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Smart Traffic Light Control System for Emergency Ambulance

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***Abstract*-In emergency system, the transfer of patients to the hospital should be in fast and save manner to increase the rescue and survival rates. Thus, the ambulances take the short and safe way to the emergency department at a hospital. To satisfy this, this paper tackles the problem of road jamming by controlling the underlying traffic lights and selecting the optimal path depending on crowed sensor readings. The proposed system includes two main parts; data center and ambulance. The data center collects the information regarding the location of patients and hospital as well as the current location of an ambulance and crowd sensor readings fixed on the roads. This is to implement the proposed algorithm that guides the ambulance to the optimal path in which the patient can be delivered to the emergency department safely and shortly. Moreover, this algorithm sends signals to the considered traffic light to be green in front of ambulance arriving. In the ambulance side, the location has been sent to the data center using Arduino, Global Position System (GPS) shield and Global System Mobile (GSM) shields fixed on the ambulance. In addition, the ambulance is provided with navigation screen to guide the driver using the best path. All the traffic data and locations of patients and ambulances are stored in a database at the server of datacenter for more reporting and actions. Different software has been used, such as PhP, SQL server, C#, Arduino and Google maps. The obtained results satisfy the expected objectives of the proposed system.**

***Keyword*-GPS Arduino shield, GSM Arduino shield, SQL server, PHP.**

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I. Introduction

It is well known that the increasing of car numbers in big cities arises a real problem of traffic congestion. Different research papers have been introduced to solve this problem, although people is still suffering. The congestion traffic between the position of patient and hospital becomes case of delivering. Thus, the need of a system to reduce life loosing, and delivering delay has been required necessarily [1]. The system controls the traffic lights using wireless communication system and selects short path with less congestion. All that to reduce the time taken by ambulance to deliverthe patient to the hospital in optimal time.

Numerous technologies can be utilized to cover the hardware requirements of the automatic control system, such as Arduino and related shields as well as other embedded systems. Moreover, wireless communication systems have been employed to send and receive data between the terminals. The most common used communication system is GSM. This is due to low cost and availability around the covered area in addition to reliability[1, 2].

In terms of data centers, the different software and algorithms have been implemented to reach the target of ambulance movement control systems. Moreover, special specifications are selected to the servers to overcome the problem of data storing and processing speed [3].

The database is used to store the information as well as producing a number of reports as requested by mangers. It is important to note that all the applications are built as a webpage based to be more global and easy in access from different places [1].

In the proposed system, the ambulances are monitored, tracked and guided by implemented algorithms at the data center. In addition, this algorithm selects the optimal path for an ambulance depending on crowed sensor readings fixed on the roads to offer the shortest and safe way to deliver the patient to the emergency department. The investigated system consists of two main parts, which are data center and ambulance. The

job of data center is explained above, while the ambulance includes the hardware equipment. It uses the microcontroller of Arduino added to GPS and GSM shields. The GPS shield is used to obtain the current location of ambulance, whilst the GSM shield is utilized to transfer the GPS readings the data center for processing and decision. Numerous software environments have been utilized and web based databaseis built. The achieved results show a superior performance of the proposed system in terms of accuracy and reliability [4].

II. Related works

As mentioned above, recently numerous researchers considered the problem of traffic congestion and finding the solution for them. It is important to note that the proposed system motivates from previous work explained below in application of ambulance, the utilized technologies, data center and database, tracking facility, controlling the underlying traffic lights and navigation system.

In [2], the authors designed a system to monitor the current location of an ambulance in the way of getting a patient to be delivered to hospital using google map. This was done by sending a sms that contains the location of ambulance to emergency department necessary preparations.

In [3], another tracking ambulance system has been introduced. It tracked the ambulance by sending the current location to the local system using GPS signals obtained from mobile phone application.

In[4], the authors proposed a system to handle three problems of congestion control, stolen vehicle detection and changing the green traffic light to emergency vehicle. Different hardware components were used, such as ZigBee, RFID in each vehicle. When emergency vehicle wasbeing at the traffic junction the ZigBee transmitter module in vehicle sends a signal to the ZigBee receiver in traffic to change the traffic light to green. In addition the RFID is used to detect stolen vehicle.

III. System design

Figure (1) shows the architecture of the proposed system design. The embedded system fixed in ambulance contains Arduino uno as a microcontroller, GPS Arduino shield to get latitude and longitude (GPS signals) for tracking the ambulance and GSM Arduino shield to send location for ambulance to data center. The database, which is web based one, is built to store the information of ambulances' trips and crowd sensor readings. It is important to note that the data center includes the database, administration computer and server. In this center, the control algorithm of changing the traffic lights is implemented as well as the map tracking and monitoring of an ambulance. The data center is responsible on sending the map and optimal path for navigation the ambulance driver using a screen. Moreover, it sends the changing signals to the traffic lights when an ambulance being close to the underlying traffic junction. The information of patient's location, names and essential information is sent to the data center from the emergency department after registering an emergency case required sending an ambulance.

