Health Monitoring System for Ambulance Emergency System using Wireless Sensor Network

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ABSTRACT

The health sensor is one of the technologies of the Wireless Sensor Network for Medical (WSNFM), which has a wide range of sensors that can be used to check a person's health data. In this work, a health sensor system is used to monitor a patient inside the ambulance along the way to the emergency department at a hospital. The system sends the vital readings to the emergency department using web based application and then save them in the server database. Two main types of sensors are used which are: body temperature and pulse rate sensors. The proposed system includes three main parts: hardware components at the ambulance, website, and SQL server at the hospital. The website is designed using ASP.net and PHP environments, while the database at the hospital is built utilizing SQL server 2012 in addition to visual studio C# for graphical User Interfacing (GUI). Simply, the readings of sensors are transferred from the ambulance using the internet throughout a website to the SQL server at hospital. The achieved results show a superior performance of the presented system in obtaining the designed target as well as high accuracy and efficiency.

Keywords: WSNFM, GSM Arduino shield, temperature, pulse rate, SQL server, PHP, C#.

INTRODUCTION

Recently, the electronic health applications are getting acceptance due to their reduction of caring expenses. Since ten years ago, both wired and wireless networking systems had been attempting to unify, provide efficient and dependable services to healthcare procedures [1,2]. In [3,4] is presents precise improvement for applying Wireless Local Area Network (WLAN). The monitoring of patients is not enough anymore, therefore it is important to take further actions to save life of them [5]. In the modern health monitoring schemes, the sensors' readings can be transferred through wireless technologies and categories. The development in different underlying technologies can provide efficient characteristics of speed and cost [6], in which the progress in development is rapidly increased [7].

There are different motivations to do research in this field. These motivations can be summarized as:

- Improve the life style for people.
- Providing efficient healthcare services remotely in ambulance, in which it continuously monitors and sends the vital information to the concerned hospital.
- Providing an efficient network algorithm.
- Programming web page and system in emergency departments for information accessing.
- Introducing notifications to doctors.
- Low cost, privacy and availability.
- Getting fast and precise medical support and information.

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- To digitize the system.
- Improve fast support for emergency situations.
- Secure system and taking into account privacy of patients.

Throughout this project, a system that encompasses all of the above techniques with new contributions is proposed. The ambulance unit measures the temperature, pulse rate of the patient and sends to the nearest hospital through GSM technology. The readings of sensors are sent firstly from ambulance to the web page and then such readings send to the server at hospital emergency department. This is to provide the emergency staff to prepare the required doctors and tools that can save the life of a patient.

Related works

A system in [8] proposed a designed medical monitoring system based on Zigbee technology. The proposed system could detect real-time body temperature, heart rate and other physiological information of the patient. These information were transmitted to a coordinator and then to a surveillance center through wireless network. The results proved that the error in body temperature, heart rate, and other information was very slight, which satisfies practical usage, and meets the demand of the design. In [9], the pulse rate and patient temperature are monitored along the way to the hospital. Another system represented in [10] consists of data communication networks, remote server, management/monitoring units, mobile care unit, monitoring of the biomedical signals from multiple patients. In [11], the authors provided a health monitoring of patients, suffered from high risk of distinct diseases. Thus, it deals with patients who should be permanently supervised. It is noted that the recent advances in computing technologies wireless communications have provided the flexibility of offering health monitoring.

System design

Figure (1) shows the proposed emergency health monitoring system design architecture. As mentioned earlier, the health devices contain a temperature and pulse rate sensors that read the living conditions through a patient's body in ambulance. The health data is collected and controlled using Arduino and in turns it sent by GSM Arduino Shield from ambulance to website. At the website, these data is stored in database server. Furthermore, the results from the web database can be viewed via a website in the form of a report in hospital and sent to the SQL server at the emergency department in a hospital.

The specifications of the hardware and software used in this work can be summarized as:

Arduino UNO Board:

The Arduino is a type of microcontrollers with known properties. Different accessories have been provided to the Arduino to be connected to a computer via USB port. The Arduino enables electronic process in multi-disciplinary projects to be more accessible. The companies introduce numerous shields that are connected to the Arduino to ease the interfacing. These shields have the ability of interfacing with other Arduinos and electronic devices as shown in Figure (2.A) [12].

