Original Article

Design and Implementation of a Customable Automatic Vehicle Location System in Ambulances and Emergency Vehicle Systems

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Abstract

Background: Automatic vehicle location (AVL) refers to a system that calculates the geographical location of any vehicle, i.e., latitude and longitude. Vehicle location information about one or more moving vehicles can be stored in the internal memory and accessed when vehicles are available (offline tracking). It is also possible to get location information on a real-time basis (online tracking). The real-time tracking systems designed to date may incorporate three devices: global positioning system (GPS), geographic information system, and cellular communication platforms that may be either a general packet radio service (GPRS) or any private and local radiofrequency network. **Methods:** The GPS-based navigation system has been designed so as to allow for user-friendly real-time tracking applications for any emergency vehicles like ambulances. First, GPS coordinates are obtained from the SIM908 module and sent via to a server transmission control protocol/internet protocol. Server codes, which are written in C#, load Google map to show real-time location. **Results:** We designed online tracking AVL hardware in the two simple and advanced versions. The latter enables both the ambulance driver and the data center to monitor path real-time besides enabling the vehicle driver to receive and make calls and send or receive messages. The former only sends latitude and longitude to the data server continuously, and the path travelled by vehicle is displayed. **Conclusion:** SIM908 integrates GSM, GPRS, and GPS in one package. It can be a proper choice for real-time economic tracking systems despite its low accuracy in finding geolocations.

Keywords: *Automatic vehicle location, general packet radio service, geographic information system, global positioning system, Google map, latitude, longitude, transmission control protocol/internet protocol, vehicle tracking*

Introduction

Today, the proper use of resources and facilities at our disposal constitutes one of the vital factors of management. Automatic vehicle location (AVL) and tracking systems are the most effective tools in managing the movement of vehicles, which are widely used in emergency medical aid and for civilian and military purposes all across the globe. These systems rely on the principle of mobile instantaneous positioning which are powerful tools for fleet control and management. The outstanding benefits of AVL real-time systems are as follows:

- Information about routes traveled by vehicles
- Recognition of the current location of vehicles
- Displaying vehicle direction details on urban and national maps
- Continuous tracing and control of vehicles
- Collecting accurate and reliable information about traffic
- Preparing comprehensive data for accurate application planning
- Providing realistic data for an improved design on roads and bridges.

It would be also possible to get information about the quality of moving vehicles in terms of speed, stopping times, minimum and maximum speed, and all motion parameters. Finally, the AVL system can detect, track, and control vehicles real-time (online) or nonreal-time (offline).

In recent years, research has widely been conducted on the AVL systems. An offline framework for the recognition of time reliability by AVL data was proposed to provide an opportunity to keep buses on schedule and/or maintain planned headways in Cagliari, Italy. This offline framework is suitable for any bus path as it allows

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for a precise calculation of bus stops and time intervals where reliability is insufficient. Reliability may be viewed as the dependability of a transit service in terms of such aspects as waiting and riding times.[1] Real-time AVL and monitoring system for taking Hajj pilgrims to the city of Mecca in Saudi Arabia was suggested. This system is able to locate and track mobile vehicles and identify pilgrims. Performance results have been proved for LAN, WLAN, and Bluetooth in the data distribution service.[2] The Vehicle Tracking System in application consists of an Arduino platform, XBee module, and global positioning system (GPS). The purpose is to obtain coordinates from GPS and send them via the XBee wireless technology and display the results on Google earth.[3] The real-time vehicle monitoring and tracking systems are designed to monitor school buses based on Raspberry Pi, Embedded Linux board. The proposed system also looks after the safety of travelers using Liquefied petroleum gas (LPG) gas leakage sensor MQ6 and temperature sensor DS18B20.[4,5] A vehicle monitoring, tracking, and controlling system based on SIM900A module was used. In this system, when the driver takes the wrong path or when the vehicle's speed exceeds limits, an alert message will be sent from the system on the vehicle owner's mobile phone. Furthermore, the driver will be alerted on speakers.[6] In a bid to provide safety and security for drivers, vehicle tracking and monitoring system was developed based on the SIM800 module. In addition to obtaining geographic coordinates via GPS and sending them to the server, this system monitors the driver using an alcohol sensor to prevent possible accidents.[7] A vehicle tracking system based on Arduino Intel Galileo and the SIM908 module was proposed. Arduino will use the SIM908 module to obtain vehicle location coordination and send geolocation via the GSM modem to the PHP site page that utilizing Google map service to display the route.[8] A vehicle tracking system based on Micro-Controller Operating Systems (UC-OSII) and the LPC2148 processor was designed to track the vehicles using real-time operating system (RTOS) programming.[9] Getting geographic coordinates or obtaining AVL data can be useful in other problems pertaining to transportation. A system was proposed to detect potholes and humps on the roads and notify the drivers with the help of an ultrasonic sensor, Android application, and GPS receiver.[10] An short message service (SMS)-based and multimedia messaging service (MMS)-based immediate accident reporting system was developed in vehicles to improve the efficiency of accident reports.[11] The travel time and speed mean data were collected from the vehicle to predict accidents with a view to increasing safety on freeways and expressways.[12] In the discussion section, a comprehensive comparison is made between this study and previous research.

