Design and Implementation of Automated Law Enforcement using the Internet of Things (IoT)

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Abstract

Due to a lack of legal enforcement, numerous vehicle accidents occur every year throughout the world. An effective vehicle tracking system is developed, tested, and classified in order to identify the speed of any vehicle in any street at any time and from any location (highways, crowded or secondary roads). The suggested system makes use of IoT technology, which is a relatively new development that has already made significant contributions to scientific research as well as offers many wonderful conveniences in daily life. The in-vehicle device utilizes GPS and GSM/GPRS, two of the most commonly used tracking technologies. The device is integrated into a moving object (vehicle) that is automatically tracked and observed in real-time. Through the OBD interface, the Raspberry Pi microcontroller periodically reads the vehicle speed. The Raspberry Pi microcontroller is equipped with GPS and GSM/GPRS modules to track the location of the vehicle. and, when the speed limit is exceeded, sends the coordinates and speed to the central station over the internet. The data pertaining to each vehicle is kept in a database at the central station. Based on the data gathered from the in-vehicle gadget, the driver who exceeded the speed limit will immediately receive a fine through the central station. The proposed system will help in reducing the likelihood of driver fraudulence and has demonstrated its efficiency and accuracy to reduce excessive speed and traffic accidents, leading to the daily saving of many lives. The system has been successfully built and effectively tested at a lower cost than traditional systems that rely on the use of cameras on each road.
Keywords- vehicle tracking, raspberry pi, IoT, SIM868 GPS, GSM & GPRS.

I. INTRODUCTION

The original idea behind today's hotly debated "Internet of Things" technology was to integrate sensors into common objects to give them some level of intelligence, The phrase "internet of things" (IoT) is a broad word that encompasses a variety of technologies, uses, and applications. These are made possible by technology based on IP addresses (Internet Protocol) and the interconnection of objects [1]. Urban mobility is on the rise, and numerous incidents happen on the roads every day. It is necessary to create a secure and dependable monitoring system to address these problems [2]. Inattentional driving and vehicle theft have increased over the last 10 years, which has resulted in a number of accidents and other dangerous circumstances. We frequently see or hear about such events that raise questions about our safety and security in both the public and private sectors. The car must therefore be watched in real-time, and its database of particular conditions must be saved and updated [3]. An estimated 1.3 million individuals worldwide have their lives cut short as a result of automotive accidents every year, according to reports from governments around the world, including Iraq. Recently, more accidents have occurred on the road as a result of this. Between 20 and 50 million more, non-fatal injuries occur every year, and many of them cause disability [4]. People will typically oppose change until they are forced to by bylaws or suffer harsh consequences because it is human nature. Therefore, damage-related costs put additional pressure on society's advancement. Therefore, providing solutions to these issues is beneficial [5].

II. VEHICLE TRACKING SYSTEM

The main objective of this system's design is to protect our safety and lives by reducing traffic accidents brought on by driving too fast. Previously, the movement of vehicles and their speed were controlled and monitored by employing cameras. However, this system has numerous flaws, including the vulnerability of cameras to damage due to weather conditions or vandalism, in addition to being costly and unable to be deployed in all streets. this system was created utilizing reasonably priced, easily obtained sensors and electronics and is not vulnerable to breaking or damage Because it is installed inside the car. Despite the presence of GPS and the option of utilizing it to determine speed, the OBD II was used to compute the speed of the car because it can check a variety of engine parameters, including temperature, tire pressure, fuel consumption, and other parameters The OBD II opens up great opportunities for us to control the vehicle remotely in future work. For instance, air pollution can be preserved by controlling the combustion emissions of the car engine, or it is possible to detect car malfunctions remotely through the OBD and other cases that cannot be diagnosed through GPS. The suggested vehicle tracking system in this paper includes the following features:

- Using the GPS to determine the latitude and longitude of the vehicle's location
- Using the OBD interface to get information about the vehicle's speed, time, and other engine parameters.

- Sending the vehicle's data to the server via the GPRS module.
- text message was sent to the owner of the vehicle containing details of the volitation
- A comprehensive website and database are created to keep track of the position, speed, and management of vehicles.