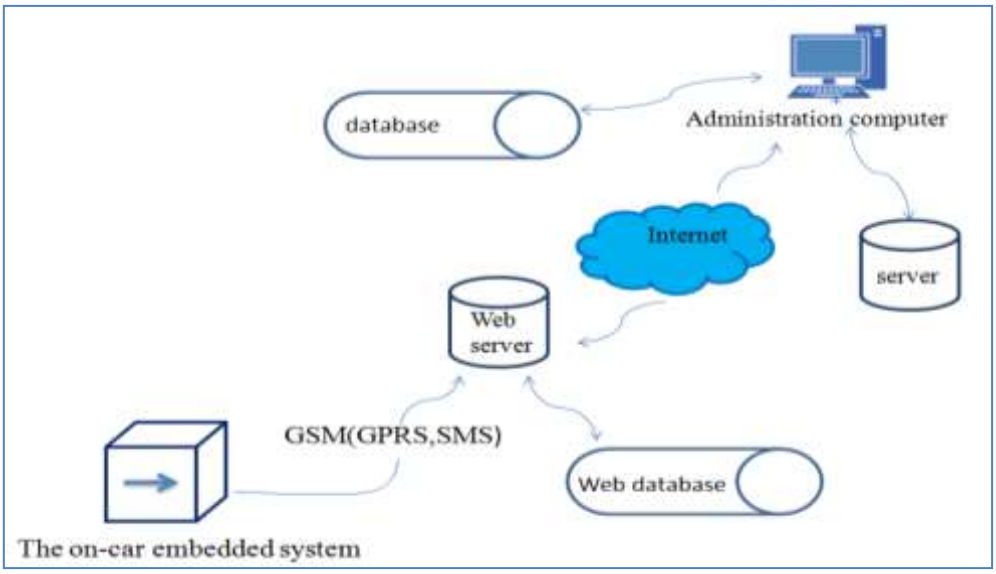
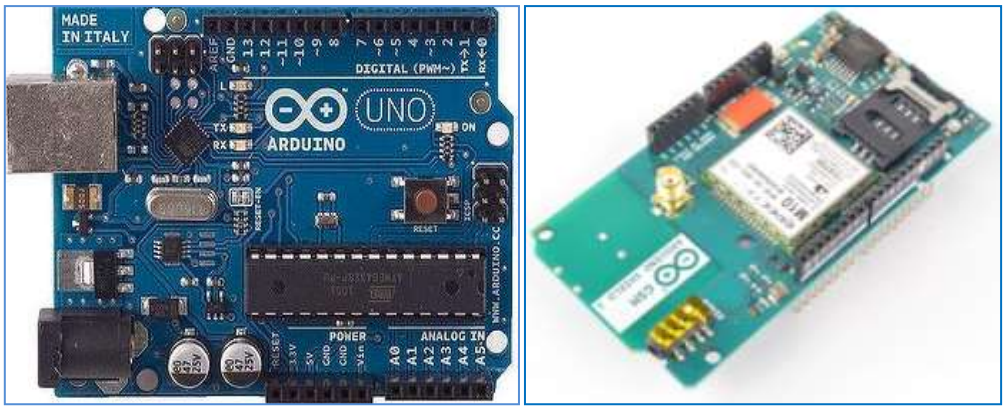


Figure (1) System design architecture

Arduino GSM Shield*:*

The shield of Arduino GSM can provide mobile phone calls in addition to sending SMS messages and getting the GPS signals. It is installed to the Arduino and the selected mobile network SIM card is inserted to the shield to get the mentioned services as shown in Figure (2.B) [12].



A. Arduino. **B. Arduino GSM Shield.**

Figure (2) Hardware Components [12]

Pulse rate Sensor:

Pulse Sensor is a heart-rate sensor for Arduino. It can be used by different users depending on the applications with numerous levels. The sensor is clipped to the patient's finger and plugged to the Arduino. It also provided a graph in time domain to simulate the pulse as shown in Figure (3) [13].

