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Real-Time Feedback Healthcare Monitoring System with IoT Sensor

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ABSTRACT

The purpose of this study was to determine the accurateness of the Healthcare monitoring system by the application of real-time alarm to a continuously monitored system. It can be defined as a mobile computing medical communication technology for Healthcare. This fantastic concept shows the evolution of the traditional desktop telemedicine platform to a wireless mobile configured wireless communication. This integrated development in wearable technology will have a radical impact on future Health Care facilities and services that can be provided to any patient, irrespective of their location. It requires simple mobile access using the GPS (Global Positioning System) and Wi-Fi(Wireless Fidelity) technology that is readily sudden heart attacks and lack of time to reach medical professionals from remote places can then be dealt with efficiently and timely, causing the user to take immediate corrective actions to avoid any fatal event. Henceforth, reduction the cost both at theHospital infrastructure and the patient's end as well as we discussed the essential developments contributions made recently to this health sector, the constraints and challenges faced and the future work that can be implemented to evolve the e-health wireless technology further using wearable sensors.

Keywords: Healthcare, Cardiac, IoT and Wearable Sensor.

1.INTRODUCTION

Cardiovascular is a common chronic disease, and it accounts for approx. 39% of all deaths each year. Among which 30% of deaths occur before reaching

Due to the short duration of a sudden heart attack, it is difficult, especially for remote cardiac patients to get medical help. Still, such incurable events can be avoided if the cardiac rhythm is continuously monitored at their homes[2]. To resolve this issue, we needed to develop a user-friendly, low cost, and a handy monitoring system[2][3]. The measured heart rate is then used by medical professionals to diagnose and treat such chronic illnesses. M-Health is emerging as a new communication technology between patient-doctor. It creates communication using mobile computations and medical sensors. This evolving concept is setting new health care standards switching from the old traditional desktop medical facilities to the wireless and mobile pattern medical systems. These ongoing advancements in wireless communications united with the latest wearable technologies will have a significant impact on future healthcare delivery systems[3][4][5].

Sensors play an essential role in such monitoring systems. If configured correctly and a suitable integration of medical sensors in M-Health systems will result in a change in the health care system that is currently provided. It will let medical doctors identify, analyse, and treat patients remotely with the same standards of care that can be provided at a hospital. This monitoring will help them to warn and alarm a patient in real-time in case of any adverse incident occurs[6].

Besides, timely examination and treatment of the patient. It also reduces the infrastructure cost at the hospital end as well as travelling and other similar values at the patient end[7].

Recently a lot of work-related to wireless sensor networks and monitoring systems of cardiac patients has been done, which included the integration of wearable sensors with wireless transmissions, using GPS Sensors as well as lots of processing using microcontrollers or embedded systems, or developing a simple hardware platform for monitoring and displaying data. All the essential factors and parameters are considered that could be used in diagnosing the cardiac patient's condition, like ECG(Electrocardiogram) data, GPS position, scan temperature, and galvanic scan response[8].

The primary purpose of our research was to provide such standard health care facilities to the remote patients who unfortunately lack the latest and advanced technologies to reach them easily. Limited funding for public health care services and an ageing population are driving factors for reducing the reliance on traditional health care and moving toward the adoption of a home telecare paradigm[9].

In our research, we developed such a monitoring system that uses wireless and wearable sensors, which are capable of capturing and storing the essential diagnostic parameters of patients kept under constant observation. This information is further forwarded to an ANDROID smartphone wirelessly via Bluetooth that is a low energy technology to make it readily available, low cost, and energy-efficient. Moreover,The information gathered from the smartphone is transmitted via Wi-Fi to a web interface. [10]. We also added an alarm to the system that can alert the user in real-time in case of some emergency, allowing them to take quick corrective action to avoid severe events. The signal works onpredefined threshold values. This way, we can raise the doctor-patient communication ratio and make the connection time to reach[11][12].

The analysis performed proved this system to be low cost, easily applicable, and reliable. Most importantly, the patient's track recorded is kept secure at both ends.

2.LITERATURE REVIEW

Health Equipment is a wearable device for tracking health in real-time. It is composed of a series of wireless physiological sensors linked to a Bluetooth-enabled cell phone via Bluetooth.Health Gear implementation performed using a blood oximeter that continuously tracks and analyses the level of blood oxygen (SpO2), heart rate, and plethysmographic signal during sleep. This defines two algorithms for the automated detection of sleep apnea cases[13].