In our suggested approach, the maximum speed on each road is decided based on the speed restriction established by the relevant authorities on each road, according to its classification as highways, congested routes, or secondary roads. a time limit is established before going over the speed limit for crucial circumstances. When a car goes over the speed limit, its data are automatically transferred to a server where a fee is issued. Additionally, a text message is sent to the owner of the car informing him of the infraction and the fine amount.

A-System Design

The proposed system is designed using the following hardware:

- SIM868 Module

The SIM868 GPS/GPRS/GSM module, which is available in a variety of operating frequencies and is usable everywhere, is depicted in Fig. 1. This module has voice calling and answering capabilities, a short message transmitter, and other features. It performs exceptionally well and is extremely accurate—about 5 meters of positional precision. SIM868 supports simultaneous GPRS/GSM and GPS capability. [6].

Fig. 1. SIM868 Module

- Raspberry pi (Embedded Linux Board)

As seen in Fig. 2, the Raspberry Pi is a little computer with a single board that weighs just 50g. It requires 5V, 700mA of electricity, which is less expensive than a true computer. The board comes in three models: A, B, and B+, which is a more advanced version. By attaching accessories to the board's four USB ports, such as a mouse, keyboard, and Wi-Fi adapter, you can turn it into a full-sized computer. furthermore a networking Ethernet port. The Raspberry Pi has a wide range of uses because of its various features [7].

Fig. 2. Raspberry pi B+ Board

- On-Board Diagnostics (OBD II)

This vehicle's diagnostic and reporting system is known as OBD (On-Board Diagnostics). OBD and the ECU are connected by a DLC (Data Link Connector). PID (Parameter ID) codes are used to collect vehicle sensor data [8], one of the computers found in automobiles. OBD's main advantage is that it makes it easier to diagnose faults in the systems and subsystems of automobiles. Typically, the foot well is where you'll find the OBD-II port. It is now necessary for all new cars. Figure following illustrates this, despite the fact that the specification only allows the use of 9 of the 16 OBD-II pins:

Fig. 3. On-board diagnoses of OBD II

B- System Implementation

The general scheme of the implemented system is shown in Fig. 4, so, two major design units make up the overall system:

1. In-Vehicle Unit

It will be installed inside the vehicle and is responsible of recording the speed and location of the vehicle. Also, it is in charge of gathering the necessary data and sending it to a tracking server wherever it is. To make all these functionalities possible, we did the following: In order for a GSM/GPRS module to work, it needs both a SIM card and a cellular antenna. For computer communication, the SIM868 module runs at 115200 bits per second. The envisioned system would be managed by the Raspberry pi. The Raspberry Pi board and the SIM868 module would be linked by direct communication or a USB interface, as seen in Fig. 5.

The required information may be obtained after the GPS unit, OBDII, and microcontroller have been put together. As illustrated in Fig. 6, the OBDII card is inserted into the port under the steering wheel. The GPS model employs Attention commands (AT) to detect its location and contains an antenna for receiving longitude and latitude from satellites (which must be placed in an open region).

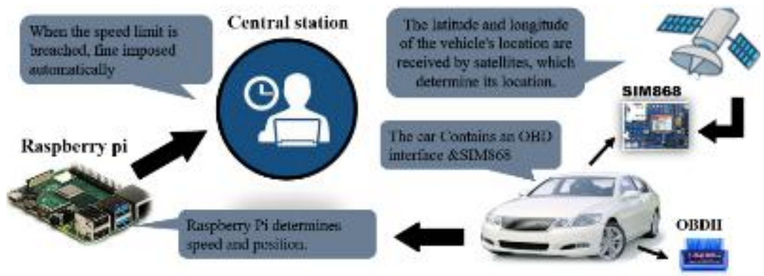


Fig. 4. Design of the project

Fig. 5. Connect raspberry pi to sim868 via direct and USB

Fig. 6. On-Board Diagnoses (OBDII)

The next step is to connect the GPRS to the network. HTTP communication normally uses a TCP/IP connection. The default port for the HTTP server is 80. If the specified speed is higher than the permitted speed when the server connection is established, the microcontroller is prepared to send the location and speed of the vehicle to the server. It's crucial to remember that the power for the SIM 868 model and the microcontroller might come from either the power bank or the built-in charging connection of the vehicle. The system chosen within the vehicle was additionally linked to the central station monitoring via an Application Programming Interface (API), a software interface that enables two programs to communicate with one another without the need for a third party (server) [9].