In this paper, an AVL hardware system was designed in the simple and advanced version. The latter is mini-PC-based while the former is based on LPC1768 microprocessors. Both versions share such features as automatically sending latitude and longitude to data center, making and receiving calls, and (c) sending and receiving messages. An advanced version is equipped with full color Thin-film-transistor liquid-crystal display (TFT LCD) and is able to load Google map to display routes real-time for ambulance drivers. The related program is written in C# to display the vehicle's position. The rest of this paper is arranged as follows: section 2 indicates materials and methods, section 3 focuses on discussion and experimental results, and finally section 4 provides conclusion.

Methods

The most important hardware in the design system is the SIM908 module which is used for the GPS, geographic information system (GIS), and general packet radio service (GPRS) applications.

System architecture

GPS is a satellite-based navigation system incorporating a 24-satellite network that was placed into orbit by the U.S. Department of Defense. The satellites were deployed in space about 12,000 miles (19,300 km) above the earth's surface.[13] To get geographical coordinates, i.e., latitude and longitude, from the GPS satellites, the SIM908 module provided by SIMCOM Company is used.

The SIM908 module is a Quad-Band GSM/GPRS module fitted with the GPS technology for satellite-based navigation. This module combines GPRS and GPS in a surface-mount technology (SMT) package, which would remarkably save time and cost for customers in developing the GPS applications.[14] Hardware for this project is designed in both simplified and advanced versions, which are described in sections 2-1-1 and 2-1-2, respectively.

Simple version architecture

The block diagram of the simple version is shown in Figure 1. After the board power is switched on, the LPC1768 chip, ARM CORTEX M3 microprocessor from Philips with 100 MHz frequency will be connected to SIM908 and will send the AT command to the module. AT commands are instructions which are used to exchange data with some telecommunication systems such as the modem or GPS modules. A comprehensive list of AT commands needed for this project is briefly described in Table 1.[15]

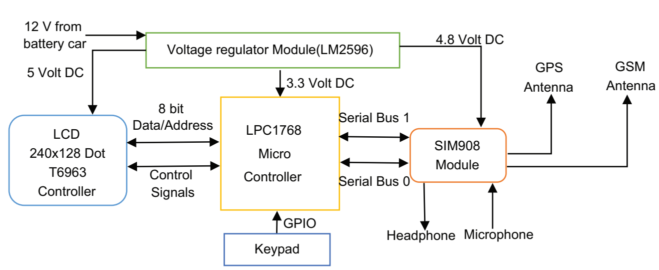

Figure 1: Block diagram of simple version

Table 1: Comprehensive list of AT command used in this research

	n	AT command	Description
General command	1	AT	Check connection between module and processor
	2	AT+CPIN?	Check whether SIM card is inserted to SIM card or not
	3	AT+CGREG?	Check device registration status
	4	AT+COPS?	Get network information
	5	AT+CSQ	Check signal quality and return signal strength from 0 to 30
	6	AT+IPR=?	Determine what UART baud rates are supported
	7	AT+IPR?	Determine current UART baud rates
	8	AT+CGSN	Get IMEI
Make and receive calls	9	ATD+xxxxxxxxxxxx;	Dial number (x is number)
	10	ATA	Answer incoming call
	11	ATH	Hang up the call
SMS command	12	AT+CMGL=”ALL”	Display all received text messages
	13	AT+CMGF=1	Set SMS for text format
	14	AT+CMGS=” +xxx…xxxx”	Send SMS
	15	AT+CMGL=” ALL”	Display all received SMS
	16	AT+CMGD=x	Delete message number x
USSD command	17	AT+CUSD?	Check USSD status
	18	AT+CUSD=1	Active USSD
	19	AT+CUSD=1,” xxxxxx”	X’s are related code of network operator
GPS command	20	AT+CFUN=1	Sets full access level of functionality
	21	AT+CGPSPWR=1	Turn GPS unit on the module
	22	AT+CGPSRST=0	Reset GPS in autonomy mode
	23	AT+CGPSSTATUS?	Get GPS Status
	24	AT+CGPSINF=0	Get current GPS location
GPRS command	25	AT+CIPSHUT	Close current GPRS PDP context
	26	AT+CGACT?	PDP context activate or deactivate
	27	AT+CGATT=1	Attach module to network
	28	AT+CSTT=”APN”,”mtnirancell”,””	Start task, set APN, user name, and password
	29	AT+CIICR	Bring up wireless connection
	30	AT+CIFSR	Get module IP address
	31	AT+CIPSTART=”TCP”,”xxx, xxx, xxx, xxx”,”x”	Startup TCP or UDP connection
	32	AT+CIPSEND	Send data through TCP or UDP connection