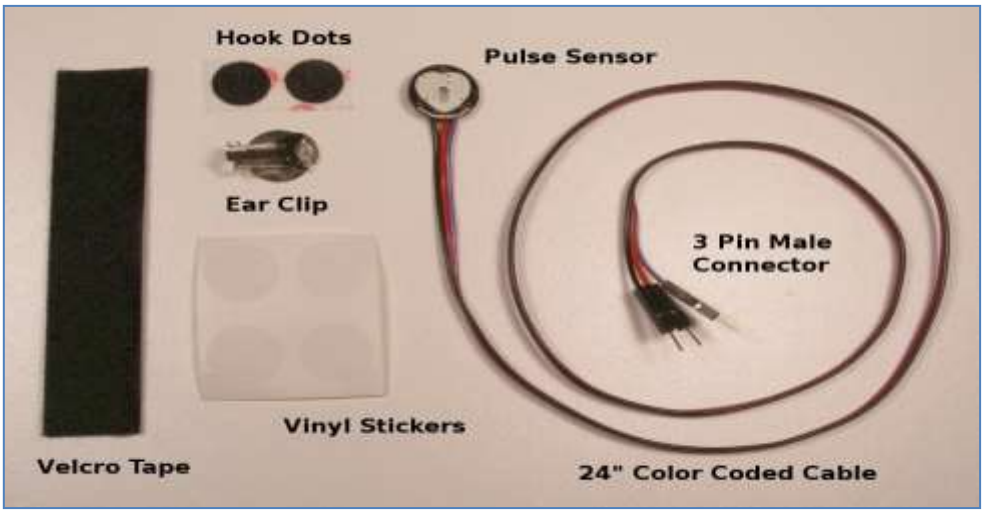


Figure (3) The Pulse rate sensor.

Temperature Sensor:

In Figure (4), The LM35 is temperature sensor that can transform the heat to electrical signals and digital readings [14]. The output voltage is normalized depending on the applications using specific equations.

Figure (4) the temperature sensor.

Database Building

Recently, An open-source relational database management system called Microsoft SQL server (MSSQL) represents a vital rule among all the databases in the world by performance, maintain security and compliance, and optimize your data platform infrastructure [15], [16]. In this paper, we build a database utilizing SQL Server Management Studio. SQL Server represent as a graphical management tool which is easy to using and dealing with it [17]-[19]. The underlying database, called "***sensors***", has been built in local SQL server that contains one table structure, for the patient information called "***PatientInfo***" .The "***PatientInfo***" includes 9 columns as shown in Figure (5).

Another database called "***asmaasha_patient***" built in remote server called "***XAMPP"***, includes one table structure called "***from sensor***" for saving data, obtained from health sensor through GSM Arduino shield. The table of "***from sensor***" includes 6 columns that are: ***id***, which is represented a patient number in this table. Each row with the same ***id*** represents new reading

arrived from health sensor placed in ambulance for same patient. For example a patient with number of 33 in ambulance has two readings of pulse rate and two readings of temperature as shown in Figure (6).