2. Central Monitoring Station

We employed the Django platform, which supports the Python programming language, in this project. HTML programming is used to design the front end. We used a My SQL lite database for testing, which has numerous tables connected by database relationships. Users are authenticated on the server at one of three levels: Admin (who has complete permissions), Manager (who has certain permissions), and User (who can see his data only without changing). We utilized the Python Anywhere server to put the server online; Python. Anywhere is a web hosting company that provides hosting for web applications created in Python. Python programs and web applications can be hosted on it [10] that supports web applications like Django, and finally, using API, the system designated inside the vehicle is connected to the central monitoring station (server).

III. MAKE A DECISION

After we designed the system installed inside the vehicle and implemented and tested the work of each technology, as we explained in the previous section, on the other hand, we designed a web application to follow and monitor the specific vehicle and design the databases for the server. The necessary decision about the violating vehicle is taken through the central station after sending the data of the violating vehicle. the system applies to all vehicles and in all streets, where the existing streets are determined, whether they are highways, crowded or secondary roads, as each street has a certain speed and fine. If the specified vehicle exceeds the speed limit for each street, the data of the vehicle are sent via a GPRS packet to the central station and imposed fine for that vehicle

In the first step, we will choose a specific straight street (the chosen street must be straight), in case the street is curved, a set of points is taken that is considered a segment and specify the starting point (longitude and latitude) and the endpoint (longitude and latitude) for each Street, It is worth noting that this mechanism is determined manually by the administrator. In the next step, we will create a database of segments, the database will contain several of information that is:

1-each segment will be defined with a specific ID to determine the point received located in which segment

2- also contains a starting point and end point, each consisting of X and Y since the X is the longitude and the Y is the latitude

3-the speed limit for the street

4- the fine

5- the calculated slope and shifting for each segment.

When determining the location of the vehicle, the point received from the GPS is calculated or compared, is it within the segment or outside it through the linear equation, there is three forms of the linear equation as below:

$$\boldsymbol{Y = MX + B}$$

$$\boldsymbol{AX + BY = C}$$

$$\boldsymbol{Y - Y1 = M(X - X1)}$$

M = slope

B= interception point with axis-y

A, B, C = coefficient

The slope of two point (x1, y1), (x2, y2) is:

$$\boldsymbol{M = \frac{Y2 - Y1}{X2 - X1}}$$

When determining a specific point through the GPS, it must be determined where exactly that point is located by calculating its slope of it and using it to apply the linear equation to it.in the event that the specified point is within the line segment, the product of the equation must be zero (the product is rarely equal to zero but not impossible) or close to zero, so the closest value to zero is the closest point to the straight segment.If the result of the equation is greater or less than zero, this means that the specified point belongs to the segment with which it was compared. When the vehicle exceeds a certain speed, the information about the offending vehicle (its location and speed) is sent As mentioned to the central station as a preliminary procedure to know the location of the car and whether it is within the scope of a highway, crowded or secondary road and compare the speed of the vehicle with the speed of that street, in the event that the actual speed of the vehicle is greater than the speed specified for this street, a fine is imposed automatically and Send a text message to the vehicle owner to inform him of the violation. A fine will not be recorded for the vehicle that exceeds the set speed immediately. A specific distance will be set for each street according to the speed of the vehicle on that street and based on the distance to be set, a timer will be set for overtaking by converting the distance into time through the following equation:

$$\boldsymbol{V = X/t}$$

Where:

V= velocity (speed) in meters per second

X = displacement inkilometersr per hour

T= time in second

The same scenario and calculations can be repeated after the process of imposing a fine. Another specified distance is set, but greater than the distance that was previously determined and to impose another.