JMSS – General packet radio service; GPS – Global Positioning System; USSD – Unstructured supplementary service data; UART – Universal asynchronous receiver-transmitter; IMEI – International mobile equipment identity; TCP – Transmission control protocol; UDP – User datagram protocol; APN – Access point name

LPC1768 has four serial ports while two ports are used in this project to communicate with the SIM908 Module. When the GPS antenna is connected to at least three satellites, the geographic information will be determined by the module. Geographic coordination will be received by a microprocessor via the serial port. On the other hand, through another serial port, the processor will command the module to connect to the telecommunication network. If the connection was successful, longitude and latitude can be sent by the processor to the data center or server. To use the telecommunications network, SIM908 must be connected to the SIM card. Any kind of SIM card is allowed; however, it must be registered on the network. The registration can be verified by the AT command. Sending data from the processor to the server can be carried out by three methods, namely User Datagram Protocol (UDP) and transmission control protocol/internet protocol (TCP/IP) methods which are Internet and SMS based. SIM908 supports all of them.[15] As it is shown in Figure 1, SIM908 has audio input and output port for making calls. These ports will be connected to a headphone and microphone via the capacitor network.[14] This module must be connected directly to two antennas.

A monochrome 240 × 128 dots LCD, with T6963 chipset controller via eight-bit parallel data bus and five control signals for reading and writing, is connected to the microprocessor. T6963 is a chipset controller from Toshiba that enables the LCD to display graphic and English characters simultaneously. Voice call and SMS message notifications will appear on the LCD. Driving LCD and keypad is implemented by connecting general purpose input output processor to them.[16] The board is shown in Figure 2. All codes were written in C language and compiled by Keil-u Vision.

The power supply range of SIM908 can have variations from 3.2V to 4.8V. The transmitting burst will cause voltage to drop sharply. For this reason, the power supply must be able to provide sufficient current up to 2A.[14] The LM2596 regulator is a monolithic buck converter switching integrated circuit that is capable of driving a 3.0A load with excellent load regulation line.[17] This regulator is available in adjustable and constant output. In this project, three LM2596 modules are used to provide three levels of voltage for SIM908, the microprocessor, and the LCD module.

A comprehensive list of AT command needed for this project is provided in Table 1.[15] In addition to controlling all SIM908 functions such as calls, SMS, GPS, and GPRS with these commands, there is a possibility of checking the SIM card credit through unstructured supplementary service data (USSD) codes. Like SMS, USSD is a method of communications in the GSM network, which allows the subscriber to purchase SIM card credit, declare inventory, balance check the SIM card internet, and so on. USSD commands are shown in Table 1.

Advanced version architecture

An advanced version is based on J1900 core 2 Duo, fan-less Intel processor, 2 GB RAM, Wi-Fi, LAN, USB, and two serial ports. The block diagram and system setup are shown in Figure 3. Mini-PC is equipped with a solid-state drive (SSD) that makes it ideally resistant to vibration and any shaking of vehicle. The operation of this system is similar to the simple version. After the mini-PC is turned on and the operating system is ready to run, the program written in C# will run automatically and start sending AT command to the SIM908 module and subsequently get GIS data via the serial port. Then, the GIS data are sent from the LAN port to Google server via a 3G modem. After that, Google map will be loaded, and the vehicle's position will be shown to the driver. The LCD size or the type of mini-PC are the components that change according to the user preference. The board and mini-PC are shown in Figure 4.

In Figure 5, a screenshot of software's GUI that is running on the mini-PC is shown. This program is written in C# that is integrated with GMap.NET.Core.dll. This is free license DLL file showing Google map in various modes such as the 3D map (capable showing building and trees in 3D), open street map [capable of showing streets and roads like in Figure 5], and other modes. All of these modes are available, and drivers can choose among them under different circumstances.

In Table 2, the power consumption of SIM908 at 12 VDC with LM2596 voltage regulator has been shown after having been measured by the current meter. According to datasheet, power supply must be able to provide momentary current up to 2 A.

