IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 22, Issue 1, Ser. III (Jan - Feb 2020), PP 01-12
www.iosrjournals.org

An IoT Based Analytical System to Predict the Condition of an Emergency Patient

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Abstract: *In much discipline, particularly in personalized healthcare, IoT is gaining rapidly increased interest. While, for example, body area sensor network (BASN) has been widely applied under the IoT system for universal health monitoring. ECG testing was widely accepted as a critical method for diagnosing cardiovascular diseases. This paper's main contribution presents the novel system, the WISE (wearable IoT-cloud bases health monitoring system for real-time personal health monitoring. WISE adopts the framework of the BASN (body area sensor network) in support of real-time health monitoring. Our paper's main purpose in light of the luxury or discussing better patient care. By improving the quality of care and patient safety, the health monitoring system can be used to promote basic nursing care in hospital environments. Bangladesh's rural area lacks the proper monitoring system for patients. Therefore, the main objectives are remote control and advice through sharing information in an authenticated manner. We have proposed a system for the monitoring of patients in real-time during major disasters. Our system is designed with scalable algorithms to track large numbers of patients, an intuitive interface to assist overworked responders, and ad-hoc mesh networking capabilities to maintain access to patients in chaotic environments. This paper describes an iterative approach to user-centered design adopted to guide development of our system.*

Key Word*:Patient monitoring; Body sensor network; Wireless body sensor network; GSM Module; IoT; ECG Sensor.*

Date of Submission: 04-02-2020 Date of Acceptance: 19-02-2020

I. Introduction

Medical institutions would be constraining to decrease nursing staff for patients because of the expansion in labor costs. Our project aims to develop new technologies to use emergency patients for prediction. In this paper we presented a safe IoT-based surveillance system for health care. In order to achieve simultaneous device efficiency and transmission robustness within public IoT communication networks, we will use robust cryptography primitives to construct two communication mechanisms to ensure confidentiality of transmission. Through introducing the nursing program, each patient can be tracked remotely get a new dimension. By this, if a patient is in a critical situation, an immediate instruction can be given to the one in charge, based on derived data. It can play a vital role in lowering labor costs, so it will be easy to measure at anytime from anywhere and will be helpful in making immediate decisions. This method of nursing will be digitalized. People are affected in day-to-day life by various severe and complex diseases such as Diabetic Mellitus, Cardio Vascular Diseases and Hypertension etc. which are highly sensitive diseases. People are therefore constantly anxious about their state of health. They need to meet with physicians to verify all of that according to sources Internet of Things (IoT) is a growing phenomenon of the present that has an impact on many aspects of human life. Different processes with different concepts like data acquisition, data transmission, and data analytics empower IoT-based systems to support smart solutions for healthcare in particular. Four sensors (ECG Sensor, Body Temperature, Oximeter, and Pulse Rate Sensor) and a BASN (Body Sensor Network) model are used in IoT based system. Job success in IoT-based system depends on 3 systems that work with sensors, get away and cloud. First, speak about the sensor network, which is the first step in patient monitoring and data collection. Second is the gateway system which is a continuous network connection between sensors and cloud system. Every year, the death rate of 55, 3 million people dying or 1, 51,600 people dying every day or 6,316 people dying every hour is a major issue for the whole world. So, we are proposing a model where patients can measure heart beat rate and ECG by themselves and the report is sent to the doctors immediately. The doctors can take immediate action in every short period of time after that. It also cuts valuable time for patients and doctors alike. They don't have to wait for the reports, as sensors give real time data. The model is very useful for patients in emergency situations. The unsuitable BSN architecture to track the human body and its internal environment has directly triggered the creation of Wireless Body Sensor Network (WBSN) with computational intelligence at the local level. A typical WBSN model architecture consists of three layers which include sensor interactions. Here we focus on 3–layer hierarchy, because the architecture is a full model based on other variants. Therefore, more can be learned from the various technologies that are used in3-layer BSN systems. This approach will reflect the current state of the art in this area in general. This program is very useful for people in rural areas. IoT provides data through GSM/3G/4 G technologies or a patient report with time and date is sent to doctors. The proposed model may or may not use any kind of people like him or her with a disease. Therefore, they should regularly check it, as people pay more attention to prevention and early disease detection. IoT apps produce large amounts of information and data. Such health care services are getting better and less costly by treating emergency patients by healing and receiving them. In addition, our program would support people of all ages, particularly for the elderly or ICU patient. It will measure the patient's pulse, oxygen and ECG and upload the result into the text message, web server and mobile apps. Therefore, we will develop a website as well as mobile apps in which people can get access and see the output by searching date and time. Moreover, in case of emergency, nurse or patient's relative check out patient's condition by using live monitor option. Sometimes, it is quite difficult to know about health condition of patients for doctor and nurse. For this, they cannot give the proper treatment and instant result to the patient. Now it is very important to build a system that can help doctor and nurse to maintain patient monitoring for emergency situations.