Overall, the paper includes: (1) Implementing a real-time, lightweight wearable health monitoring system to transmit physiological data wirelessly to a cell phone; (2) processing, visualizing and analyzing physiological information on a cell phone in real-time; (3) Implementation of two algorithms to automatically detect sleep apnea events from blood oximetry; (4) testing of the entire system (hardware and software) in a 20-party sample[14][15].

Heart rate monitoring system uses the heart rate control method, using Arduino and a fingertip. It is based on the principle of photoplethysmography (PPG), which measures the deviation in blood size in tissue[16], using a light source and detector. T Heart pumping pumps blood throughout the body, which also causes blood volume to shift within the finger artery.This blood fluctuation can be observed using an optical sensing device mounted around your fingertip [17]. In this phase,the sensor kit includes an infrared light diode (IR LED) and a photodiode. The IR LED transmits an infrared light to the tip of the finger, part of which is transmitted from the blood inside the arteries of the body[17].The photodiode detects the part of the light that is reflected. The reflected light intensity depends on the amount of blood within the fingertip.And the amount of reflected infrared light varies every time the heartbeats, which can be determined via the camera diode. A small change in amplitude can be transformed into a pulse with a high gain amplifier.With the assistance of serial port communication, the signal is sent to Arduino. Heart rate control and counting are performed with the help of processing software[18].

Microcontroller Based Heart Rate Monitor is a basic wireless patient heart rate monitoring system based on low-cost controllers patient's heart rate is measured via IRD (Infra-Red Device Sensor) from the thumb finger; the pulse counting sensor is set to check whether or not the heart rate is average[19]. So that in case of an irregular situation, an SMS is sent to the mobile number using the GSM module interfaced with the transmitter.Also issued is a buzzer alarm. This system consists mainly of three components such as cardiac sensor circuit, GSM modem and MCU[20].

"A Signal Processing based design in which the algorithm uses digital filtering, adaptive threshold, statistical properties in the time domain, and differencing of local maxima and minima has been developed for the simultaneous measurement of the fetal and maternal heart rates from the maternal abdominal electrocardiogram during pregnancy and labour for ambulatory monitoring[21]. A microcontroller-based system has been used to implement the algorithm in real-time,and a Doppler ultrasound fetal monitor was used for statistical comparisons" [22].

PlaIMoS, a technology framework, consists of wearable sensors, a fixed measuring unit, a network infrastructure using IEEE 802.15.4 and IEEE 802.11 for data transmission using security mechanisms, a server for storing all collected information and applications for iOS, Android and Windows 10 mobile real-time measurement operating systems.The evolved structure also measures parameters associated with chronic respiratory diseases including saturation and respiration rate of the patient's blood oxygen, body temperature, fall detection, and galvanic resistance, primarily intended to monitor and report electrocardiogram and heart rate data[23].

PlaIMoS offers the significant advantage of the real-time tracking and transfer of data to the doctor.It also provides significant-time data on body temperature, heart rate (recording the ECG during regular activity), blood oxygen, breathing rate, galvanic resistance and dropout, while maintaining a high level of clinical flexibility[24].

This technology is a step forward, as it provides patients with a useful diagnostic tool. Who is suspected of having chronic health problems or need continuous monitoring to identify or validate health problems associated with cardiovascular diseases [25][26]?

The PlaIMoS platform's innovation is that it incorporates health sensors to track parameters associated with chronic respiratory diseases, a wireless sensor network, an advanced 128-bit encryption standard (AES) protection level, a patient translation algorithm and mobile device software applications for IOS, Android and Windows.

The healthcare monitoring system consists of a wearable sensor device for the constant monitoring of cardiac electrical activity, heart rate, body temperature, and fall data, working in conjunction with a fixed measuring station that allows the patient to regularly access blood oxygen saturation, respiration rate, and galvanic resistance tracking. The aims of this research included creation[27][28].

PlaIMoS comprises two devices: the PlaIMoS fixed measurement station, which measures patient saturation of blood oxygen, respiration rate, and galvanic resistance detected by the RFID (Radio-Frequency Identification) sensor."A WIRELESS BODY AREA SENSOR NETWORKS" (WBANs) consists of multiple sensor nodes, each able to track, process, and communicate One or even more vital signs (heart rate, blood pressure, oxygen saturation, activity) or parameters of the environment (location, temperature, moisture, light).Usually, these sensors are strategically placed on the human body as tiny patches or concealed in the clothes of users allowing for long-term, omnipresent health monitoring in their native environment[29][30].