Figure (5) PatientInfo table

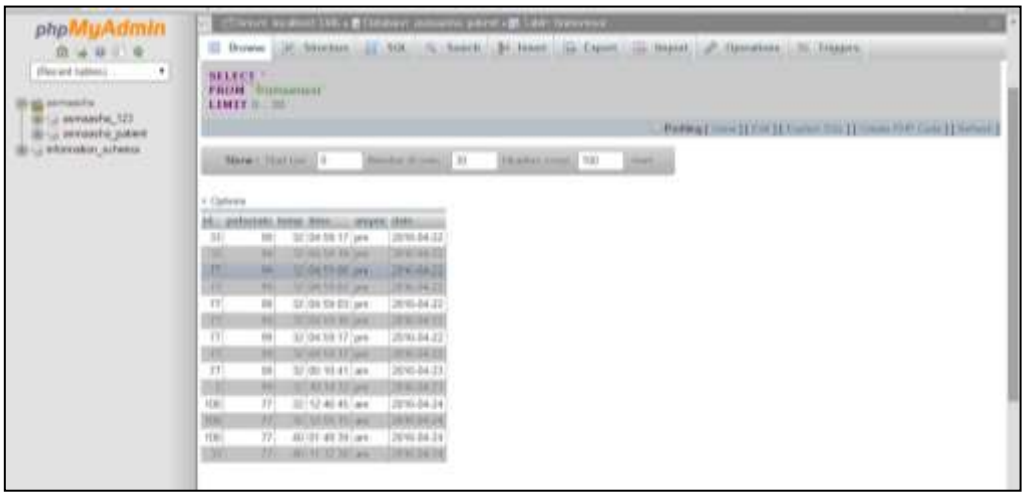


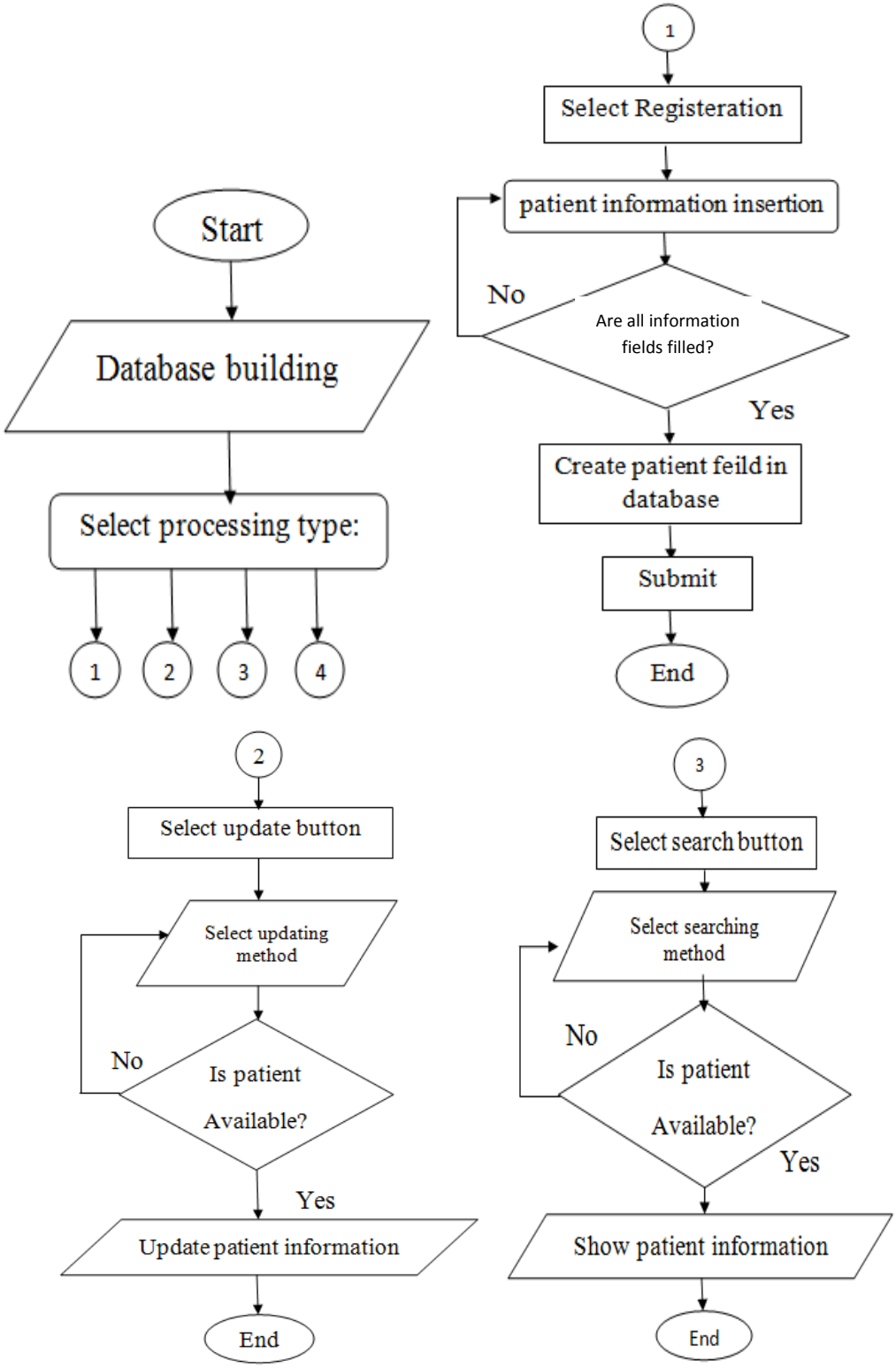
Figure (6) Sensor table

Proposed Algorithm

The proposed algorithm composes of four main processes which were explained in the Figure (7) as a flowchart. These processes are: registration, updating, searching and request ambulance where each one is clearly explained as:

- Registration: This process is used to insert a new record to the ***PatientInfo*** tables.
- Updating: This process is done on the records that were already included in the database. To find the required record, a patient ***id*** or ***patientname*** of the required record can be used. This process can easily update any field of the whole profile.
- Searching: Here, inspection of a desired record can be performed by the searching process. As the updating process, a patient ***id*** or ***patientname*** of the required record can be used to search for that record.

- Ambulance: Can request any ambulance and insert a patient number to the database (from sensor) in remote server through a web page in website. Then, data from sensor is viewed using another web page.



