi application connected to Ethernet. This system can also connect the to the caretaker/family members by clicking a button that lets them interact with that person. It will transmit location data back to the server at regular intervals.

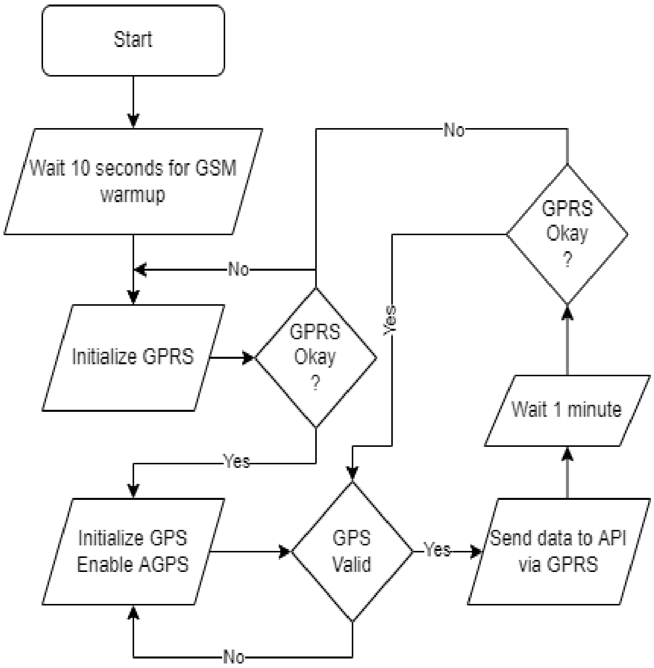


Fig 1: Flowchart for send data to API

Research Gap Analysis

Precisely, the authors attempt to address the following open research queries:

1. Systems available in the market mostly do not provide an end-to-end solution in which the nodes and the data generated by the nodes are in control.

2. Nodes mostly use AGPS (assisted GPS, it only knows tower location. Not actual location of the tracking unit). This AGPS data can be incorrect by over 1-2 km in rural areas/highways [21]. Units which use an actual GPS receiver and operate as standalone devices are rarely available.

3. Existing products have data pushed to third party cloud. Also, system crashes are commonly observed.

II Literature Review

Macro Cavallo et al. observed that in patients having the condition of dementia, the neuropsychological and neuropsychiatric evaluation of the disease may be true for some particular moment only [3] stresses the highly essential requirement for such assistive device.

Units which use an actual GPS receiver and operate as standalone devices in a cost-effective manner are very minimal. Peter Stopher et al. in the study on GPS data on personal travel and vehicular travel, manipulated data collected from GPS devices carried by people or placed in personal vehicles, and used to produce records of the trips made over a period of days or weeks [4]. But data management was projected as a critical issue here. Pankaj Verma and J.S Bhatia [5] has come up with the design of a GPS-GSM based tracking device for controlling theft of a vehicle and proposed the further enhancement by the use of developing a mobile based application to get the real time view of the vehicle instead to check it on PC, which would be more convenient for the user to track the target. Sakib, S. and Bin Abdullah, M.S [6] , in the study PS-GSM based inland vessel tracking system for automatic emergency detection and position notification. R Pramana et al. [7] in the work SMS gateway for ship emergency, had proposed tracking device that is developed is to determine the position of the GPS in Ship emergency navigation. Both these works did not properly addressing the cost efficiency and the security of data.

A study resulted in a tracking device for dementia people, which sends the location coordinates of the person travelling to the caretaker's mobile device by Manasi H. Kasliwal et al. [8]. The study could address only the current location and SMS facility to mobile, and could not help if the caretaker is not having an android enabled mobile device. In view of Covid’19 pandemic medical emergencies, review on the potential of mobile applications for quarantine monitoring, medical emergency and contact tracing was done by many researchers [9,10] revealed the impact of mobile apps for location tracking.