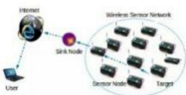
II. Objectives

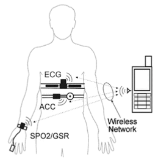
- Simple to use, this will be a very handy tool, as it displays all data collection and information using the internet only. It therefore reduces the workload and discomfort of the patient's relatives who work outside.
- Better patient experience to be linked to the health care system through IoT, doctors will improve the accuracy of the diagnosis as they get all the requisite patient data in hand.
- By using this method, providing accurate diagnosis, we can get preliminary results based on patient health. In fact, it will be less error, collect data in less time and more accuracy than any human performance.
- Showing the treatment outcome by accessing patient health data in real-time information helps the doctor decide how to treat and what to do next. Ultimately, this system will allow physicians to use the data collection results and analyze the data in real time.
- This system is not expensive. The total cost will be lower than any other machines used in hospitals. It's additionally compact, lightweight and easy to use.

III. Literature Review

Two parts which are the advantages and limitations of smart healthcare application are discussed in this section. Below is the accompanying further clarification. Because IoT was first introduced in the area of healthcare, it has recognized several profound benefits that help maintain a healthy lifestyle and improve the industry.

Table no 1: Previous works on IoT based patient monitoring system

Related works	Description	Limitations	Architecture
"Autonomic Wireless Sensor Networks[1]PPGI-iNCE/DCC-IM/Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.	Autonomous computing is a promising approach to meeting fundamental requirements in the design of wireless sensor networks, and its concepts can be applied to control node activity efficiently and maximize network resources.	It can potentially compromise privacy. As we have said before, networks are being hacked. There will need to be a lot of attention to data security, which requires significant additional spending.	
"The Impact of Mobility Model in the optimal placement of Sensor Nodes in Wireless Body Sensor Network" B. O. Sadiq, A. E Adedokun, Z.M Abubakar	Power and energy usage is a fundamental issue in Body Sensor Networks (BSNs), as nodes must function properly and autonomously for a certain period of time without removing or modifying batteries. This is because the sensors in BSNs are either embedded in the body or located very close to the body.	Unauthorized Centralization access.	
"A Review of Three-Layer Wireless Body Sensor Network Systems in Healthcare for Continuous Monitoring" Chen Chen 1, 2* , Alois Knoll 2 , H.-Erich Wichmann3 , Alexander	The use of wireless body sensor network system based on information and communication technology to track elderly people's health status slowly becomes common in the telemedicine field. E Health services based on such technologies can provide	Regulations governing global healthcare.	

Horsch 1, 4 1 InstitutfürMedizinischeStatistik und Epidemiologie, Klinikumrechts der Isar der TU München, Germany.	healthcare for elderly and chronically ill people in and outside their homes, allowing for an independent life even under difficult health conditions.		
"The Wireless Body Area Sensor Networks and Routing Strategies"V.T. Venkateswarlu, Dr. P. V. Naganjaneyulu, Dr. D.N.Rao	The program is an effective solution that has been implemented to improve the solutions and there are various benefits that have been gained from using WBASN solutions in communication, healthcare domain.From the study of stats on the increasing number of wireless devices and solutions that are coming up, which people embrace as wearable devices, implants for medical diagnostic solutions, etc.	HWSNs should include multiple access points and help route variations to address this issue, in order to reach each sensor node.	
Proposed System An IoT based analytical system to predict the condition of an emergency patient.	Our machine will monitor the vital signs and symptoms of the patient on an ongoing basis. The data being tracked is forwarded to physicians. The system warns the medical personnel about the abnormal parameter when they find abnormalities. Reduces physicians need for manual supervision.		