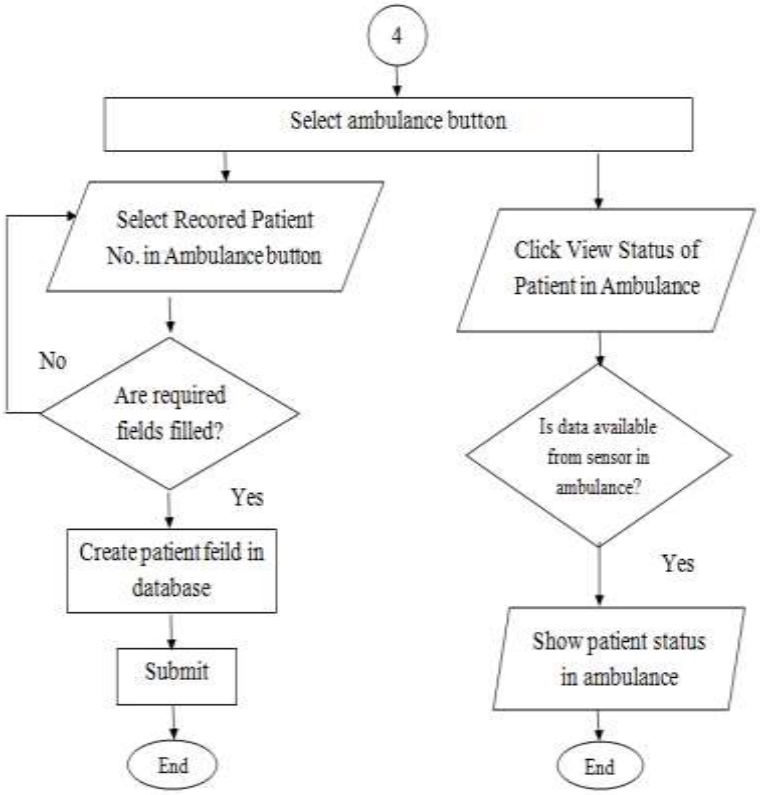


Figure (7) Flowchart of the proposed algorithm

GUI Design

Visual Studio (VS) C# environment is utilized to design and implement the GUI of the proposed system. Using the VS C# as a designer application, easy dealing with the designed forms is guaranteed without requirements of skilled users. Figure (8) shows the system home page which involves four main buttons: Registration, Update, Search and Ambulance.

Figure(8) Home page of system.

When the user click on the "***Registration***" button, the personal information fields will appear. Here, the user can fill the fields before clicking on "***Save***" button as shown in Figure (9). This information is saved as record in the Patient Info table.

Figure(9) New Record Insertion.

The update process is achieved when the user click on the "***Update"*** button. The user can utilize the ID or NAME to obtain the required information that wants to be updated. The outcome of this process is the possibility of the user to update any field of the earned record in an easily series. Figure (10) shows the chosen profile based on its ID to updating it.

Figure (10) Patient information updating

At the same manner, searching process was done by clicking the user on the "***Search***" button as shown in Figure (11). The obtained information is shown by doctor.

Figure (11) Search for any patient information

It is important to talk about main process in the proposed system which is the patient status in ambulance that contains three links. These links are: To Record Patient No. in Ambulance, View Status of Patient in Ambulance and Search for Any Patient as shown in figure (12). This page is connected to the designed website at the "***XAMPP***" remote server to save and view patient status in ambulance.

Figure(12) Home page of Ambulance.

Figure (13) show the website page that shows the saving of patient number in ambulance. This is to recognize the received readings from different ambulances at a time.