E. Bhaskaran Priyanka et al., exploited the possibility of data storage and analysis with a cloud server wirelessly via Wi-Fi efficient data communication, in their study on the integration of IoT for intelligent transportation in oil industry [11]. The option of a local server that connects to the VPS to upload all the sensor collected data in aquaponics farm was explored by Akhil Nichani et al. [12]. The possible usage of VPS to provide this data in real time was a motivational literature for exploring the possibility of a cloud enabled VPS with a secure network.

III Methodology

The study has designed an IoT based assistive device. The system has a replicable node which once designed can be simply manufactured in any quantity, each with a unique nodeID. The nodeID (or nodeHash) is programmed into the unit at the time of manufacture. It cannot be modified during the life of the node unit. There is an Arduino based Global Positioning System (GPS) node which shares real-time position back to the server. The node is connected to the cellular network at all time. Nodes operate independently of each other. They are connected to the GSM network using an individual SIM card. As long as the node is in the coverage area of the SIM provider, it will post data in real time back to the server. The node can operate autonomously for several days without requiring its battery to be recharged as one of the lowest power consuming GSM modules is used.

A server connected to the Ethernet/Wi-Fi will be collecting the data from the nodes as well as serving the user side web/API components. Use of VPS enables seamless movement of the server from one internet provider to another. No reconfiguration is needed every time a network change happens beyond the control of the infrastructure administrators. As a VPS is used to relay messages from the nodes to core server, the data is secure, and its movement is guaranteed. There is no data stored on the cloud VPS. The assistive device (node) can be customized and embedded inside backpack, everyday essentials etc. when position is to be determined and tracked in real-time. Smartphone users can use associated mobile application to track the location of the person in real time. Only authorized people can log into this application. Figure 2 depicts the working architecture of the system.

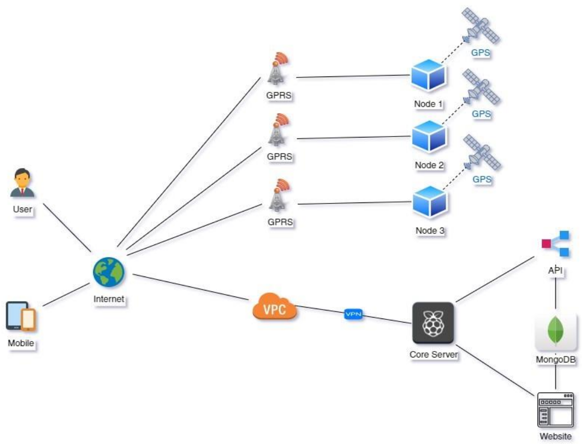


Fig 2: System Architecture

The technical design:

a) Get location data in real-time of the node – The study has chosen to use the A9G module by AiThinker for determining location (latitude & longitude). The module uses a hybrid positioning system, including GPS, BDS and GNNS.

b) Push location data to a centralized storage/database – Design includes Arduino Pro mini as the master to push location data via A9G's GPRS connection. A raspberry pi runs a Python API to receive the data and insert it into mongoDB. A9G consumes about 460 milliwatts for 2-3 seconds to push the data over GPRS. The Raspberry Pi server consumes about 2-5 watts when powered on.

c) Will need to have built in battery – Uses BL-5C cellular phone battery which has a capacity of 1000mAh.

d) Should be able to safely recharge the battery –Selected a TP4056 based charger module with built-in battery protection to provide recharging capability to the node.

The administrator function embedded in the GPS-Based Location Tracking System provides the functionality for monitoring the user. The database chosen for this design is residing on the Core server. Database Engine used is MongoDB Community Edition and MongoDB 4.2.12 version is used.

Table 1 presents the Hardware specifications for the design.