Software processing and locking on satellite

Software processing for both simple and advanced versions are distinct but are identical in LCD initialization, serial port, and SIM908 module. In this section, the GPS hardware section of SIM908 has been investigated. The flowchart of AT command execution is demonstrated in Figure 6. After the power supply is stabilized in the first step, the GPS engine must be turned on and reset, respectively, with an appropriate AT command by the processor. In this state, the GPS engine will acquire geolocation automatically and will track the GPS satellites. In the next step, the status of finding enough satellites has to be examined continuously. At the start of this stage, the "location unknown" or "location not fix" message is sent by the module sequentially. In datasheet, it is said to

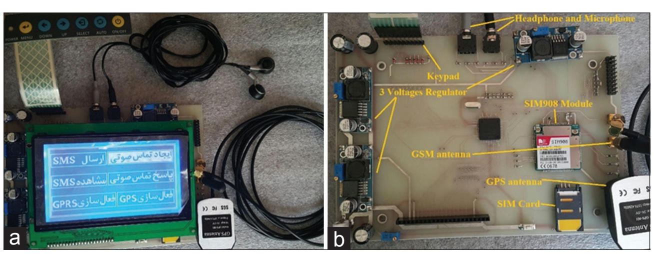

Figure 2: Complete simple version of automatic vehicle location board with SIM908 Module and LCD in (a). Annotated board without LCD is shown in (b)

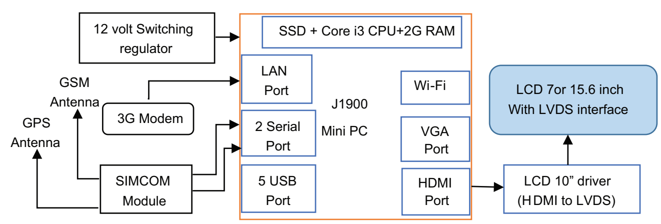

Figure 3: Block diagram of advanced version

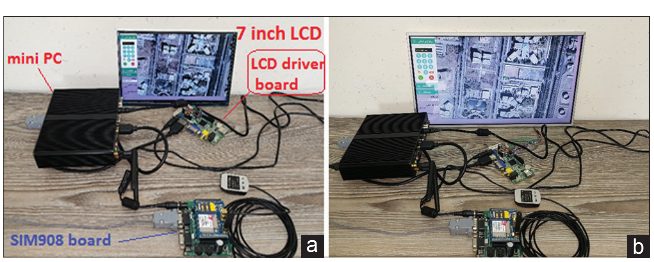

Figure 4: Complete automatic vehicle location board with SIM908 Module in advanced version is shown with two sizes of LCD. (a) 7-inch LCD (b) 15.6-inch LCD

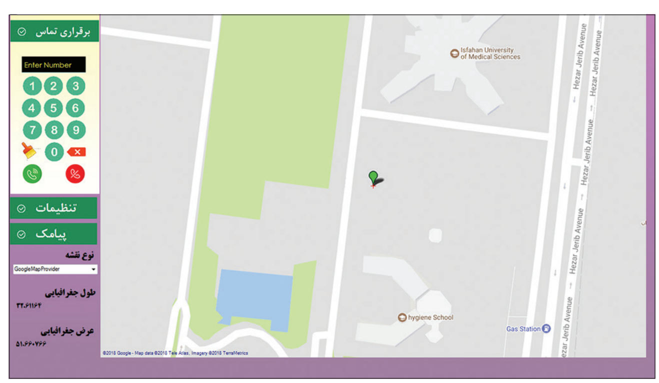

Figure 5: Screenshot of software running on mini-PC

take about 30 s typically, in practice it takes about 1 min. During this time, geolocation has an enormous deviation, around 700 meters or more. This time having been passed (depending on weather conditions), "location 2Dfix" will be sent by the module. When the "location 2Dfix" message is sent by the SIM908 module, it will be possible to display geolocation on the map but coordinates are not accurate. If more precision is needed, the module status must be checked iteratively in loop until "location 3D fix" is detected. When the module sends "location 3D fix," it means geolocation is detected with high precision. Before sending geolocation to Google map, a preprocessing of data is needed, as described in 2–3. Eventually, the latitude, longitude, altitude, and satellite numbers will be extracted as reported in Table 3. During this process, if the system experiences any defect such as breakdown in the GPS antenna connection, the enclosed GPS antenna, and so on, geolocation cannot be found. In other words, "location unknown" or "location not fix" will come back by SIM908 continuously.

Data processing

As mentioned before, the processor sends the AT command to SIM908 and waits to receive the appropriate answer. This response has some additional characters. Two commands and the corresponding answer are provided in Table 4.[15]

As shown in Table 4, there are some redundant characters in response and just green characters are needed; red characters are redundant and are therefore ignored. In this case,[1] the expression "Location 3D Fix" means that coordination is detected with high precision. It is remarkable that this response is not constant and may vary under different weather conditions. In case,[1] to eliminate redundant data, some processing in C# is applied to the response string, and useful data are extracted from the received data. In this case[2] 5139.647626, 3236.694076, and 9 show the longitude, latitude and the number of satellites, respectively in National Marine Electronics Association (NMEA) data format. GPS data formatting output from SIM908 is according to NMEA string protocol.[9] This format does not apply to Google map, and the data need to be converted to decimal latitudes and longitudes. These conversions can be done by the two conversions provided in Table 3 in MATLAB language.