IV. EXPERIMENTAL RESULT

A-GPS Calculation

In the first step, the satellites provide geographic coordinates to the GPS module. The microcontroller reads the location data of the vehicle from the GPS module as shown in Fig. 7. Where The letter A indicates that the GPS state is active to extract the longitude and latitude every 10 seconds. Then, the coordinates are projected onto Google Maps to determine the vehicle's location.

B-Speed Calculation

In the second step, Using the OBD2II WIFI, the vehicle speed is extracted periodically every 5 seconds as shown in Fig. 8

C-Connect the Microcontroller to the Internet using GPRS

After that, we connected the microcontroller to the internet via GPRS using a mobile phone sim card, as shown in Fig. 9.

D-Imposed Fine in Case of Access the Limit Speed

As illustrated in figure 10 (A,B), which displays the information for each user and the details of the violation, the vehicle speed is continuously monitored, and in the event that it exceeds the specified speed, the data of the vehicle is transferred over the GPRS to the central station to impose a fine. the system was tested on numerous streets in Baghdad seen in figure 11, where the red color denotes highway streets, the pink color denotes congested streets, and the green color denotes secondary streets, Then, in table 1, we record all system readings for each tested street, with (True) designating a violation for which a fine has been imposed. Nine overtaken locations were noted, and they are depicted in red mark on the map in Figure 12 along with a recording of the readings of the locations where violations were discovered in Table 2. Here, we note that the vehicle's actual speed is higher than the maximum speed, indicating that the decision was true. The owner should then be notified of the violation through text message via GSM, which should include the speed, location, and the amount as shown in fig. 13:

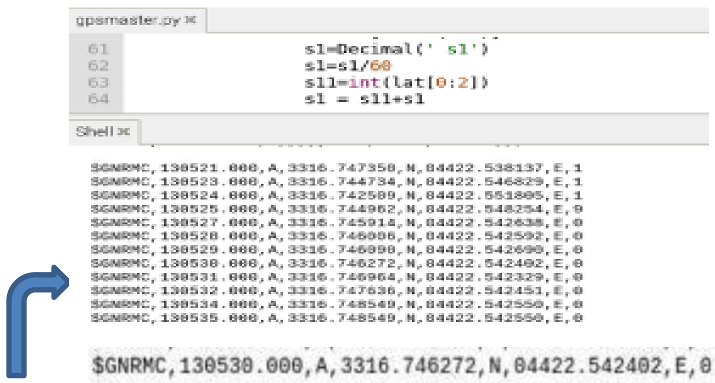
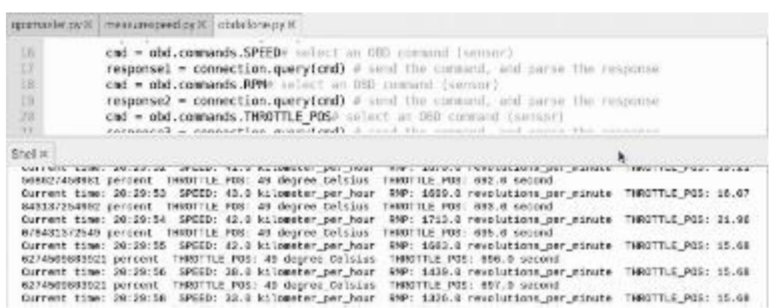


Fig. 7. A small clip of the GPS readings.