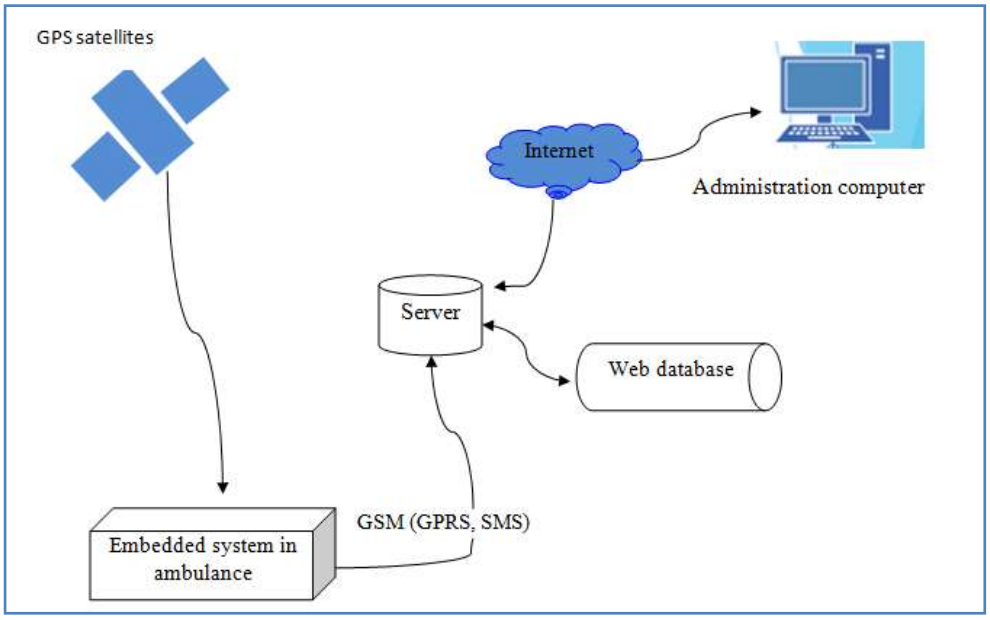

Fig. 1.System design architecture.

The specifications of the component used in this project can be summarized as :

A. Arduino UNO Board:

In this paper, we use Arduino uno shown in figure (2) as a microcontroller due to its high flexibility in using additional shields, such as GSM and GPS[5]. This can provide us with easy connection to other electronic devices and using of GSM internet services.

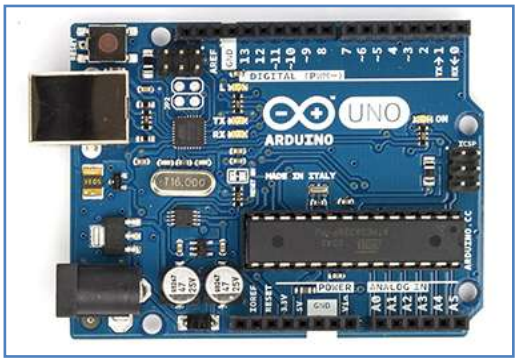

Fig. 2 Arduino UNO Board

B. Arduino GPS Shield:

The second component used in this work is Arduino GPS Shield space-based satellite navigation system as shown in figure(3). It provides the location and many information in different conditions for different applications, such as humans and vehicles [6].

Fig. 3.Arduino GPS Shield

C. Arduino GSM Shield:

Arduino GSM shield is a type of shields that offers a connection to the internet and sending SMS messages to the included SIM card. It is easy to insert to the Arduino to get the services as shown in figure (4) [6].

Fig. 4.Arduino GSM Shield.

IV. Proposed System

As mentioned earlier, the proposed system consists of two parts; Ambulance (hardware) and data center (software). The hardware part includes Arduino, GPS and GSM Arduino shields, and they are placed in the ambulance. This part starts in collecting the GPS signals and sending them to the data center using GSM network. In terms of data center, the software environments are used to build a database for data storing and implementing the proposed traffic light control algorithm in addition to ambulance tracking and monitoring as well as guiding the ambulance drive to the selected best way. In order to explain in more details, the parts can be illustrated as:

A. Ambulance (Hardware) Part:

Figure (5) explains the utilized hardware components (Arduino uno, GSM Arduino shield, and GPS Arduino shield. GPS shield is connected to the Arduino and GSM shield using pins of 0 and 1. It is important to note that the GPS antenna is important part that should be long enough to be fitted outside the ambulance with reasonable amplification units. The collected GPS signals is sent to the data center web page, which is an intermediate media before saving them in the server using GSM network passing through Arduino

Fig. 5.Hardware of the proposed system.