IV. Proposed System Architecture

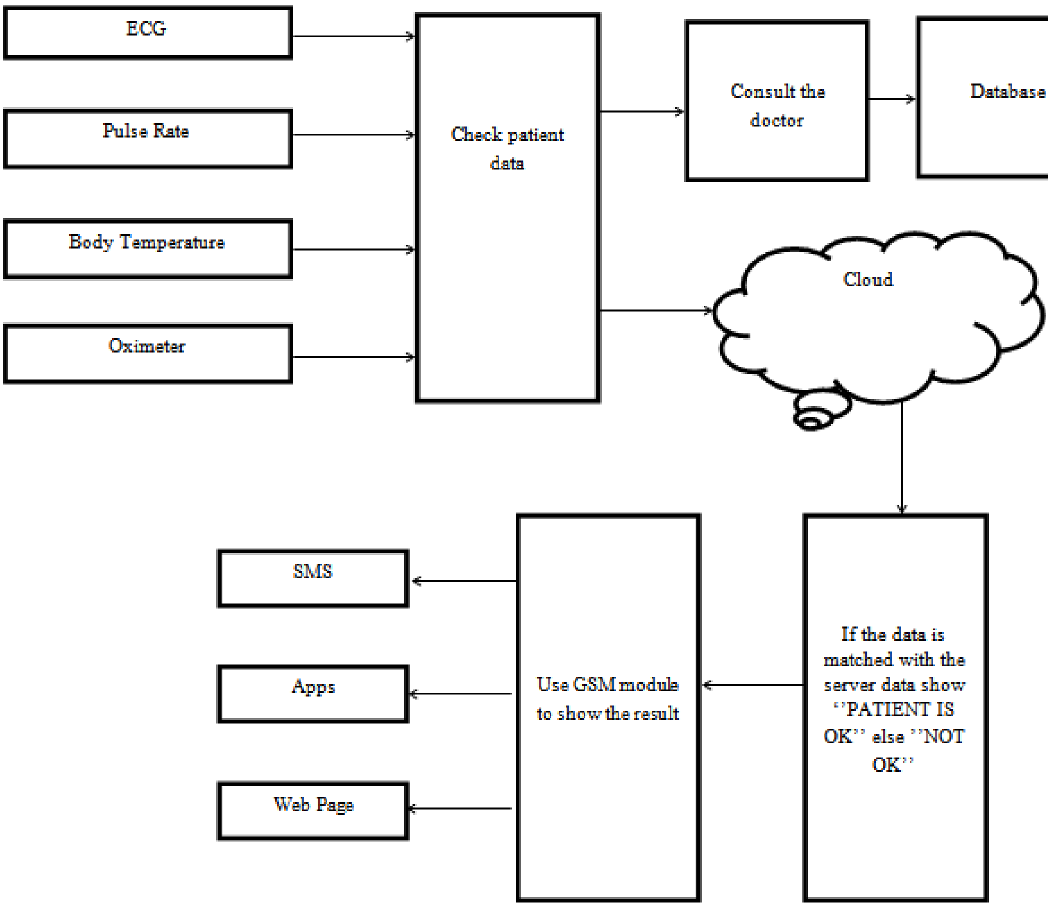


Figure no 1: System Architecture

First there will be a couple of switches in this proposed system indicating if the patient has any previous medical history. The system will then measure the body temperature, pulse rate, ECG rate and the Oximeter will then monitor the functional oxygen saturation in the patient body. This will then store the data in the cloud. Afterwards the program contrasts the ideal data with the data of the patient. If the data does not match, the system will display the data using the GSM module. The three networks are text messages, applications and the hospital web page. Finally, if the patient has any previous medical history, the doctor will be notified before taking the service.