Table 1: Hardware Specifications

VPS vultr – 512MB Cloud Compute	Core Server Raspberry Pi: CPU: 1x ARM CPU	Node Arduino Nano
CPU: 1x 64bit	MEM: 512MB	GPS
MEM: 512MB	Disk: 32GB	GPRS
Disk: 20GB	Network: 1xEthernet	Battery: 2600mah

Raspberry Pi : A computer monitor, or television can work as display for Raspberry Pi, but for best results, a display with HDMI input has to be used. An appropriate display cable to connect the monitor to Raspberry Pi and computer keyboard and mouse also is required in hardware. Any standard USB keyboard and mouse can work with Raspberry Pi and a good quality power supply is essential [13].

Tinc: Tinc is an open-source piece of software that is used to connect a home server and set up a basic VPN on Ubuntu. SSH Keys can be used for authentication which secures the Raspberry Pi as only someone with the private SSH key only is authenticated to the system. tinc needs to be installed on both the home server and the cloud server. Initially establish a reliable VPN between Pi and cloud server to enable access to a static IP address. The cloud server can pass the traffic through the VPN link to the Pi at home. Raspberry Pi uses Raspberry Pi OS and cloud server is a Vultr cloud server running Ubuntu [14,15].

Python Flask Framework: An API (Application Programming Interface) is a simple interface that defines the types of requests (demands/questions, etc.) that can be made, how they are made, and how they are processed. In order to create the API [16, 17,19], Flask framework is used. Flask is a widely used micro web framework for creating APIs in Python. It is a simple yet powerful web framework which is designed to get started quick and easy, with the ability to scale up to complex applications.

Table 2 shows the software specifications of the system.

Table 2: Software Specifications

Virtual Private Server OS: Debian 10	Core Server OS: Debian 10	Node
tinc VPN	Python 2.7 with Flask module	Arduino custom software
Static public IP	tinc VPN	

IV Real Time Experimental Analysis

When the Node is in on state, Boost module status boosts the battery voltage to a stable 5V DC from the battery input that can vary between 3.2 to 4.2V depending on the state of charge of the battery. The Node Status LED will blink in various patterns depending on the status of the node, the GPS and GPRS module.

When the server starts powered up and pyServer.py (API and web pages) is run. The node data is cleared from DB via mongo db.remove command. The node is powered up and user confirms a solid green light on the unit. The node data logged is seen to update in real time on the web UI. An Android mobile application also has been designed for feasibility of the use of the device.

File Description:

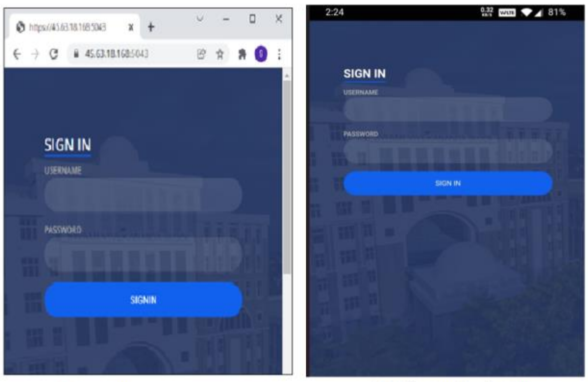
pyServer.py – main API and web code

MAP2.html – template of tracker page with Google maps integration

MAP_Blank.html – template of tracker page with "No Data" text overlay

login.html – template of login page.

The User Interface has two components namely Login page and Tracker page. Figure 6 illustrates the User Interface Login pages of Web and Mobile Application.



UI Login Page Mobile App Login Page

Fig 3: UI Login of Web and Mobile App

The tracker page gets the map data from Google maps. The page has the waypoints in MongoDB sent to Google maps to plot the data points before sending to user's browser. The page also provides information on the Start and End location, node ID, **username** and last updated time. It auto refreshes every 30 second which ensures accuracy.

V Results

The sample results obtained on the route travelled by the person wearing/carrying the assistive device at various travel distances is represented in Figure 4 through Figure 6.