B. Software part:

Due to the important of this part, it can be divided into the following:

1. Traffic Light Control Algorithm:

The proposed traffic light control algorithm is shown in Figure (6) as a flow chart. The first stage is the requesting of monitoring page from the emergency department to know the address of patient and hospital. The second stage is checking the sent latitude and longitude of both patients and ambulance with the database of around addresses of the considered area. If

there is no match then the algorithm is ended and message sent back with negative acknowledgement. Otherwise, the algorithm checks the received real-time latitude and longitude of current location of ambulance while driving if being near the underlying traffic lights. A table is saved in the database regarding the values of (x2 and y2) represented the latitude and longitude of nearby traffic lights of the considered area. The last stage of the proposed algorithm is sending the changing signals to the traffic lights to green and waiting for a while to be return to normal performance situation.

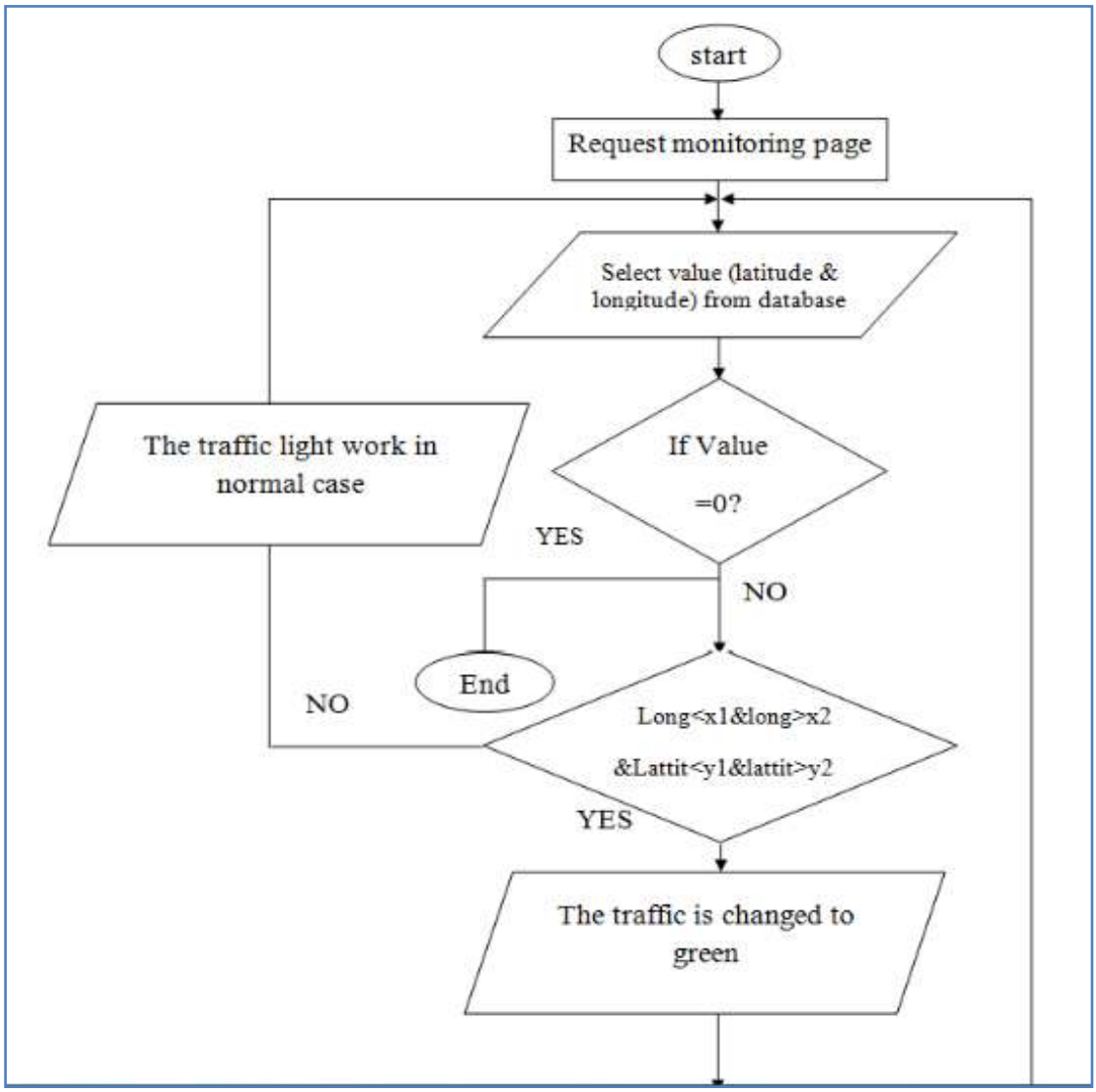

Fig.6 Flowchart of the traffic light control algorithm.