Handshaking

Both TCP and UDP protocols are the components in the IP suite and are used by programs running on different computers on a network to send and receive data. There is a difference between the two protocols. TCP is a connection-oriented protocol and guarantees receipt of the data packet by the receiver. The receiver sends messages back to the sender, saying it received the messages when packets were checked for errors. UDP is similar to TCP but does not use the handshaking technique, leading to unreliable telecommunications. Since these two methods are based on internet, they reduce the price of communications in comparison to SMS. Consequently, TCP is the best protocol in this project since it has been inexpensive and more reliable. To implement TCP and socket programing in C#, free license DLL file was used. Simple TCPDLL package file is a significant and remarkable tool in creating connections and handling tasks between the client and server. This package can be integrated to visual studio via nugget package manager.

Table 2: Current consumption of SIM908

Module status	Before pull-down PWRKEY pin	After pull-down PWRKEY pin	Turn on GPS engine	Make call	Receive call
Power consumption	33 m A	Max 100 mA Continues 41 mA	70 mA	110 mA	80 mA

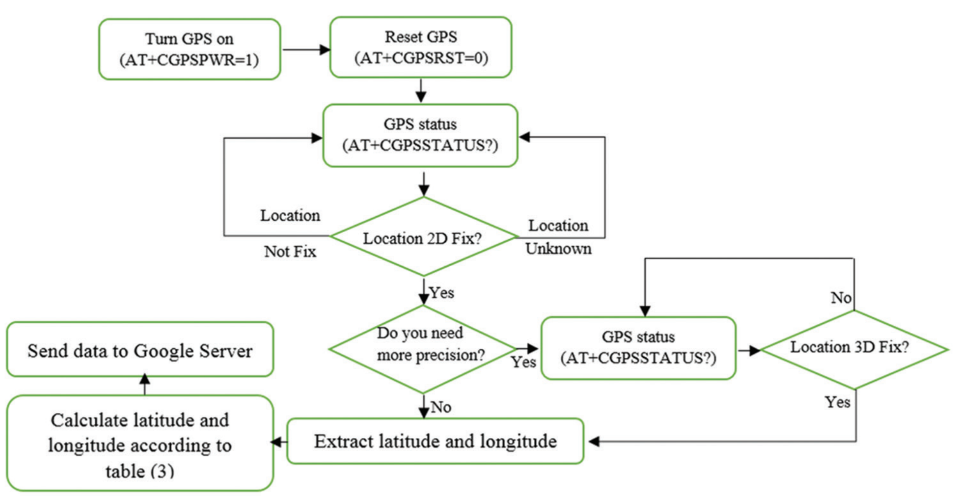

Figure 6: Flowchart of AT command execution

Results

About 50 experiments with approximate 20-min recording data have been carried out to check the performance of hardware. It has been found that the accuracy of SIM908 is dependent on weather conditions and the environment where the antenna is located. It means that if the module is placed outdoors, it can find enough satellites and obtain more precise coordinates. To find satellites with high precision, GSM antenna must be set outdoors. In other words, this is one of hardware restrictions as hardware does not work properly indoors and in roofed places. The module operation can be affected by cloudy and polluted weather. The precision depends on the number of satellites found by the module. The results of two experiments carried out outdoors are given below. The first test was done in clean, warm, and sunny weather. As shown in Table 5, after about 60 s, geolocation with 22-meter deviation and seven satellites was obtained. Although the test lasted 21 min and the number of satellites increased slightly, finally 75 s after powering the GPS engine, the ultimate accuracy was achieved. Repeated experiments proved that under sunny and clean climate, SIM908 is able to find desirable geolocation in about around 75 s. As the sketch and Table 5 show, increasing satellite numbers would not give remarkable accuracy. Satellite changes and the amounts of deviation are plotted in Figure 7.

Figure 8 shows another test in a fairly cloudy day in winter. As shown in this figure, after around 12 min, acceptable results were achieved. During this time, although the trend of satellite numbers was upward, and their numbers increased gradually, deviation fluctuated but the overall trend of deviation was downward. From the 13th min, variation of deviation decreased steadily, and in the 13.30th min, it leveled off with a round four meter and continued until the 21st min. The values pertaining to this test are shown in Table 6.

Discussion

In this section, the results of this study with previous research are compared.