3.METHODOLOGY

Our approach was to focus and study in detail the cardiac illness parameters that lead to sudden and heart attacks and how they can be avoided by alarming and alerting the patient beforehand. This could be done by constant monitoring of such patients in real-time. Hence we studied the research in which a platform was developed that is compatible with wearable sensors that can monitor and analyze heart-related health factors like heart rate, person's blood pressure, body temperature, and likewise.

These parameters play an essential role in the timely diagnosis of many chronic diseases like Arrhythmia, Hypotension, Hypertension, and Hyperthermia. In the proposed system, two interfaces are developed at both the sender and receiver ends—patient's side as well as doctors. The sender interface consists of the wearable sensors that sense and analyze the medical condition and transmit this information to an Android-based receiver port via Bluetooth, which is further forwarded to a web interface server. The alarm set up at the sender side is based on the predefined upper and lower threshold values that can be changed as per requirement. We can divide the system architecture broadly into three parameters.

1) Sender's interfacehas wearable medical sensors.

2) An android-based device integrated with the sensors as well as the web servers to transmit information in real-time.

3)Web server doing the measurements and calculations and respond as an alarm based on the threshold values specified.

The first parameter compromises the vast field of medical sciences, which deals with wearable sensors that are used to collect the desired medical information. The second parameter describes how wearable sensors are connected to smartphones through a secure Bluetooth connection for data sharing between the two devices. A smartphone can be termed as a platform that collects the data from wearable sensors and transmits it to the webserver/portal through secure Wi-Fi / 3G / 4G / LTE. One of the prominent advantages of the smartphone is also that we can use the smart phone's GPS for the location finding of the patient. In the third parameter, the webserver/portal receives the information at online My SQL from the multiple patients. Itshows it on a web interface, which is also known as the doctor's interface.

Figure 1. Heart Rate wireless sensor.

The proposed study canintegrate multiple wearable sensors with a smartphone that is connected to a web server/portal. In this study, we have restricted ourselves only to cardiac-related issues, and that too only will discuss the few basic parameters from which we can find out any abnormal activity in the heart. The basic settings which are being discussed in this paper are Heart rate, Blood Pressure, and Temperature. Heart rate can be monitored through Zephyr BT, a commonly used wearable sensor that is readily available in the market. The said sensor can easily be connected with any smartphone through Bluetooth (less power consumes) which has the Android version 4.4 or above. Zephyr BT sensor extracted information from the patient and communicate to the doctor for monitoring heart rate. The patient needs to be wearing the sensor; once the contact is created, the sensor will begin to transmit heartbeat information to the smartphone's listening port at a frequency of 1 Hz with acknowledgements after every 1.008 seconds, and a smartphone will pass the information to the web app.

The second parameter, Blood pressure (BP), can be monitored through a lightweight OMRON wireless sensor. The device can record 200 values of (BP) and transmit them to a smartphone.

Figure 2. OMRON Blood Pressure wireless sensor.

Body temperature is the 3rdfactorbelow the opportunity of this study, which is mandatory to be dignified for early detection and diagnosis of any abnormal heart activity. GPlus Bluetooth sensor is being used for the monitoring of body temperature.

Figure 3. Body Temperature wireless sensor.

It is pertinent to mention that the data transmission process form sensor to Android listening ports (smartphones) through Bluetooth is represented in STX. It means the Start of Text, and it is described in the ASCII code to define the message. The Message-ID is binary, used to identify the type of message. Zephyr BT's standard message ID for heart monitoring is 0 X 26-byte number within the payload of the data. It is stated that data range from 0 to 128 is transferred from the sensor to the smartphone's listening port [31][32].

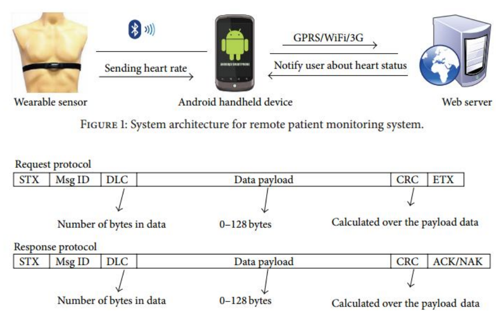


Figure 4.Message format for Communication.

CRC 8-bit 0 x 8C (CRC-8) polynomial which initialized the accumulator to zero before the CRC calculation began.The standard ASCII control character ending the message is ETX (End SMS).Bluetooth technology (using short-wavelength 2400 – 2480 MHz ISP band radio transmission) is used as a standard for short-range communications.This technology is used in serial port transmission with a baud rate of 115300 bps appropriate.