V. System Flowchart

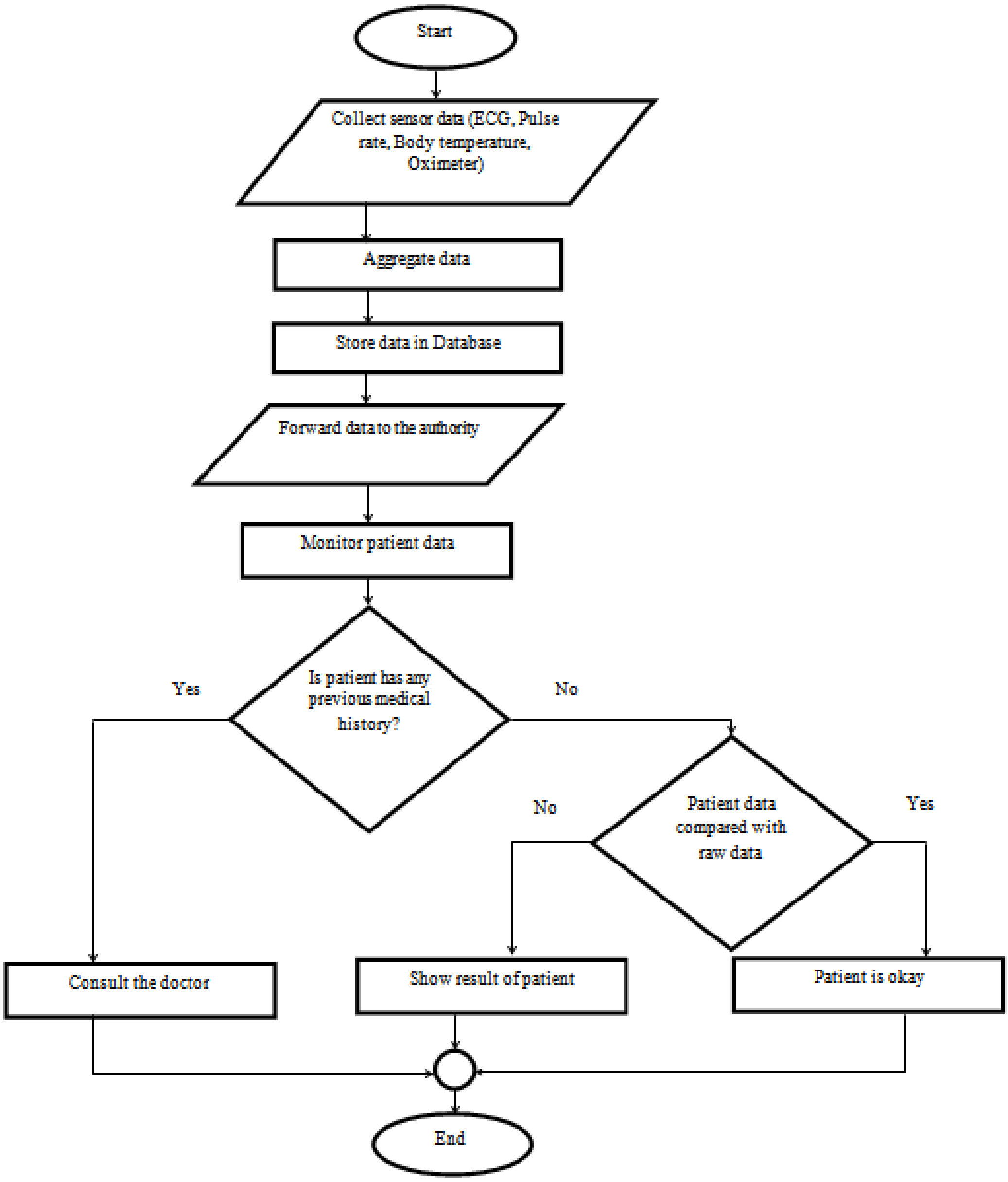


Figure no 2: System Flowchart

ArduinoConnection with all the Components

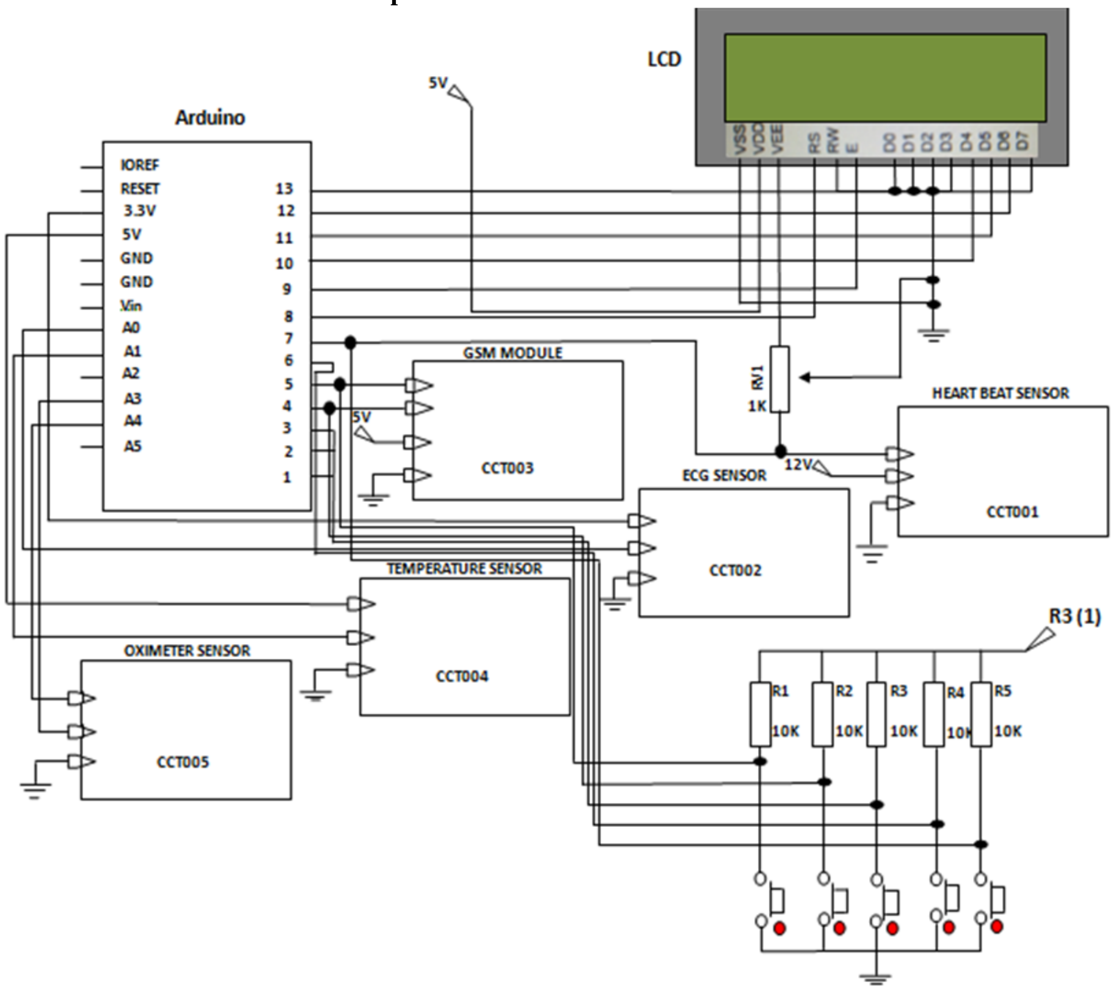


Figure no 3: Connection Setup

Arduino's 7 number pin is attached to the sub circuit of the heart beat sensor. Heart beat sensor comes with 3 inputs. One is connected to Arduino, the other to 12 volt (PCB Board) and the last to wall. Oximeter sensor also has 3 inputs.First one is attached to Arduino's pin A3. The input binds to Arduino A4. The last is grounded. Temperature sensor also has three inputs. First one is connected to Arduino pin A1. Another input is connected to Arduino 5 Volts. The last is grounded. The ECG module has 3 inputs, as well. First one connects to Arduino pin A0 (pin number 5). The input connects to Arduino's 3.3 Volt (pin number 10). The last is grounded. GSM module has 4 sub circuit inputs. First one is connected to Arduino's pin 3, second one is connected to Arduino's pin 2 and third input is connected to the 5 volt PCB board, and fourth is grounded. Last, there are 14 pins to the LCD. The LCD pin 14,13,12,11 pins are connected to Arduino's pins 13, 12, 11, 10.Pin 4, 6 of Arduino's LCD