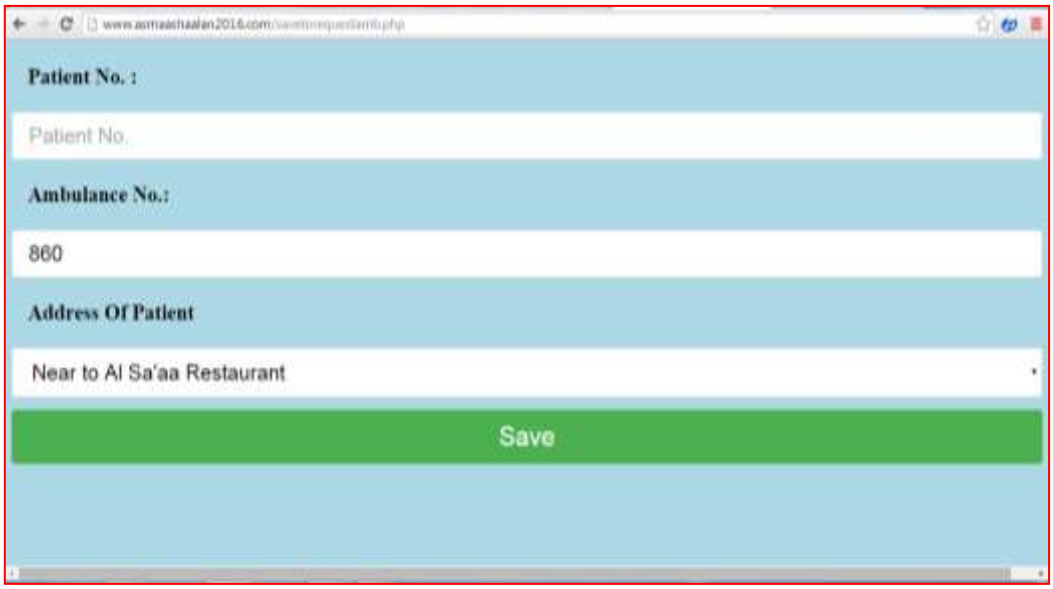


Figure (13) Insert patient number to an ambulance

The link of ***To View Status of Patient in Ambulance*** is shown in figure (12) views the status of the underlying patient with a unique number in an ambulance as shown in figure (14). It is important to note that this page refresh itself automatically each 5 seconds.

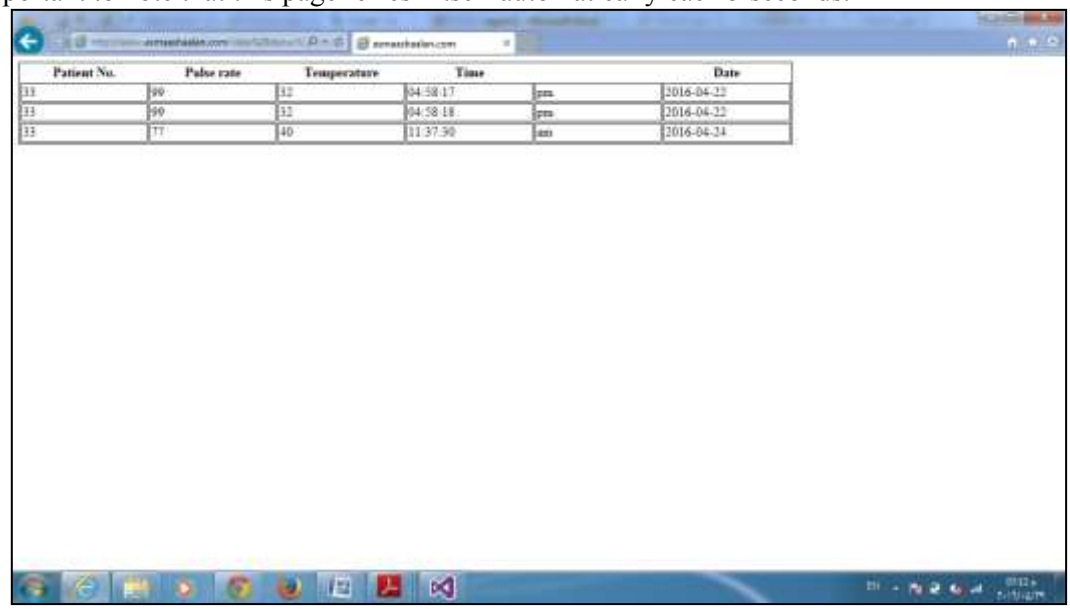


Figure (14) View Status of Patient in Ambulance

In order to offer a searching option for doctors to a specific patient, they can enter the patient name or number as shown in Figure (15) and the outcome result is shown in Figure (16).