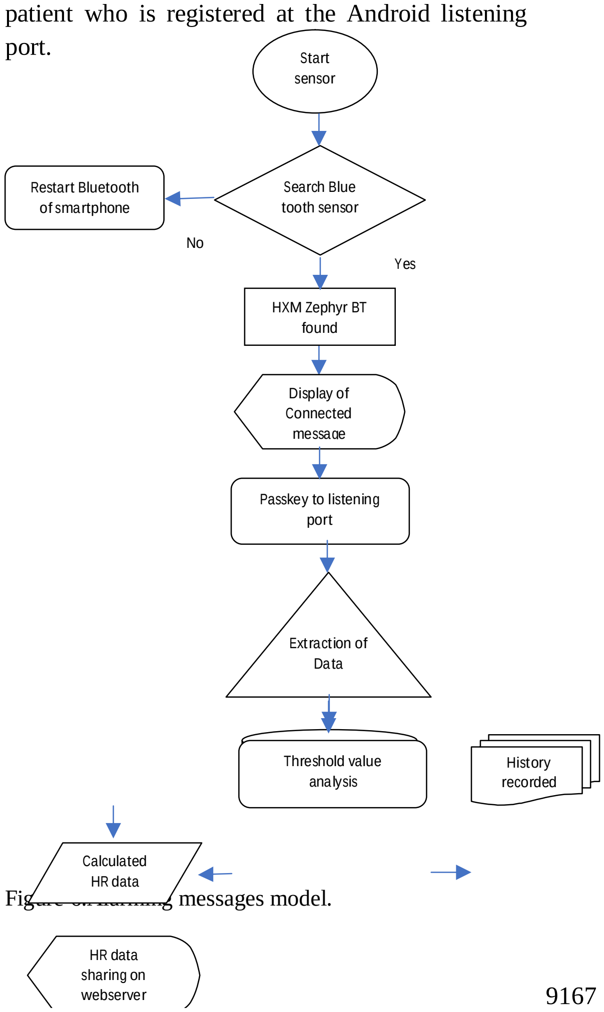
The android listening interface is installed in a smartphone to developeda listening port to receive the data from Bluetooth connection. Once the connection is established, the listening port of the system starts scanning the process like to detect the sensor, connect the sensor, and close the listening port when the process is finished. The smartphone's heart rate data is transmitted to the data processing center using protocol (XMPP) network messaging presence. SD card is being used for the storage of records to maintain the patient's data history. Web server/portal processes the received data to calculate average values of different parameters under discussion concerning time.

On receiving any abnormal values, the server will generate alarm/buzz to inform the doctor. Also, unction identifies the geographical location of the patient by using GPS function in a smartphone.

The first listening port device is a patient registration, which collects the patient's personal information such as name, age, gender and contact details.The second interface displays the relation between wearable sensors and listening port. In contrast, the third interface receives the data stream/values of various parameters in real-time (Heart rate, Blood Pressure, and Body Temperature) under study concerning time.

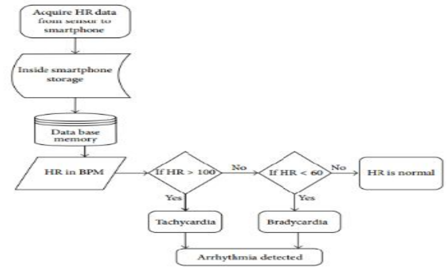
At the webserver/portal, it will be ensured that physicians/doctors at medical centers can monitor the received data and further can prescribe the right action in case of any emergency. This web interface using the Larval PHP framework will also ensure the correct data visibility, real-time updating of the records, patient status, and authentication.

The patient's personal records module interface displays patient data acquired by wearable sensors through real-time data transfer concerning time. It also contains the history/record of every single patient who is registered at the Android listening port.



Fig[illegible]g messages model.

Alarming messages module includes disturbing messages created at both the listening port and the



webserver/portal for the Android handheld. Upon comparison with assigned threshold values, physiological parameters extracted will give the alarming signals to the system.These alarming signals indicate abnormalities in heart function, which can be like Hypotension, Arrhythmia, and fever. The American Heart Association (AHA) has given the threshold values produced an alarm in the predefined handler task if average heart data deviates from the threshold value.The alarming mechanism consisted of three components under Java classes. These components provide scalability using an alarming polymorphism mechanism and numerical model, defining the cardiovascular system during different activities. The worrisome system work on the principle of upper and lower threshold values for the given threshold table. In this module, we have tailored monitoring setting adaptive boundary limits which keep on changing throughout the monitoring phase. In the proposed system, it compares heart rate after every ten minutes with pervious values to find out the change. To define the mechanism of the alarming module to take the information of heart rate, blood pressure, and body temperature through sensors, the concept of the Fuzzy logic method is used in conjunction with diagnostic terms such as hypertension, hypotension, fever, and hypothermia to infer the preprocessed data.