attached by pin 8, 9 number pins. Finally, the LCD pin 2 is wired to 5 volts which are attached to the PCB. We use 5 push-buttons in this project. For those 5, 5 push buttons are connected to 5 series registers. The sum of every 5 registers is 10K. Here, Arduino's R1, R2, R3, R4, R5 bind to pin 9, 6, 5, 4, 3. All five pushbuttons are mounted.

VI. Pulse Heart Beat Rate

ECG or electrocardiography is a system that uses electrodes on the skin to record and measure the heart's electrical activity over a certain period of time. Electrodes for bio monitoring have undergone great evolution and progress since the 19th century. In 1883, Carlo Matteucci, who was a physics professor at the University of Pisa, first demonstrated and introduced sensors that regularly track and control electricity in the human body.

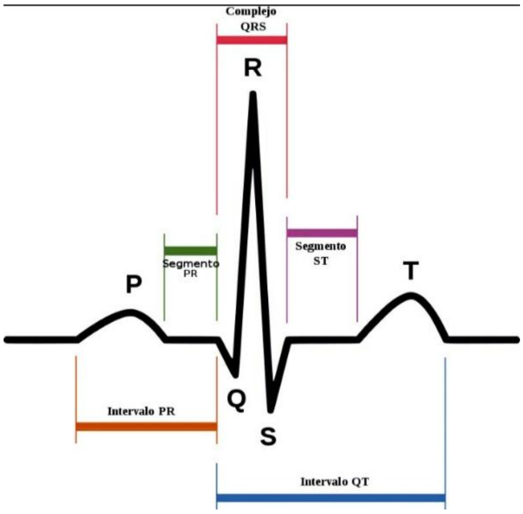


Figure no 4: Heart Activation Rate Graph

At the sinoatrial node that is installed, the heart starts activation and produces heart frequency about 70 cycles per minute. This activation created muscle tissues to both the right and left. There is delay which allowed the ventricles to fill in the ventricular node with blood from atrial contraction.