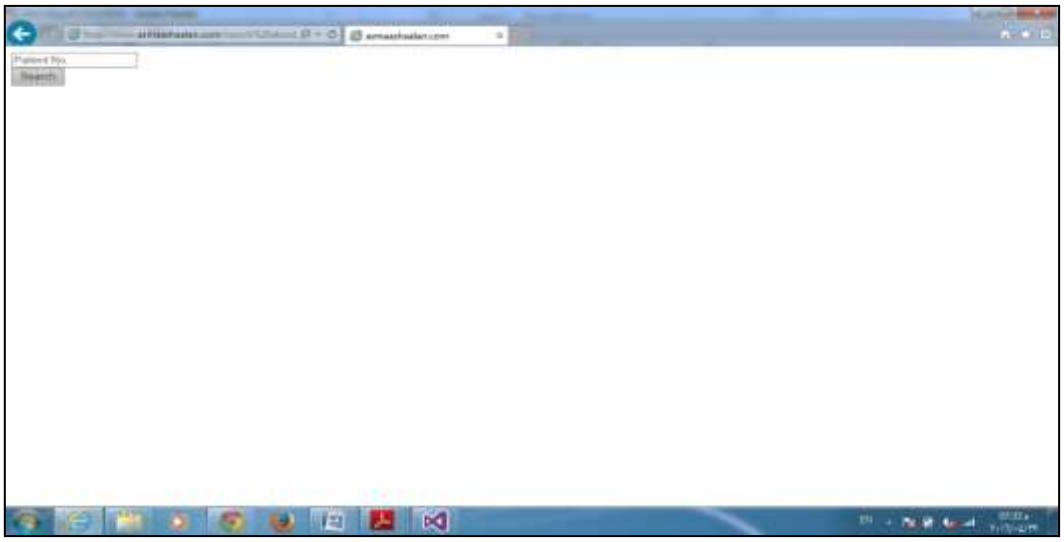
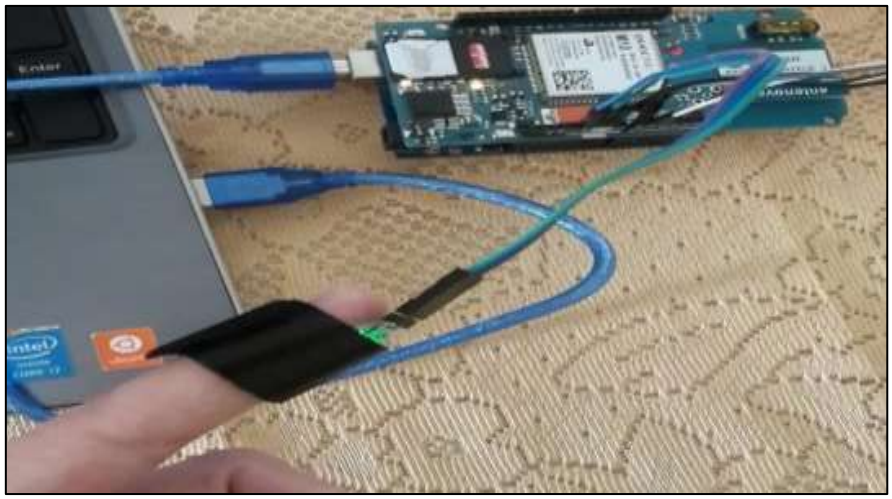


Figure (15) Search about patient

Figure(16) Results of searching.

Experimental Results

The proposed system is tested in terms of ambulance, website and emergency department database sides. A practical experiment is performed as shown in Figure (17), where the considered equipment and connections are illustrated.



Figure(17) Arduino Uno and GSM Arduino shield to send vital sign data for patient.

In emergency department, the insertion function of new record (patient) is following the steps explained in Figure (9). It is noted that the insertion process is done with high flexibility and efficiency. In order to test the updating process, we select the method of ID searching, for example the information of (ID=14) as explained in Figure (10). Using this process, all involved fields can be edited easily. For the searching process, the patient with the name (Hala Salem Qaus) is selected as shown in Figure (11). The first page, shown in Figure (18), inserts the patient's information to data base "***asmaasha_patient*** ". This page is requested by emergency department or patients to order an ambulance. Then this information is sent to the server of data center for processing the order. The ambulance number and patient number are chosen by system depending on availability and unique number. After the insertion, "***Save***" button is pressed.