References 1 and 12 have been assumed that AVL data, i.e., geolocational data are available and have been concentrated on mathematical algorithms for the processing of AVL data. The latter is focused on crash prediction while the former proposes methods of gauging reliability on buses in terms of passenger loads, safety, waiting, and riding time. Reference 2 designs real-time AVL for Hajj pilgrims in Saudi Arabia. To reduce costs, instead of installing a navigation system and RFID Tag for each pilgrim, the RFID reader will send the IDs of pilgrims that are integrated into GIS data to the DDS (Data Distribution

Table 3: Converting GPS data format from National Marine Electronics Association protocol to latitude and longitude

Latitude calculation	Longitude calculation
Latitude=3236.694076	Longitude=5139.647626
Deg=Floor (latitude/100)	Deg=Floor (longitude/100)
Min=Latitude - (100 * deg)	Min=Longitude - (100 * deg)
Latitude=deg + (min/60.0)	Longitude=Deg + (min/60.0)
disp('latitude=')	disp('longitude=')
disp (num2str (latitude))	disp (num2str (longitude))

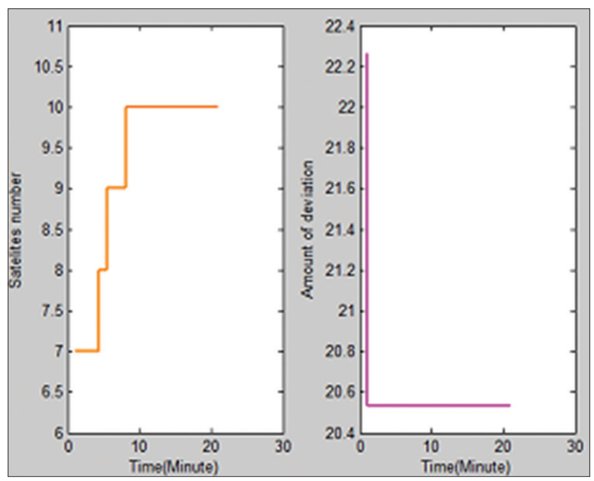

Figure 7: Variation of satellite and deviation versus time for test 1 on hardware

Table 4: Two Global Positioning System AT command and appropriated answer

n	Command	Brief description	Answer
1	AT+CGPSSTATUS?	Get current status of module	+CGPSSTATUS: Location 3D Fix
2	AT+CGPSINF=0	Get GPS data from module	0, 5139.647626, 3236.694076, 1639.543579, 20180514051028.000, 336, 9, 0.000000, 28.392771

Table 5: Experimental results for test location 1 in Isfahan, Iran

Time passed (M:S)	Real latitude	Real longitude	Measured latitude	Measured longitude	Deviation (meter)	Satellites number
1.00	32.611632	51.660751	32.6115	51.6606	22.2	7
1.15			32.6115	51.6607	20.53	7
10.30			32.6115	51.6607	20.53	9
21.00			32.6115	51.6607	20.53	10

Table 6: Experimental results for test location 2 in Isfahan, Iran

Time passed (M:S)	Real latitude	Real longitude	Measured latitude	Measured longitude	Deviation (meter)	Satellites number
1.00	32.611632	51.660751	32.6173	51.6570	726.3282	6
5.15			32.6123	51.6592	157.6336	8
5.30			32.6173	51.6570	722.2539	8
7.45			32.611	51.6595	133.9677	9
8.00			32.6173	51.6570	722.2539	9
12.15			32.6173	51.6570	722.2539	10
12.30			32.6115	51.6605	27.9318	11
12.45			32.6116	51.6606	13.5622	11
13.00			32.6114	51.6605	32.9073	11
13.15			32.6116	51.6607	8.6225	11
13.30			32.6116	51.6608	3.9062	11
21.00			32.6116	51.6608	3.9062	14

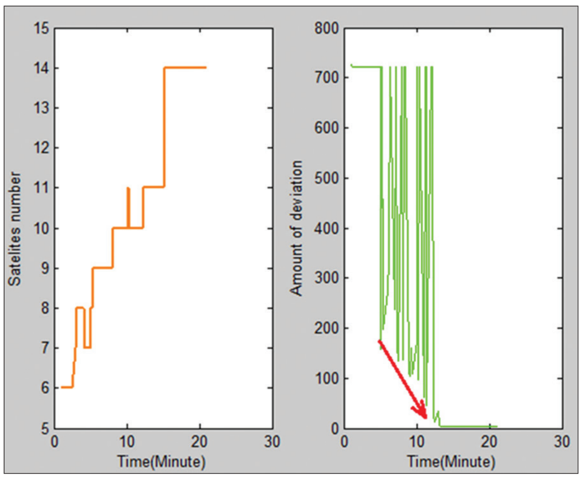

Figure 8: Variation of satellite and deviation versus time for test 2 on hardware