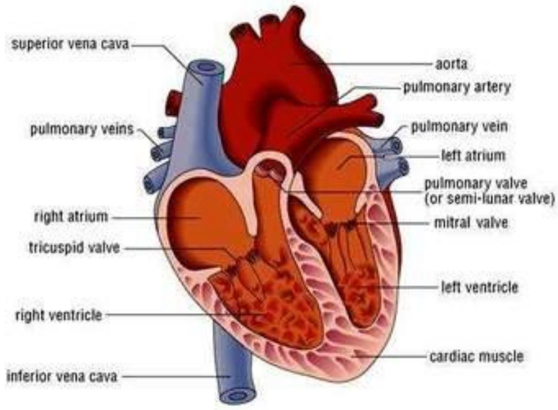


Figure no 5: Heart diagram

VII. Heart Beat Rate

Heart rate is the pulse rate, measured by the number of heart contractions (beats) per minute (bpm). ... The American Heart Association states that the normal resting heart rate of adult human beings is 60–100 bpm. Tachycardia is a rapid heart rate, defined at rest as above100 bpm.The Target Heart Rate or Training Heart Rate (THR) for healthy people is an ideal range of heart rate achieved during aerobic exercise which helps one's heart and lungs to obtain the most benefit from a workout. This theoretical range varies mainly according to age; however, the physical condition, sex, and previous training of a person are also used in the calculation. Below are two ways of calculating your own THR. There is an item called "strength" in each of those methods which is expressed as a percentage. The THR can be measured as an energy range of 65–85 per cent. Nevertheless, it is important that an accurate HR_{max} is obtained to ensure that these estimates are meaningful.

Example for someone with a HR_{max} of 180 (age 40, estimating HR_{max} as 220 − age):

65% Intensity: $(220 - (age = 40)) \times 0.65 \rightarrow 117$ bpm

85% Intensity: $(220 - (age = 40)) \times 0.85 \rightarrow 154$bpm

The Heart Beat Rate of Different ages People

Table no 2: Heart Beat Rate Results

Subject	Gender	Age	Heart beat developed by System	Heart beat by manually	Error Rate (%)
Subject 1	Male	22	85	84	1.04%
Subject2	Male	22	84	82	2.38%
Subject3	Male	20	78	78	0%
Subject4	Male	22	90	87	3.33&
Subject5	Male	32	100	102	2%
Subject6	Female	22	76	77	1.32%
Subject7	Female	40	104	103	0.96%
Subject8	Female	20	68	66	1.47%
Subject9	Female	22	72	71	1.38%
Subject10	Female	22	84	85	1.19%

Source: Results measurement of 10 people (Heart Beat rate per minute)

Age: 20
Target Heart Rate (HR) Zone (60-85%): ** 120 – 170
Predicted Maximum HR: 200
Age: 25
Target Heart Rate (HR) Zone (60-85%): 117 – 166
Predicted Maximum HR: 195
Age: 30
Target Heart Rate (HR) Zone (60-85%): 114 – 162
Predicted Maximum HR: 190
Age: 35
Target Heart Rate (HR) Zone (60-85%): ** 111 – 157
Predicted Maximum HR: 185
Age: 40
Target Heart Rate (HR) Zone (60-85%): 108 – 153
Predicted Maximum HR: 180
Age: 45
Target Heart Rate (HR) Zone (60-85%): 105 – 149
Predicted Maximum HR: 175
Age: 50
Target Heart Rate (HR) Zone (60-85%): 102 – 145
Predicted Maximum HR: 170
Age: 55
Target Heart Rate (HR) Zone (60-85%): 99 – 140
Predicted Maximum HR: 165
Age: 60
Target Heart Rate (HR) Zone (60-85%): 96 – 136
Predicted Maximum HR: 160
Age: 65
Target Heart Rate (HR) Zone (60-85%): 93 – 132
Predicted Maximum HR: 155
Age: 70
Target Heart Rate (HR) Zone (60-85%): 90 – 123
Predicted Maximum HR: 150

Table no 3: Average Heart Rate by Age

Average Heart Rate by Age		
Age in years	**Average maximum heart rate in beats per minute**	**Target heart rate range in beats per minute**
40	180	90 to 153
45	175	88 to 149
50	170	85 to 145
55	165	83 to 140
60	160	80 to 136
65	155	78 to 132
70	150	75 to 128

Source: American Heart Association (AHA)

VIII. Pulse Oximeter

Pulse Oximeter is a non-invasive method used to control oxygen saturation (SO2) in a human. Althoughits reading of peripheral oxygen saturation (SpO2) is not always the same as the more favorable reading of arterial oxygen saturation (SaO2) from the study of arterial blood gases, the two correlate well enough that the safe, simple, non-invasive, inexpensive method of pulse Oximeter is useful for measuring oxygen saturation in clinical usage. In its most common (transmissive) mode of application, a sensor device is placed across a foot over a thin part of the patient's body, usually a fingertip or earlobe, or in the case of an infant. It measures the changing absorbance at each wavelength, allowing the absorbance to be determined by the pulsing arterial blood alone, excluding venous blood, skin, bone, muscle, fat, and (mostly) nail polish.

Figure no 6: Oximeter

Because pulse oximetry tests only the percentage of bound hemoglobin, if hemoglobin binds to something other than oxygen, a falsely high or falsely low read may occur:

- Hemoglobin has a higher sensitivity to carbon monoxide than it does to oxygen, and even though the patient is not hypoxemic a high reading may occur. This inaccuracy can delay the detection of hypoxia (low cellular oxygen level) in cases of carbon monoxide poisoning.
- Cyanide poisoning gives high reading as it reduces the extraction of oxygen from the arterial blood. The reading in this case is not false, since arterial blood oxygen is indeed high in early cyanide poisoning.
- Methemoglobinemia triggers pulse oximetry readings usually in the mid-80s.
- False readings can cause COPD [especially chronic bronchitis.