Fig. 8. A small clip for



the OBD II readings

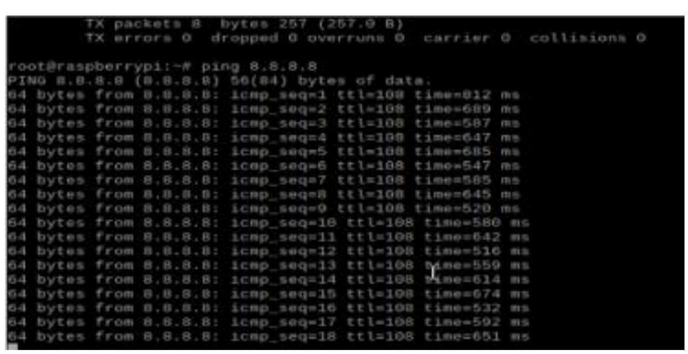


Fig. 9. Check the internet on raspberry pi

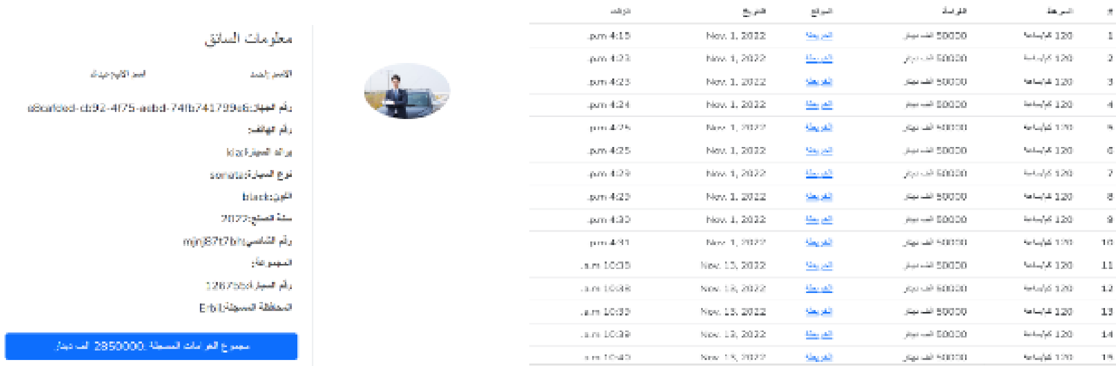


Fig. 10. A- Driver's record (the driver's information)

B- Fine imposed on the driver

Fig. 11. The street where the system tested

date	time	vehicle's number	Actual speed	Location	segment ID	maximum speed	fine	Decision
11/15/2022	26:56.8	xC105234-Baghdad-personal	5	http://www.google.com/maps/place/33.278788,44.374962	25	70	50000	False
11/15/2022	27:00.8	xC105234-Baghdad-personal	12	http://www.google.com/maps/place/33.278766,44.374510	25	70	50000	False
11/15/2022	27:04.8	xC105234-Baghdad-personal	13	http://www.google.com/maps/place/33.278760,44.374770	25	70	50000	False
11/15/2022	27:08.8	xC105234-Baghdad-personal	9	http://www.google.com/maps/place/33.278785,44.374505	25	70	50000	False
11/15/2022	27:12.8	xC105234-Baghdad-personal	17	http://www.google.com/maps/place/33.278825,44.374486	25	70	50000	False
11/15/2022	27:16.8	xC105234-Baghdad-personal	16	http://www.google.com/maps/place/33.278815,44.374175	25	70	50000	False
11/15/2022	27:20.8	xC105234-Baghdad-personal	14	http://www.google.com/maps/place/33.278788,44.37407	25	70	50000	False
11/15/2022	27:24.8	xC105234-Baghdad-personal	6	http://www.google.com/maps/place/33.278755,44.373886	25	70	50000	False
11/15/2022	27:28.8	xC105234-Baghdad-personal	8	http://www.google.com/maps/place/33.278725,44.373780	25	70	50000	False
11/15/2022	27:32.8	xC105234-Baghdad-personal	11	http://www.google.com/maps/place/33.278606,44.373784	25	70	50000	False
11/15/2022	27:36.8	xC105234-Baghdad-personal	10	http://www.google.com/maps/place/33.278540,44.373726	17	30	75000	False
11/15/2022	27:40.8	xC105234-Baghdad-personal	11	http://www.google.com/maps/place/33.278446,44.373721	17	30	75000	False
11/15/2022	27:44.7	xC105234-Baghdad-personal	8	http://www.google.com/maps/place/33.278328,44.373708	17	30	75000	False
11/15/2022	27:46.7	xC105234-Baghdad-personal	3	http://www.google.com/maps/place/33.278290,44.373692	17	30	75000	False
11/15/2022	27:49.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278215,44.373601	17	30	75000	False
11/15/2022	27:53.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373603	17	30	75000	False
11/15/2022	27:57.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373603	17	30	75000	False
11/15/2022	27:59.7	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373603	17	30	75000	False
11/15/2022	28:02.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373603	17	30	75000	False
11/15/2022	28:06.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373603	17	30	75000	False
11/15/2022	28:08.7	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373695	17	30	75000	False
11/15/2022	28:11.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.278212,44.373695	17	30	75000	False
11/15/2022	28:17.8	xC105234-Baghdad-personal	12	http://www.google.com/maps/place/33.278212,44.373694	17	30	75000	False
11/15/2022	28:22.2	xC105234-Baghdad-personal	47	http://www.google.com/maps/place/33.278248,44.373718	17	30	75000	True
11/15/2022	30:35.8	xC105234-Baghdad-personal	0	http://www.google.com/maps/place/33.277578,44.377840	25	70	50000	False
11/15/2022	30:39.8	xC105234-Baghdad-personal	6	http://www.google.com/maps/place/33.277573,44.377840	25	70	50000	False
11/15/2022	30:43.9	xC105234-Baghdad-personal	18	http://www.google.com/maps/place/33.277595,44.377837	25	70	50000	False
11/15/2022	30:47.9	xC105234-Baghdad-personal	18	http://www.google.com/maps/place/33.277756,44.377794	25	70	50000	False