System) via checkpoint. A gate will open automatically after a positive decision according to DDS. REF 3 used Arduino as CPU, got geolocational data via gygps6 mv[2], and sent them through the XBee module to the server software SatGen3 to display the path on Google Earth. XBee modules are used as a local transmitter and receiver. REF. 4–9 are developed by Raspberry Pi or LPC2148 or Galileo, and the coordinates are acquired via SIMCOM products. Except for REF 6, the others send tracking information to the server. The server code for REF 4 and 5 is written by PHP and MySQL. All of them compare the current vehicle path with the path predetermined in their hardware. If the driver takes the wrong way, a warning will be sent as SMS to the owner. Furthermore, the velocity of vehicle will be monitored continuously. These systems have other features such as alcoholic sensor for the awareness of drivers who are drunk. Ref 6 and 7 are equipped with 2 × 16 character LCD to display messages and coordinates. Ref 7 also proposes a system to monitor the driver's safety by alcoholic sensor against drunk state. Hardware specifications about Ref 8–9 are shown in Table 7. Ref 9 s used μCOS-II RTOS for multitasking programming. Ref 10 was prepared with ultrasonic sensors to recognize potholes and humps as well as their depth and height. Ref 11 with the aid of SIM908 and accelerometer proposed a crash reporting system. When an accident occurs, GIS data and the picture of location are sent via MMS and SMS to emergency helpers.

From the CPU point of view, although Arduino and Raspberry Pi are well known in the embedded system, they are not suitable working in noisy environments like in ambulances. NXP processors such as LPC1768 or LPC2148 with the ability of running μCOS-II and PIC microcontrollers are processors that can be used for industrial environments. J1900, Intel Celeron generation is highly efficient but it needs Windows or Linux operating system. In other words, using this CPU is impossible without an operating system.

From the handshaking angle, approximately all activities use GPRS except for REF 3 and 10. Using GSM (send data via SMS) can increase costs significantly in comparison with GPRS (sending data via internet). As mentioned earlier in section 2–4, GPRS can be ensured that the recipient has received the data. Also using the Xbee module can limit the board of hardware exceptionally.

From the viewpoint of navigation engine or GPS, SIM908 was selected for this project. However, due to the unexpected signal noise, there are differences between the real and measured data. As we mentioned previously, SIM908 works only with the GPS technology. The GPS is a satellite-based radio navigation system with five-meter accuracy. It was developed by the United States for military and civilian purposes. Under exceptional conditions where the GPS system cannot be utilized like under sanctions, other navigation techniques are available. The GLObal NAvigation Satellite System (GLONASS) is another satellite navigation system that was created by Russia with accuracy from 2.8 to 7.38 meters for military and civilian purposes. Quasi-Zenith Satellite System (QZSS) is a satellite-based augmentation system for the United States GPS with an accuracy from 0.01

Table 7: Comparison table between this study and previous references

Case study	Previews references									This study	
	Ibraheem and Hadi[3]	Shinde and Mane[4]	Shinde and Mane[5]	Jyothi and Harish[6]	Anusha and Ahmed[7]	Mohamad *et al.*[8]	Metkar and Deshmukh[9]	Madli *et al.*[10]	Manoharan *et al.*[11]	Simple version	Advanced version
Processor in vehicle	Arduino	Raspberry Pi	Raspberry Pi	LPC2148	LPC2148	Arduino intel Galileo	LPC2148	PIC16 F887A	-	LPC1768	J1900 core 2 duo
GPS hardware	gygps6mv2	SIM908	SIM900A	SIM900A	SIM800	SIM908	SIM900	SIM900	SIM908	SIM908	SIM908
Send and receive SMS	No	No	No	No	No	No	No	No	No	Yes	Yes
Make and receive voice calls	No	No	No	No	No	No	No	No	No	Yes	Yes
Handshaking method	XBeeprotocol	GPRS	GPRS	No	GPRS	GPRS	GPRS	GSM	No	GPRS	GPRS
Server software	Yes SatGen3	Yes PHP	Yes PHP	No	NM	Yes PHP	Yes NM	Yes Android	No	Yes C#	Yes C#
LCD display in car unit and loading map for driver	NO	NO	NO	Yes	Yes	NO	NO	No	No	No	Yes
Other features	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No

NM means not mentioned obviously

to 1 meter and consisted of a four-satellite regional time transfer system by the Japanese government for civilian purposes. The Global navigation satellite system (GNSS) is another navigation system with accuracy from 1 m to 1 cm in public and encrypted applications, respectively, and are being developed by the European Union for civilian and commercial purposes. U-blox Company introduces high-performance standalone modules that use GLONASS, QZSS, GNSS, and GPS techniques to find geolocations. For instance, MAX-7 series provides maximum sensitivity with low power consumption, which may be suggested for future projects. From the map standpoint, online Google map was proposed. Under special conditions where online map cannot be achieved, maps can be stored in the internal memory of Mini-PC and loaded for the demonstration of path. That would lead to higher capacity solid state drive (SSD) disk.