2. Data base building:

Figure (8) shows the second table that includes latitude and longitude of the address of the considered area. This includes the houses and known places, such as schools and markets. It is important to note that this table is associated with a table of "Misplaced" to obtain the latitude and longitude of the desired address. This table is called "Address", which contains four columns that are: id, latitude (latit), longitude (log) and addresses (alladdress). The proposed system matches the given address of the patient with the address of table "Address" to provide the latitude and longitude of such address.

The third table, shown in Figure (9), is used to store the current location of ambulance, received from the hardware part at ambulance. This table is called "FromGPS". Moreover, this table can store the data of numerous ambulances and includes seven columns that are: id, journey number (journey), latitude (latit), longitude (log), ambulance number (numberamb), current time (time), am or pm, and date.

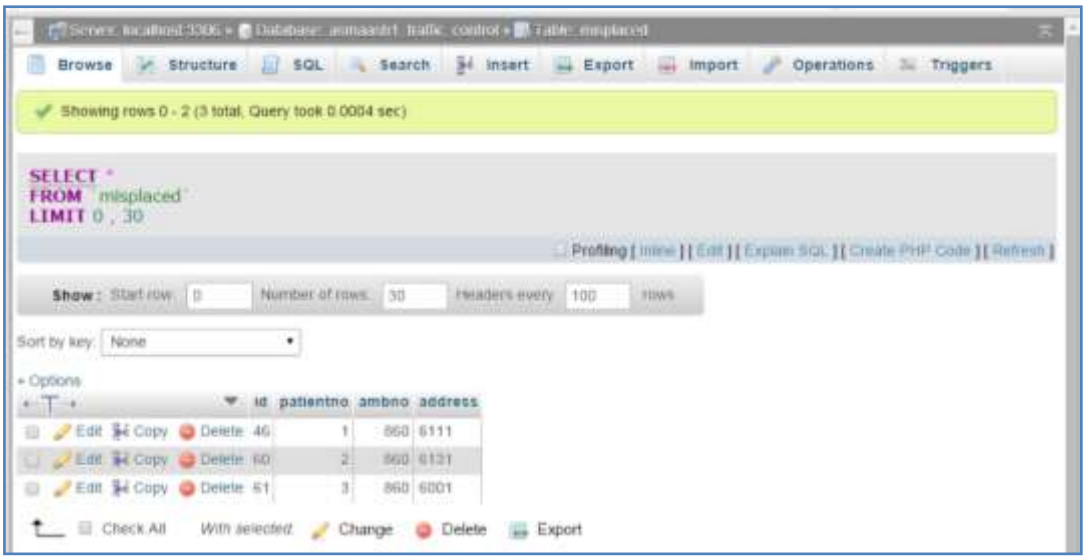

Fig.7.Misplaced table.

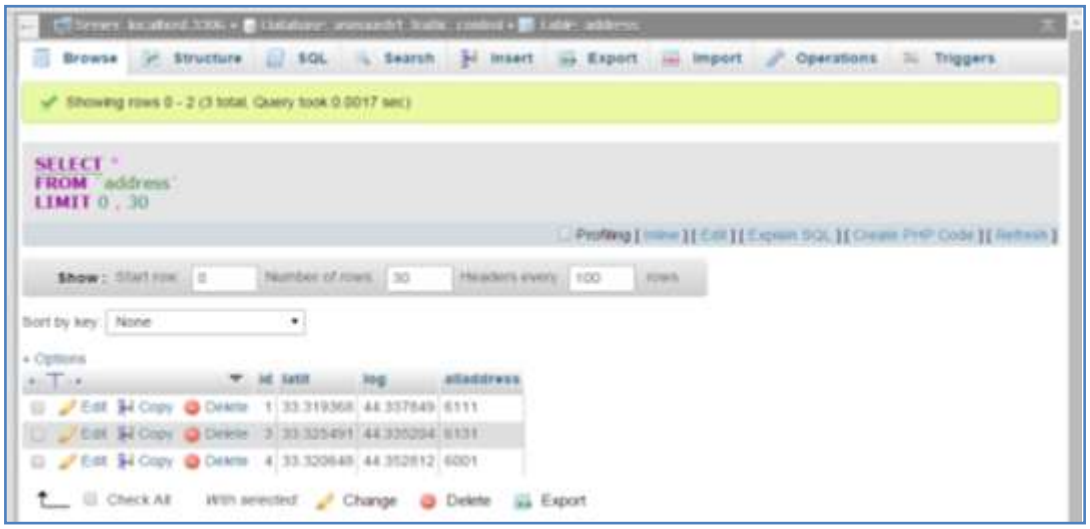

Fig.8.Address table.