Pleth Variability Index (PVI) Measurement

- A plethysmographic difference can be seen in the light signal obtained (transmittance) by the sensor on an Oximeter, due to changes in blood volumes in the skin. The variation can be defined as a periodic function which can be divided into a component of DC (the peak value) and a component of AC (peak minus valley). The ratio of the AC component to the DC portion, expressed as a percentage, is known as the (peripheral) perfusion index (Pi) for a pulse and usually ranges from 0.02% to 20%. An earlier calculation called the Pulse OximetryPlethysmographic (POP) only calculates the "AC" component and is manually extracted from display pixels.
- The Pleth Variability Index (PVI) is a measure of the perfusion index variability that occurs during respiration cycles. Mathematically, it is measured as 100 percent $(Pi_{max}-Pi_{min})/Pi_{max}$ where the maximum and minimum Pi values are from one or many cycles of respiration. It has been shown to be a useful, non-invasive measure of continuous fluid responsiveness for fluid-controlled patients. Pulse oximetryplethysmographic waveform amplitude (ΔPOP) is an analogous earlier technique for use on the manually-derived POP, calculated as $(POP_{max} - POP_{min})/ (POP_{max} + POP_{min})*2$.

[**Source:** Wikipedia, the free encyclopedia]

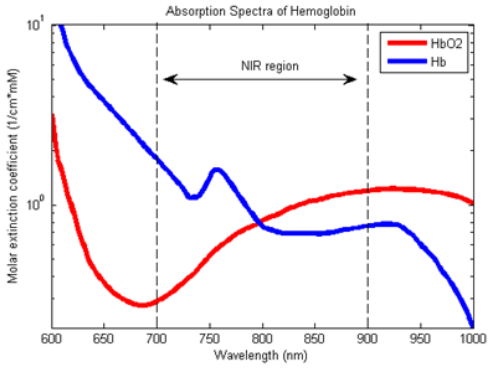


Figure no 7: Absorption of Spectra Hemoglobin Graph

IX. System Model for Sensors

Both hardware and software make up our system. Heartbeat and ECG sensor are used in hardware component. So Arduino is integrating with the GSM module. When calculating heartbeat and ECG, GSM module helps to upload it to mobile post, Web server, and APP server. In fact, LCD shows the output of heartbeat too.

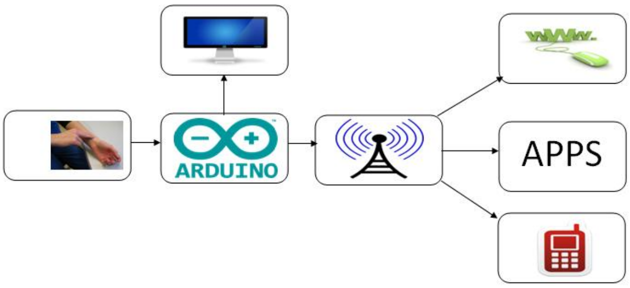
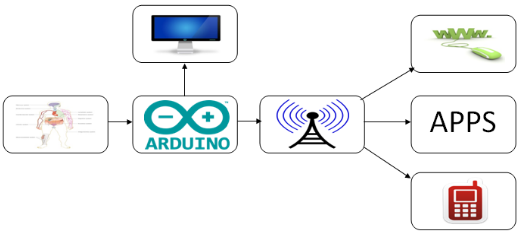


Figure no 8: System Model for Pulse Rate Sensor

Next, there will be a finger contact through the finger touch in this proposed model the device collects the patient's pulse rate data with the aid of Arduino. The Arduino will be connected to an LCD display showing the data and the device will then take GSM module to view the data.



Figureno 9: System Model for ECG Sensor

Second, there will be a finger touch through the finger touch in this proposed model the device collects the patient's ECG data with the aid of Arduino. The Arduino will be connected to an LCD display showing the data and the device will then take GSM module to view the data.

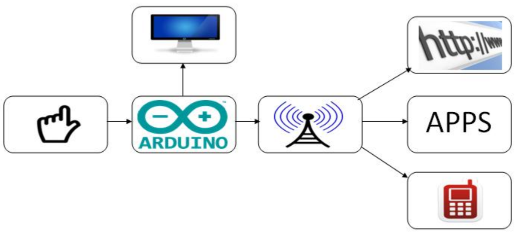


Figure no 10: System Model for Heart Beat Sensor

Next, there will be a finger touch through the finger touch in this proposed model, the device will collect the heart beat data from the patient with Arduino's help. The Arduino will be connected to an LCD display showing the data and the device will then take GSM module to view the data.