Table 1. Recording the readings of the system on many streets

Fig. 12. The location of violation vehicles

date	time	vehicle's number	actual speed	location	segment ID	maximum speed	fine	Decision
11/15/2022	46:10.2	xE105234-Baghdad-personal	47	http://www.google.com/maps/place/33.278058,44.373718	17	30	75000	True
11/15/2022	51:54.6	xE105234-Baghdad-personal	45	http://www.google.com/maps/place/33.278882,44.377653	20	30	75000	True
11/15/2022	41:26.5	xE105234-Baghdad-personal	33	http://www.google.com/maps/place/33.282787,44.386931	20	30	75000	True
11/15/2022	50:03.6	xE105234-Baghdad-personal	71	http://www.google.com/maps/place/33.289389,44.310890	32	70	50000	True
11/15/2022	51:10.5	xE105234-Baghdad-personal	71	http://www.google.com/maps/place/33.293995,44.308605	40	70	50000	True
11/15/2022	54:47.6	xE105234-Baghdad-personal	68	http://www.google.com/maps/place/33.309999,44.302966	28	50	25000	True
11/15/2022	55:50.2	xE105234-Baghdad-personal	77	http://www.google.com/maps/place/33.325350,44.300740	41	70	50000	True
11/15/2022	57:33.1	xE105234-Baghdad-personal	62	http://www.google.com/maps/place/33.327676,44.226266	36	50	25000	True
11/15/2022	02:17.6	xE105234-Baghdad-personal	52	http://www.google.com/maps/place/33.333982,44.285518	35	50	25000	True
11/15/2022	05:44.5	xE105234-Baghdad-personal	56	http://www.google.com/maps/place/33.350265,44.278830	35	50	25000	True
11/15/2022	02:17.6	xE105234-Baghdad-personal	52	http://www.google.com/maps/place/33.333982,44.285518	35	50	25000	True
11/15/2022	05:44.5	xE105234-Baghdad-personal	56	http://www.google.com/maps/place/33.350265,44.278830	35	50	25000	True

Table 2. Recording the readings of the system in the places where a violation was detected

Fig. 13. The text message that has been sent to the owner of the vehicle

V. CONCLUSION

In this study, we developed and evaluated a system for tracking moving automobiles' precise locations. We used a device installed inside the car and an online website (server) to track the car's location and speed. In terms of the central station, it was created using the Python-supporting Django platform and connected to a database to store the speed and position data coming from the device within the car in case it went faster than was allowed. A GPRS packet is delivered to the server, where the fine ticket is automatically registered, along with the vehicle's speed, position, time, and date. The system, which is also inexpensive and depends on widely accessible gadgets, has demonstrated its effectiveness in experimental vehicle tracking at any time or location. In order to improve human road safety, the proposed system seeks to achieve its aims by reducing traffic accidents, which will also reduce the expenses and the number of fatalities they result in.

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