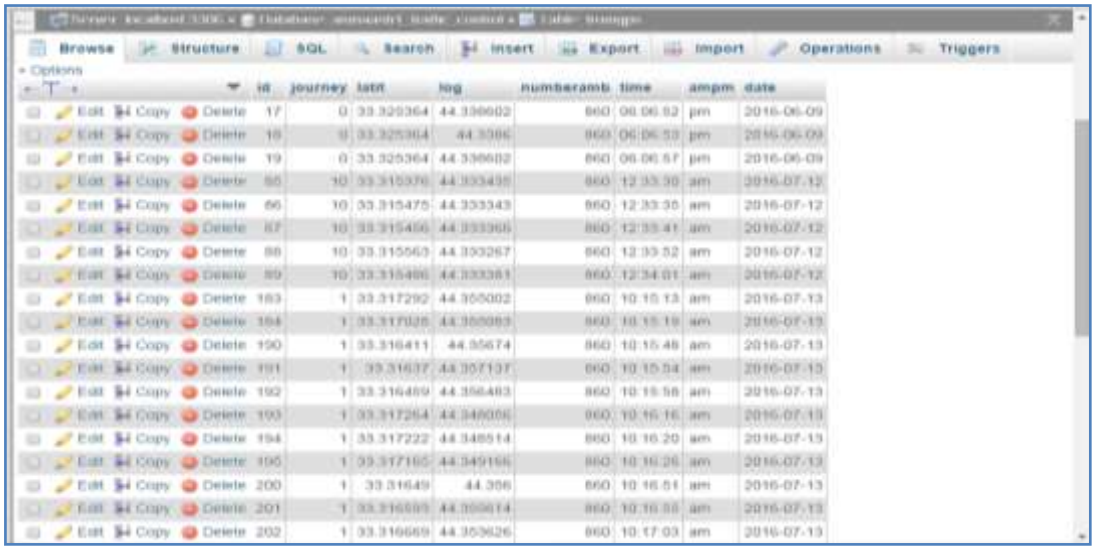

Fig.9.FromGPS table.

The last table, shown in Figure (10),is used for storing the information of available street that has been considered. This information represents the names, direction id and current crowd sensor readings. These street represent the link between the considered hospital and patients' addresses. This table is called "Way". The "Way" includes five columns that are: id, number, name, crowd sensor readings (infofromsensor), and direction (dir).

3. Web Page Design:

It is important to design different webpages for performing and arranging in addition to showing the interfaces, actions and monitoring of ambulances considered in this system. The first page is inserting the patient's information and managed by emergency department. These information is sent to the data center to send ambulance to the address. The second page is used to show the driving way to the ambulance's driver. The last page is the tracking and monitoring that shows the movement of ambulance across the roads from hospital to patients and opposite directions. The above three pages is shown in the results section to be taken as a real case study with full of results.

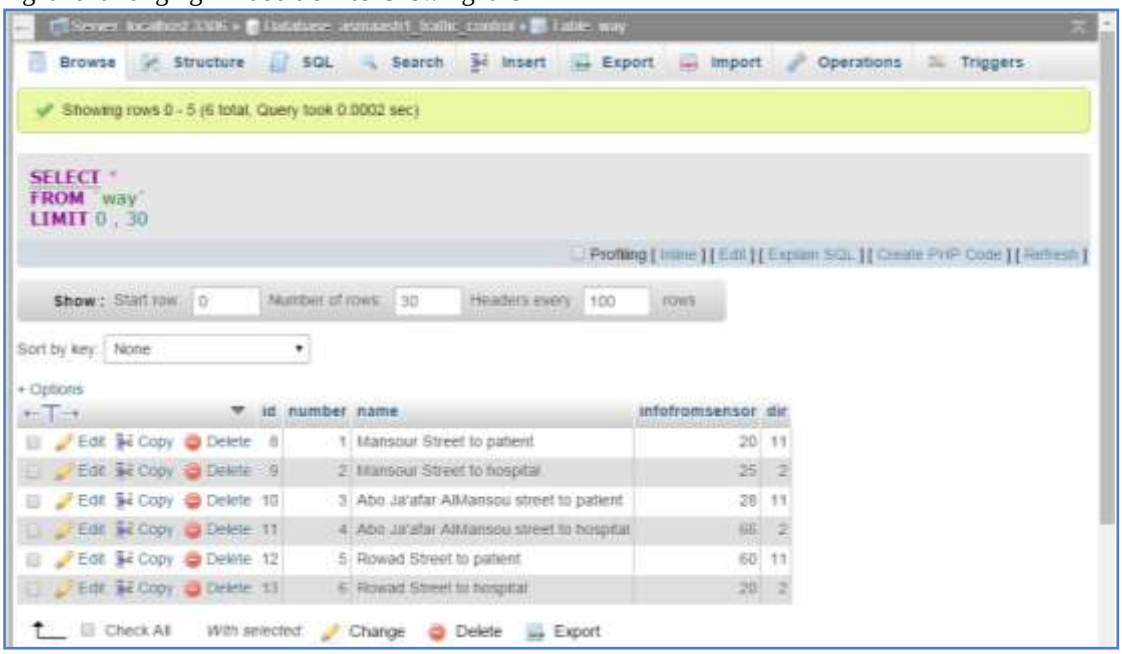

Fig.10Way table.