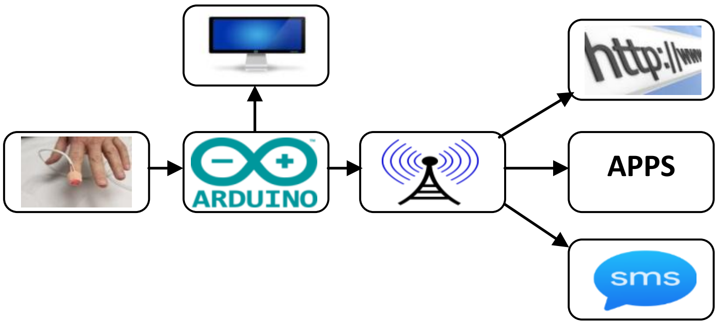


Figure no 11: System Model for Oximeter Sensor

In this proposed model, the system gathers the usable oxygen saturation of hemoglobin in the patient's arterial blood with the aid of Arduino, firstly a finger touch through the finger contact. The Arduino will be connected to an LCD display showing the data and the device will then take GSM module to view the data.

X. Implementation

When the patient is first triaged, the paramedics attach the electronic tag to the patient's neck or wrist, place the pulse Oximeter on the patient's ear or finger, and press the button on the electronic tag to set the patient's triage color. We will integrate our system with our pre-hospital patient care software system. The following sections identify five areas of our implementation: 1) wearable devices, 2) vital sign analysis, 3) patient care, 3) elimination of false alerts, and 4) usability development. To have five functionalities, we will create the wearable electronic tag: vital sign monitoring, position tracking, medical record storage, color signaling for triage, and warning signage. We would combine two types of position sensing capabilities–a GPS and an indoor tracking system to provide positioning in places where GPS satellite signals cannot be reached. Our algorithm customizes various novel techniques to each patient:

- If the patient has a previously entered medical record, information from the medical record is used to change the thresholds for warning detection.
- The thresholds are adjusted according to environmental factors like altitude and temperature.
- Thresholds are modified programmatically based on current readings of a patient.
- Paramedics can adjust patient thresholds by selecting the option "Alert Parameters" and by manually updating thresholds.

The thresholds of each patient are forwarded to the remote patient record database for later recovery. The user interface shows the overview panels for all patients containing the patient ID, the triage colour, the intensity of wireless connection and the current vital signs. All patient overview panels are listed in one scrollable tab, sorted according to priority and waiting time. When a paramedic clicks on a patient summary panel, the vital sign graphs of that patient will show up in a graph area. The dashboard approach would allow the user to keep an overview of all patients while drilling down to one patient's specifics. A warning should appear on the user interface when an anomaly is found in the patient's vital signs. All current alerts are listed within a panel which makes it easy to manage multiple alerts.

XI. System Applications

This is an important project focused on sensors which has incorporated the latest technology in it. And as stated below it has many applications & advantages.

- IoT Healthcare is the medical industry with the most demands. The idea is for, in our house, elderly people. For the senior citizen who lives alone or with 1 or 2 friends, too. This project is really helpful when family members need to go out to work in an emergency.
- Patients with disabilities can use this project. Disable patients who find it really hard to go to doctors on a daily basis or those patients who need continuous physician monitoring.

XII. Advantage of this project

- IoT Monitoring proves to be really useful when monitoring & recording and tracking changes in the patient's health parameters over time. Thus we can have the record of these improvements in health parameters with the IoT health monitoring. Doctors may take the comparison of these improvements or the patient's history before recommending the patient the medication or medicines.
- Hospital visits are minimized for normal routine checkups.
- Information about patient health criteria is stored in the cloud. So, it's more useful than keeping records in the archives on printed articles. Or even the digital archives that are stored like a pen drive in a single computer or laptop or memory unit. Because these devices are likely to get corrupted, and data might be lost. Whereas the cloud storage is more robust in the case of IoT and has low chances of data loss.

XIII. Conclusion

In general IoT-based health care platform where smart sensor concepts add to the human body for regular check-up health monitoring. We spoke about emergency patient monitoring system in this post. There are 4 sensors used to allow real time monitoring system. In addition, the data was continually updated to the cloud at a regular time interval. It helps the doctor, nurses or the patient's family monitors the patient's health status and also helps to take any action at the right time. Remote monitoring is required because of critical emergency patient observation. The system work provides the opportunity to monitor patients on an ongoing basis through the use of the site and app software, along with the live monitor and mobile message service. This paper also contrasts the medical system of early age and current health surveillance. The present time represents time reduction, reduction of healthcare costs especially for people in rural areas.

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