Fig 4: Route of Travel for a distance 4 Km

Fig 5: Route of Travel for a distance 15.9 Km

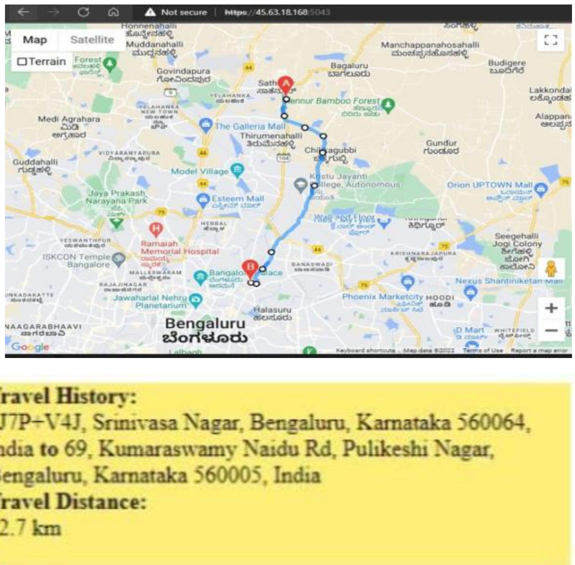


Fig 6: Route of Travel for a distance 22.7 Km

The acquired real time data when compared with the actual route of travel, error rate was minimal. Figure 7 shows the error rate in seconds for the sample distances taken in kilometer.

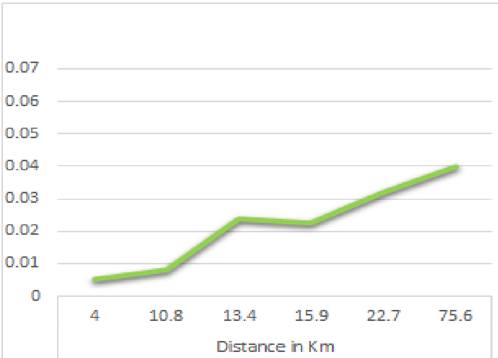


Fig 7 : Error rate in seconds

The device will work efficiently throughout the country and can work effectively if the roaming pack is activated. The performance of the network in terms of latency, propagation delay and processing time in seconds is represented in Figure 8 for various sample distance in Km. The delay was found to be very minimal in all the test cases. The location accuracy of the node is found to be 2.5 to 5 meters.

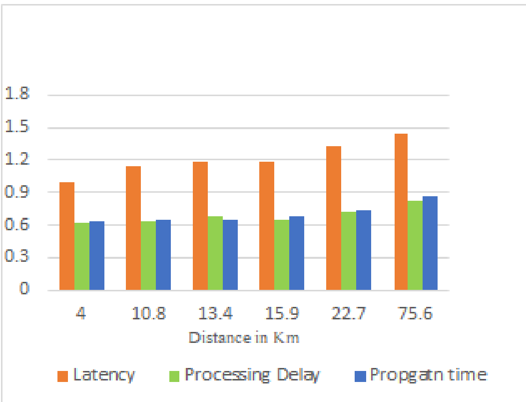


Fig 8 : Network Performance

VI Conclusion

This research has designed 'Locate Us', a tracking aid which enables the consumers of the service to receive real-time data pertaining to the age-old people suffering with cognitive function disorders. This system also helps the caretaker/family members to connect and interact with the elderly person by clicking a button. The design transmits location data back to the server at regular intervals which ensures accuracy. The proposed system makes good use of popular technology that combines a phone/ laptop/ Raspberry Pi application connected to Ethernet. The device (node) can be customized to be embedded in the user's garment also. This Implementation is cost efficient. System components are carefully chosen keeping in mind the per-unit cost as well as their long-term availability. Software which resides on the server can be customized as per the needs. Usage of non-proprietary, open-source software keeps the licensing costs at zero. Nodes operate independently of each other.

The future enhancements on which the authors are currently working include a)The node can be customized to support more functionalities. The node can be enhanced to transmit data back over 4G networks. b) SMS OTP Security (SOS) via SMS [20], email and push notification to fixed number in case of emergency.Geo fencing alarms can be implemented in software to send alert if node goes outside, a certain coverage limit/ enters any hazardous area.

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