V. Results

In order to test the proposed system, Al-Mansour area in Baghdad has been taken as a prototype. The Red Cross hospital in the same area is also considered as the emergency department. The case study of a patient requests an ambulance located near Al Sa'aa restaurant. The crowed sensor readings are assumed to be known by data center. With the above setting up of prototype, a real-time experiment is performed.

The first page, shown in Figure (11), inserts the patient's information to table "Misplaced". This page is requested by emergency department or patients to order an ambulance. Then these information is sent to the server of data center for processing the order. The ambulance number and patient number is chosen by system depending on availability and unique number. After the insertion, "Save" button is pressed.

The second page, shown in figure (12), is requested by ambulance driver that provides him with the patient's address and the roads that can be selected to reach him/her. An advice is delivered to the driver by the data center to choose the best way depending on the crowd sensor readings of each road.

Fig.11 Page one, inserting a patient's information to a misplaced table.

Now, the driver is free to select the going way to the patient and pressing the button of "Submit". The choosing of the best ways can reduce the delivering time and can save more cost and patients' life. We can see a list of roads at the right side of page to explain the roads that can be selected to reach the destination.

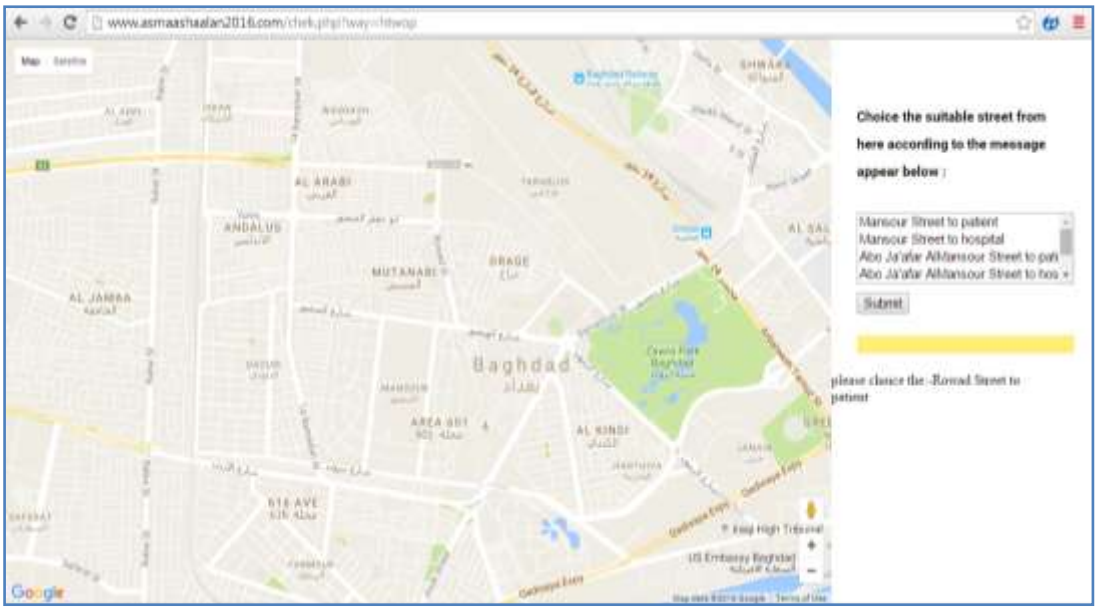

Fig.12.Page two, showing the possible routes.

Figure (13) shows the page after submitting the selected road. It can be seen that the patient's address is labeled in red mark and the hospital in green mark as a destination and source sequentially. On the right side, it is explained that the road number three is chosen, while full road information is appeared down with yellow background.

