To Design and Implement IoT Based Heart Rate and Temperature Monitoring System

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Abstract: In this current era where internet is very common and very essential, it acts as a simple and efficient solution to most of the problems faced by the society. The advantages of the internet are well-known to everyone in the society. The health of a person and it's monitoring is very crucial, and it is a very essential aspect of health. Having said this, in countries, where there is a lack of trained professionals and also a dearth of hospital beds, monitoring is usually ignored and/or is very costly. The traditional systems for this kind of monitoring are usually very bulky and expensive and hence, our proposed system provides a smart and wearable solution to the problem of health monitoring. Internet of Things (IoT) can help in providing solutions to this need of continuous health monitoring. IoT is basically a network of sensors that can communicate with a processor that is capable of taking various decisions based on the sensor values. There are various solutions to health monitoring in hospitals, which are not portable and not so affordable to most people, but our proposed system uses IoT (Internet of Things) to provide the best possible solutions to the need mentioned above. Using IoT as a platform we can monitor people with various chronical diseases especially rheumatic diseases.

Index Terms - Internet of Things, Arduino, Healthcare, Health monitoring system, Wearable devices, NodeMCU.

I. INTRODUCTION

Internet of Things, a term that is being used more and more by the passing the day, is term used for a interconnection of sensors and a processor that understands the sensed data and takes decisions accordingly with very less or human interaction at all. Nowadays, health problems like cardiac failure, rheumatic diseases are on the rise exponentially. Due to these problems, time to time health monitoring is very essential. In healthcare, and specifically in monitoring health, it becomes necessary for accuracy, timeliness and integrity of the data to be maintained. So, the modern technique involves monitoring of a patient wirelessly. An IoT enabled system that will help all those in need and allow easy monitoring and logging of the vital body parameters like heart-beat, temperature, blood pressure.

The most important applications of IoT are depicted in Figure 1.1 and explained a little later.

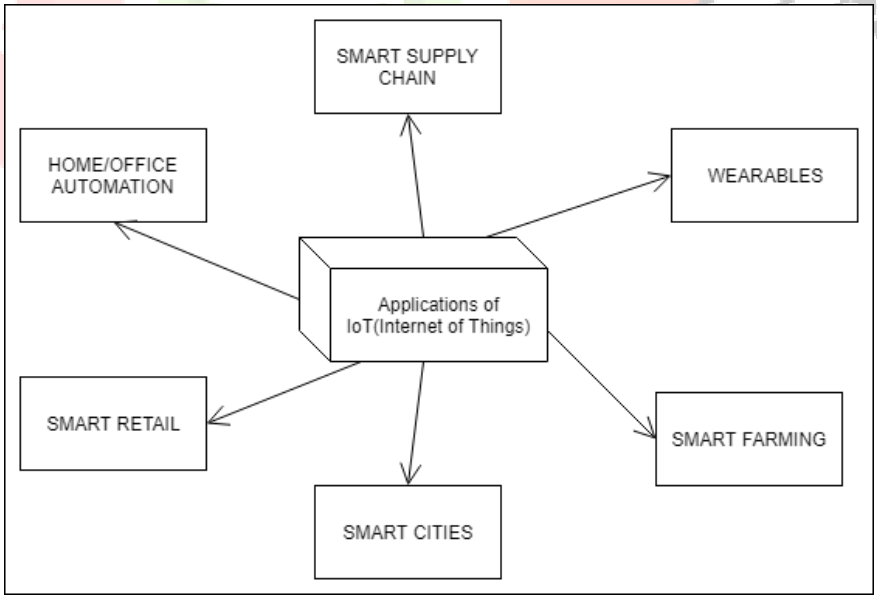

FIGURE 1.1: Applications of IoT

1. Smart Supply Chain: Supply chain is the heart of any business process and can be defined as a set of processes that include obtaining the raw materials, production of a product and also delivery of the products. Smart solutions using IoT can therefore generate value in this sector and help businesses grow. These solutions may include dynamic and automatic order placing of raw materials or automatic control in a certain production process and so on.
2. Home/Office Automation: This is another interesting and popular application of IoT, where various things in a home or office are made smart by attaching sensors to them and giving them a certain identity. This includes applications such as automatic temperature control of a room using sensors near an air-conditioner, or a smart system for watering the plants when the owner cannot do them manually and so on.

3. Smart Retail: This application of IoT involves reduction of human machine interaction thus reducing the time involved in obtaining the products, billing and so on. For example, smart shopping baskets which automatically bill the items picked by the user and thus eliminates the need for waiting in the long billing counters at large stores.