Advantages and disadvantages are as follows:

Disadvantages of this system are fairly low precision in location, taking little time to find as many satellites as possible and outdoor space needed for the GPS antenna. Whereas sending data to server is realized based on the telecommunications operator, the system will shut down if the network is disconnected for any reason. Advantages include the possibility of making and receiving calls, online tracking, very low costs, sending and receiving text messages, ultra-high security, customizing hardware according to customer and application (extensive range of selection for mini-PC and LCD, even operating system).

Conclusion

This research project has been done based on the Az-Zahra Hospital ambulance fleet demand. For this purpose, new hardware based on the SIM908 module provided by SIMCOM Company was proposed for real-time tracking. It is able to connect satellites and obtain geographic position, i.e., latitude and longitude values, and send data via GPRS to the server. SIM908 integrates GSM, GPRS, and GPS in one package. It could be proper choice for real-time economical tracking systems. To reduce the deviation error and decrease the connection time to satellite, multiengine modules such as NEO-6 or NEO-7 module series are proposed. The integration of all these techniques in one package has been done module from u-blox company.

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Conflicts of interest

There are no conflicts of interest.

References

1. Barabino B, Di Francesco M, Mozzoni S. An offline framework for the diagnosis of time reliability by automatic vehicle location data. IEEE Trans Intell Transp Syst 2017;18:583-94.

2. Almadani B, Khan S, Sheltami TR, Shakshuki EM, Musaddiq M, Saeed B. Automatic vehicle location and monitoring system based on data distribution service. Procedia Comput Sci 2014;37:127-34.
3. Ibraheem IK, Hadi SW, editors. Design and Implementation of a Low-Cost Secure Vehicle Tracking System. 2018 International Conference on Engineering Technology and their Applications (IICETA). IEEE; 2018.
4. Shinde PA, Mane Y, editors. Advanced vehicle monitoring and tracking system based on Raspberry Pi. 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO). IEEE; 2015.
5. Shinde PA, Mane Y, Tarange PH, editors. Real time vehicle monitoring and tracking system based on embedded Linux board and android application. 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015]. IEEE; 2015.
6. Jyothi P, Harish G, editors. Design and implementation of real time vehicle monitoring, tracking and controlling system. 2016 International Conference on Communication and Electronics Systems (ICCES). IEEE; 2016.
7. Anusha A, Ahmed SM, editors. Vehicle tracking and monitoring system to enhance the safety And security driving using IOT. 2017 International Conference on Recent Trends in Electrical, Electronics and Computing Technologies (ICRTEECT). IEEE; 2017.
8. Mohamad OA, Hameed RT, Ţăpuş N, editors. Design and implementation of real time tracking system based on Arduino Intel Galileo. 2016 8th International Conference on Electronics, Computers and Artificial Intelligence (ECAI). IEEE; 2016.
9. Metkar S, Deshmukh GL, editors. RTOS Based Vehicle Tracking System. 2015 International Conference on Information Processing (ICIP). IEEE; 2015.
10. Madli R, Hebbar S, Pattar P, Golla V. Automatic detection and notification of potholes and humps on roads to aid drivers. IEEE Sensors J 2015;15:4313-8.
11. Manoharan R, Balamurugan G, Rajmohan B, editors. Enhanced Automated Crash Reporting System in Vehicles Based on SMS and MMS with Fish Eye CAM Camera. 2012 International Conference on Radar, Communication and Computing (ICRCC). IEEE; 2012.
12. Ahmed MM, Abdel-Aty MA. The viability of using automatic vehicle identification data for real-time crash prediction. IEEE Trans Intell Transp Syst 2012;13:459-68.
13. Chandra A, Jain S, Qadeer MA, editors. GPS locator: An application for location tracking and sharing using GPS for Java enabled handhelds. 2011 International Conference on Computational Intelligence and Communication Networks. IEEE; 2011.
14. SIM908 module datasheet from: http://www.mt-system.ru/sites/default/files/docs/documents/sim908-c_hd_v1.00.pdf. [Last accessed on 2011 Jul 20].
15. SIM908 AT Command Manual from: http://image.dfrobot.com/image/data/TEL0051/3.0/SIM908_AT%20Command%20Manual_V1.01.pdf. [Last accessed on 2011 July 07].
16. Interfacing to a Graphics Module with a Toshiba from http://www.hantronix.com/files/down/t6963app.pdf. [Last accessed on 2000 Jan 00].
17. LM2576 datasheet from https://www.onsemi.com/pub/Collateral/LM2596-D.PDF. [Last accessed on 2006 Jan 00].

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