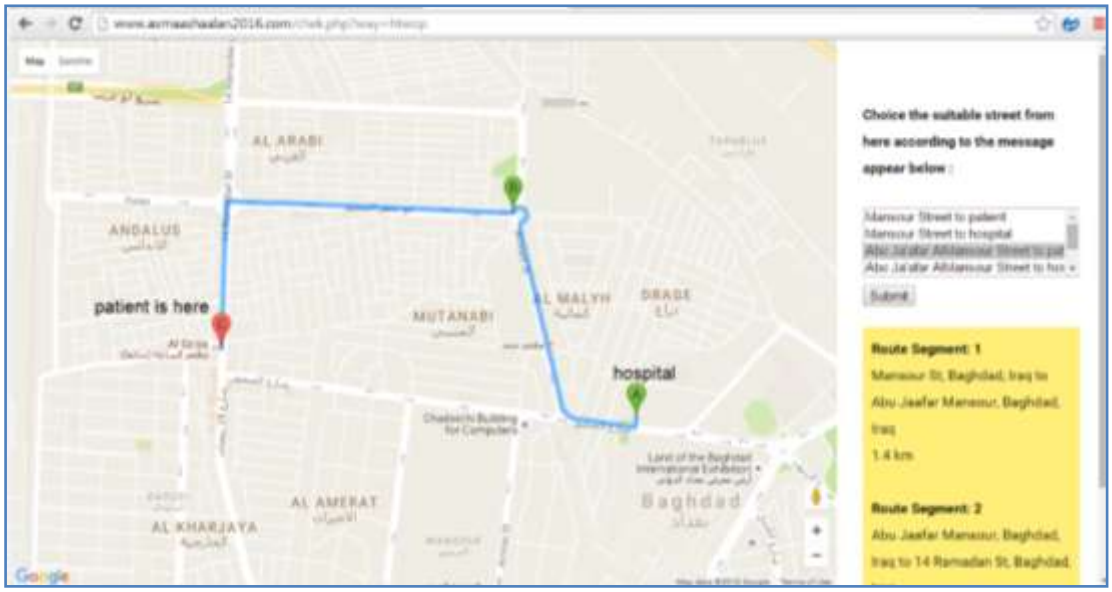

Fig.13.Page to show the information of the selected road.

In figure (14), the way back to the hospital is shown. Here, another road is selected just to show the flexibility of the system and depending on the data center's advice. It is noted that the same information of the selected road is appeared. In addition, the patient's location is labeled with green and the hospital in red as a source and destination sequentially.

The last page, shown in Figure (15), is used for monitoring and tracking ambulance as well as manual changing of best road. This page shows the related information about the ambulance's journey at the right side. At the top of page, the monitor can choose the journey number or ambulance number to show its information. In addition at the top of page, the monitor can change the chosen road manually, in case of necessary action. This figure represent a real-time experiment done at Al-Mansour area and the red labels represent the movement of ambulance with the time of driving. Figure (15) also shows the note mark of changing the traffic light to green when the ambulance being across one of the considered latitude and longitude (x2 and y2 values) illustrated in Table 1.

Figure (16) shows the return of the underlying traffic light to normal case after passing an ambulance the junction as shown in the red labels.

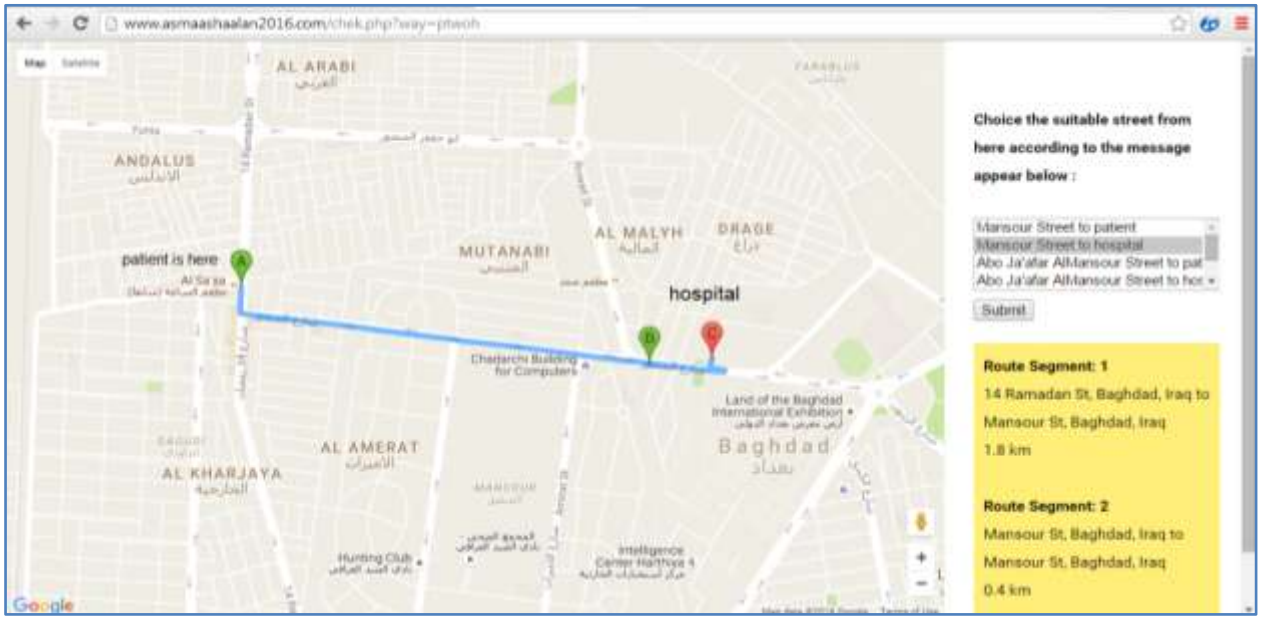

Fig.14.Page to show the information of the way back road.