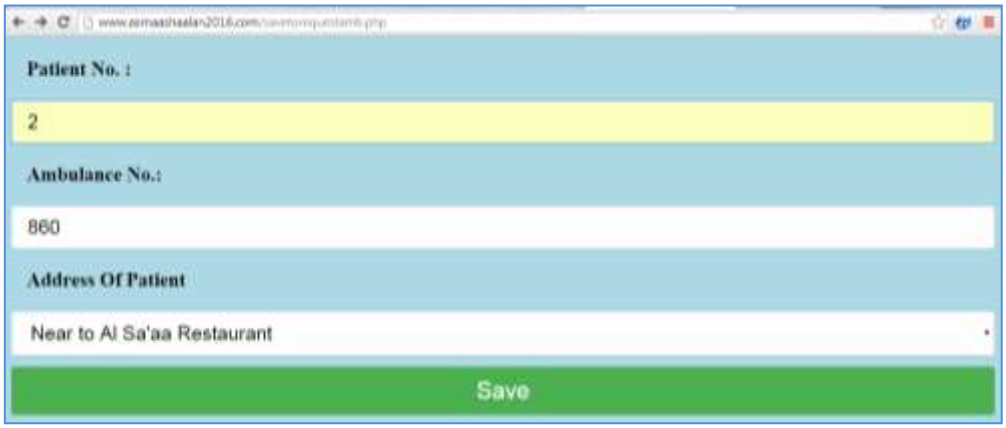


Figure (18) Inserting a patient's information to data base "asmaasha_patient"

The second page, shown in figure (19), views the status of the underlying patient with a unique number in an ambulance. It is important to note that this page refresh itself automatically each 5 seconds.

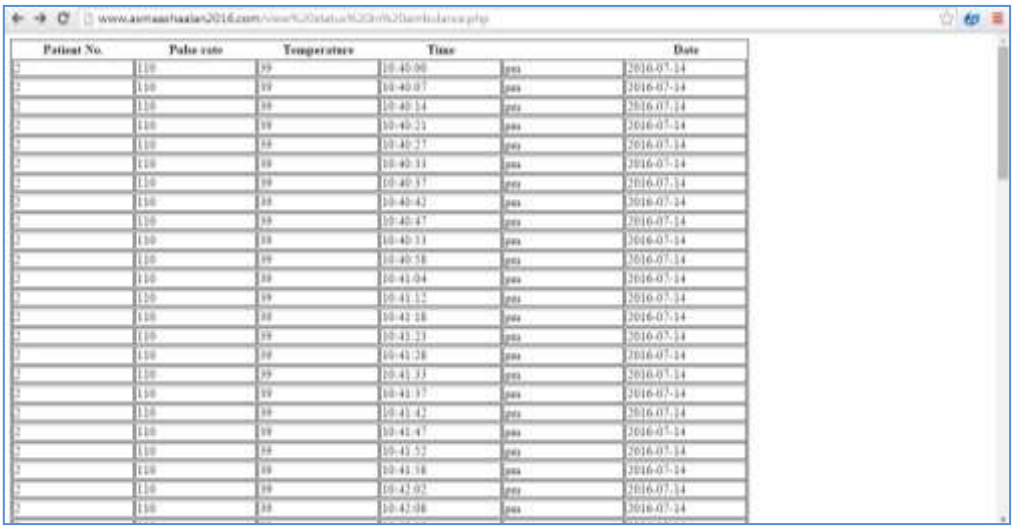


Figure (19) View Status of Patient in Ambulance

Following the above processing, Figures (12)-(16) show the results obtained. It is well shown that the proposed system can perform efficiently and smoothly. The only problem can be pointed is the absence of internet service through GSM networks. In addition, the GSM networks and rented host server need a monthly or yearly subscribing that costs some money.

It is important to note that we need a permission from Ministry of Health to implement the proposed system in a real ambulance. This is can be considered as the big obstacle as this step needs more work on people knowledge and cultural level. Therefore, the above experiment has been done on normal car and the vital information is taken from real person setting there.

CONCLUSION

An emergency health monitoring system in an ambulance is proposed. This system can offer the vital information of a patient in an ambulance to be sent to the emergency department through internet using GSM network and website based data transmission. The doctors can interact with the patient and prepare the required equipment before arriving to the emergency. The presented systems include four main processes: Registration, Update, Search and Ambulance. Each of which can perform individually to produce a satisfied services to patients and emergency department. In terms of physical representation, the proposed systems include three parts: Hardware at ambulance, Website application and SQL database server. All these parts play turns in completing and achieving the planned objects of the work.

VS C# is used for designing the GUI of the system. In addition, ASP.NET and PHP were used to design the website and applications. Finally, SQL server 2012 was used for database management. The obtained results from the real-time experiment gave the confidence to implement the proposed system in real ambulance to handle the data transmission throughout different media.

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