Sinus rhythm type	Threshold value of heart rate, blood pressure, and temperature
Normal	60<=HR<=100 (beats/minute), BP = 100-140/60-80 mmHg, and temperature = 36.5-37.5 °C
Bradycardia	HR<=60 (beats/minute)
Tachycardia	HR>=100 (beats/minute)
Hypertension (stage 1)	Blood Pressure = Sys/Day >= 140/90 mmHg
Hypertension (stage 2)	Blood Pressure = Sys/Day >= 150/95 mmHg
Hypertension	Blood Pressure = Sys/Day >= 90/60 mmHg
Fever	Temperature >= 37.8 °C
Hypothermia	Temperature <= 35.0 °C

Table 1: Threshold Value of Heart Rate

The module helps various doctors to treat/diagnose patients in the web application. In the event of any incident, the doctor can automatically monitor the patient's current location, which helps to find and send an ambulance to move the patient to the hospital.

4.RESULT & DISCUSSIONS

The proposed system is built for the management of heart disease in a real-time observing system—cardiac metrics to use wearable sensors, such as heart rate, temperature, and blood pressure.The Android listening port was developed to receive and store patient information, which is transmitted through wireless communication to the web application.The web-based interface designed to be on the side of the doctor to provide information status along with the patient's real-time location. Server accumulated data is stored and pushes the information to the doctor's web interface ultimately system located patient remote area is made visible to the doctor specialty hospital. Alarming system generated signal with computing threshold values,and also system developed the location of the patient and sent them an ambulance to the patients for transferred the patients to the hospital for saving left.

Parameters/ Age	18-35	36-64	Above 64
Normal heart rate	72-75 (BPM)	76-79 (BPM)	70-73 (BPM)
Bradycardia	HR <= 55	HR <= 60	HR <= 65
Tachycardia	HR=>110	HR=>120	HR=>100
Hypertension	BP =>150/100	BP =>145/95	BP =>140/90
Hypotension	Systolic BP < 85 mmHg	Systolic BP < 96 mmHg	Systolic BP < 117 mmHg
Fever	Temperature < 37.2°C	Temperature < 37.5°C	Temperature < 36.9°C
Hypothermia	Temperature < 35.5°C	C Temperature < 35.1°C	C Temperature < 35.0°C

BPM represents beat per minute.

Table 2: Age-wise Threshold values for Adaptive Alarming Mechanism.

S. No	Parameter	Mean Value
1	Number of Patients	40
2	Age	41
3	Gender (M/F) %	36/64
4	Heart rate	79 BPM
5	Blood Pressure	123/71
6	Temperature	36.5^0 C

Table 3: Mean value of Patient data.

S. No	Parameter	Age	Heart rate	Blood Pressure	Temperature
1	Minimum	25	62	67/45	32.5
2	Maximum	66	120	190/106	36.6
3	Range	42	93	123/61	4.1
4	Standard Deviation	13.5	16.5	21.5/13/5	0.3
5	Median	37	96.5	126/68	36.5
6	Mode	49	84	124/68	36.6

Table 4: Statistical data of Patients.

Alarm for	Average Time b/w sending and receiving Alarming Wi-Fi (H:M:S)	Average Time b/w sending and receiving Alarming 4G network (H:M:S)
Tachycardia	0:00:29	0:00:58
Bradycardia	0:00:30	0:00:59
Hypertension	0:00:31	0:00:51
Hypotension	0:00:33	0:00:57

Note: the value for each type of alarm is the average value of 20 alarms.

Table 5: Average data transmission time using Wi-Fi and 4G

5.CONCLUSION

The advances in wireless technology and embedded technology to give patients in a remote area the ability to track the healthcare system in real-time with the aid of Android smartphones and wearable sensors.The system developed consisted of sensors to collect servile cardiac parameters such as multiple patient heart rate, blood pressure, and temperature.The data obtained from the data transmitted via Bluetooth to the Android handheld device and further using 4 G, Wi-Fi, and other communication channels to send Android to the web application for further processing and web server manipulate data and take further action to alert an abnormal status.

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