Table .1 Static values for latitude and longitude.

	Y	Latitude	X	Longitude
Point one	y1	33.325286	x1	44.341064
Point two	y2	33.325201	x1	44.341064
Point three	y1	33.325286	x2	44.340400
Point four	y2	33.325201	x2	44.340400

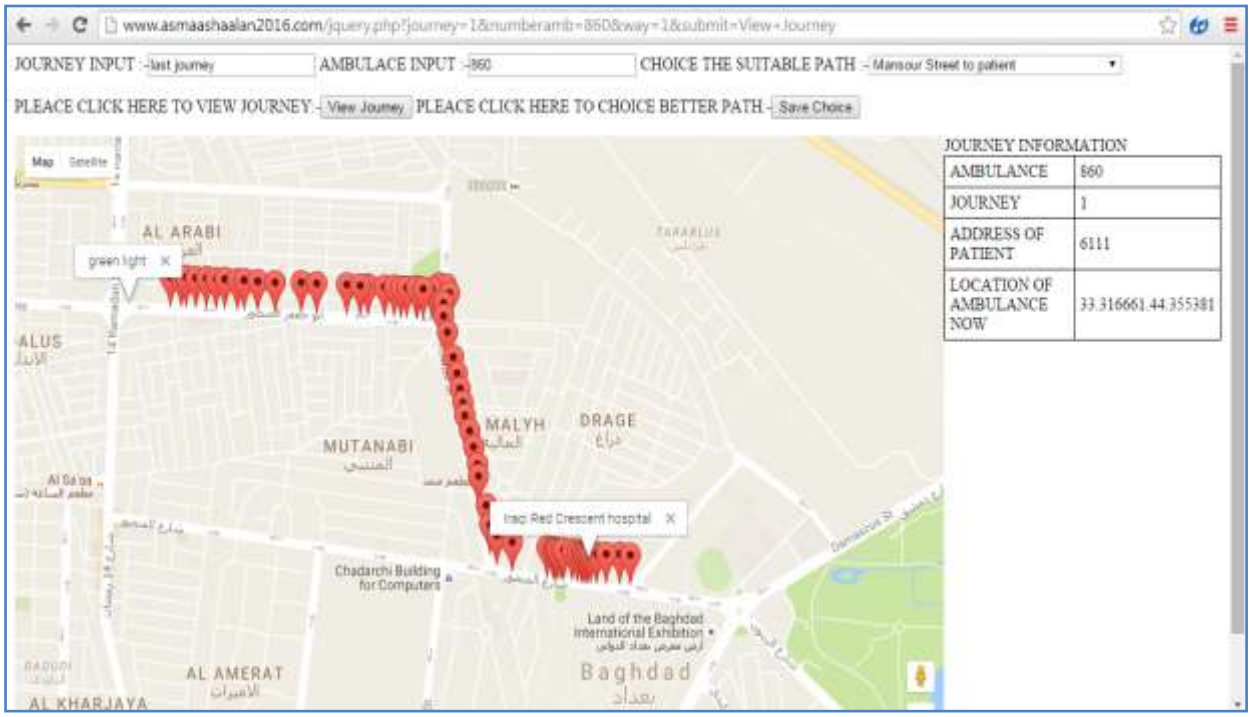

Fig.15.The monitoring page at data center.

Fig.16 .The return to normal case of traffic light.

VI. Conclusion

Ambulance traffic light control system with optimal selecting of the path was presented. In addition, a complete navigation system to the ambulance was provided. The proposed system included two parts; ambulance and data center. The ambulance contained the hardware unit that collected the GPS signals and then sent them to the webpage of the datacenter in which they saved in database later. The data center implemented the changing of traffic light control algorithm that gives green signal when the ambulance being nearby. Additionally, the selecting of optimal path from patient to hospital locations and in the opposite direction has been performed at the data center depending on the crowd sensor readings fixed at the roads. Different software environments have been utilized, such as PhP, SQL server and C#. The proposed system was tested in real-time experiment in Al-Mansour area. The obtained results showed a high performance in terms of accuracy and reliability.

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