4. Smart Cities: Smart Cities are basically a combination of various IoT solution that include smart homes, smart hospitals and also smart roads, this a solution to various problems faced by cities around the world by connecting various things to each other thus allowing them to communicate and help in making the lives of the people easier. For example, a group of traffic signals communicating automatically to create a fast passage for an ambulance travelling in the route may save lives.

5. Smart Farming: Cultivating in India is finished utilizing the unremarkable ways. The way that the vast majority of our farmers need appropriate learning makes it significantly more inconsistent. Here IoT can help in providing notifications to farmers regarding crop monitoring and so on.

6. Wearables: This is surging trend in the world where the body vitals such as heartbeat, body temperature and calories burnt and so on are measured and hence help in health monitoring. These devices are highly portable and hence are ideal solutions to health monitoring. These wearable devices are worn by joggers, who can monitor their body vitals such as heartbeat and calories burnt in real-time.

IoT provides seamless solutions in applications where human intervention should be reduced as much as possible to reduce human errors and also provide real-time solutions without conceding on data integrity or accuracy. Few of the advantages are diagrammatically represented in Figure 1.2, and they are inclusive of automation, efficiency and communication among many others. The main advantage of IoT is efficiency, where IoT is able to accurate and real-time information. Secondly, IoT provides automation where human intervention reduces drastically, and therefore the need for supervision by people is reduced. IoT also provides cost-effective solutions and more reliable information in terms of integrity and security.

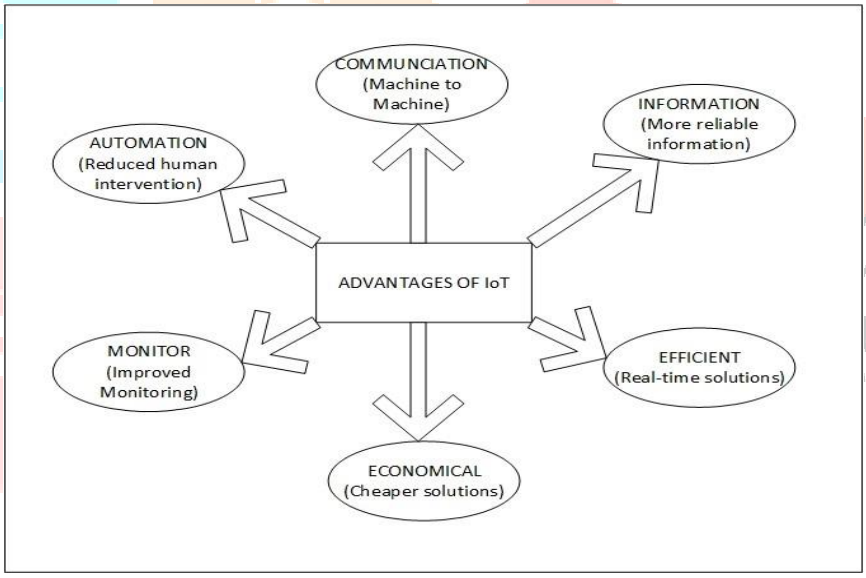

FIGURE 1.2: Advantages of IoT

Though hospitals cannot avoid critical procedures like surgeries and treatments, the post-surgery and the post-treatment observation time in hospitals need to be reduced and hence allowing hospitals to accommodate the people who actually need care. Also, the health monitoring of patients in this stage consumes the time of care-givers. This may adversely affect the care-givers, their health and careers. Therefore, these caregivers need to monitor the health of their loved ones and also lead their own lives. Our proposed system provides that solution to the care-givers and allows them to monitor the patients and also gives them the confidence to lead their life without having to worry about monitoring the patients.

Considering these factors, our proposed system provides the real-time, and accurate monitoring of patients suffering from chronic diseases especially heart-related diseases. This system will provide real-time monitoring as well notify the care-giver of any disturbances in parameters such as pulse rate, body temperature and so on.

II. BACKGROUNG WORK

There are various limitations of the existing systems that are trying to solve this issue and they are:

1. The need for these devices to be in close proximity to the care-givers: There are some devices that use either Bluetooth or ZigBee where the range is limited to 100 meters, so the need for care-givers to be in close proximity to the patients wearing the device is a pre-requisite, this doesn't solve the need for remote monitoring.

2. No source and destination initiated: The other drawback of these devices is that they cannot monitor both ways, that is, the care-takers cannot monitor the parameters whenever they want, and the device informs the care-givers only if there is an emergency and if this message/notification fails, then the care-giver is oblivious of the abnormalities.

3. No continuous monitoring: These devices provide notifications to the care-givers, but there is no continuous collection of data and monitoring of patient and hence the care-givers may find it difficult to trust these devices in informing them about any abnormalities in the health of their loved ones.

4. Costly devices: The devices that provide the monitoring in hospitals are very costly and also sometimes not affordable to the people. These devices cannot be purchased for home use as they would be a very big investment for most people.

5. Portability of these devices: The existing systems in hospitals and healthcare centers, are very heavy and cannot be ported from one place to another easily, and hence these devices need people to stay at one place and monitor them accordingly.

ARDUINO BOARD

The Arduino board is an open-source design. The hardware and its designs are covered under the Creative Commons license and are available on the internet for anyone to implement and also enhance it for their own applications if possible. There are various versions of this file as well and all are available on the same internet resource. The sketches for the IDE is released under the GNU V2.

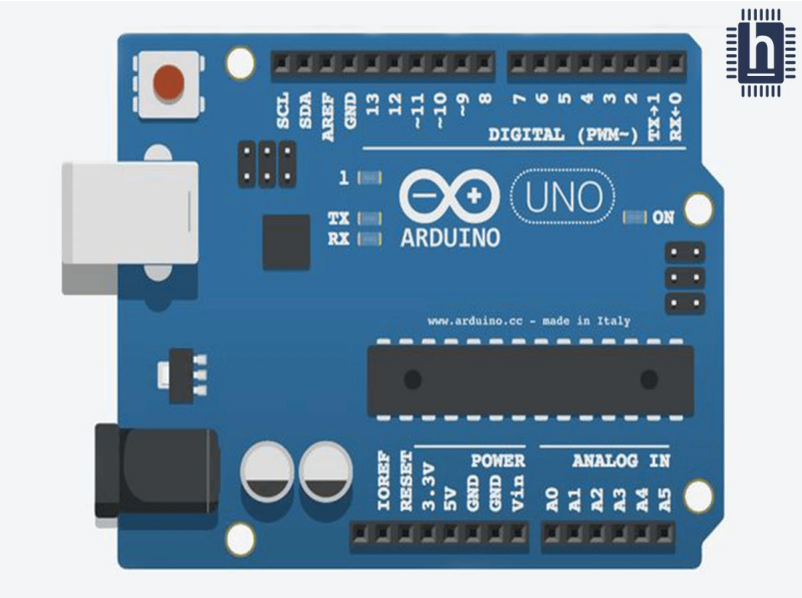

FIGURE 2.1: Arduino Uno

This Arduino board acts as the brain of our proposed system because it is powerful and efficient enough for the proposed system.

TEMPERATURE SENSOR

The temperature sensor is the LM35 which is a high-precision low noise sensor that show the output proportional to the temperature. This sensor is most robust to noise and possesses very low self-heating that may provide wrong values. This sensor operates under temperatures from -55°C to 150°C. The voltages of this sensor vary every 10mV for every degree change in Celsius.

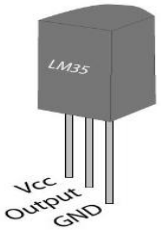

FIGURE 2.2: LM35 Sensor (Pin Diagram)

PULSE SENSOR

The principle of plethysmography is the basic principle that this pulse sensor considers, there is change in the light intensity through the organ when there is change in the heartbeat. This principle helps us in getting the pulse values from the sensor. This

sensor is usually attached to the top of the index finger and hence helps in providing the most possible accurate value of the heartbeat. Figure 2.3 shows the pulse sensor being used.

FIGURE 2.3: Pulse Sensor

TILT SENSOR

The tilt sensor is a transducer, that gives the horizontal and vertical solution that allows use to find the tilt of the sensor and hence find the tilt of the attachment. We will use this as a way to check if a person is falling forward that is, if an aged person falls down from his bed.

FIGURE 2.4: Tilt Sensor

NODE MCU

NodeMCU is a platform which is open-source and is a SoC (System on Chip) and contains the Wi-Fi module and is based on ESP-12 module. "NodeMCU" is a firmware and doesn't mean the development kits. It is based on eLUA project and built on the Espressif SDK for the ESP8266 and makes use of various open source projects.

FIGURE 2.5: NodeMCU

The NodeMCU programming model is like that of Node.js, just in Lua. It is nonconcurrent and occasion driven. Numerous capacities, along these lines, have parameters for call-back capacities.

III. PROPOSED SYSTEM

The proposed system will be worn by the user and the sensors will sense the data like body temperature, pulse, and also blood pressure of the wearer and will notify the same to the doctor or the patient. The system will inform the care-giver and a designated doctor the data about the patients and intimate them of any abnormalities in health. The Wi-Fi module will help in communication between the device and the smartphone with the data. The mobile application will provide a graphical representation of the sensed data. The block diagram of the proposed system is shown in Figure 3.1.

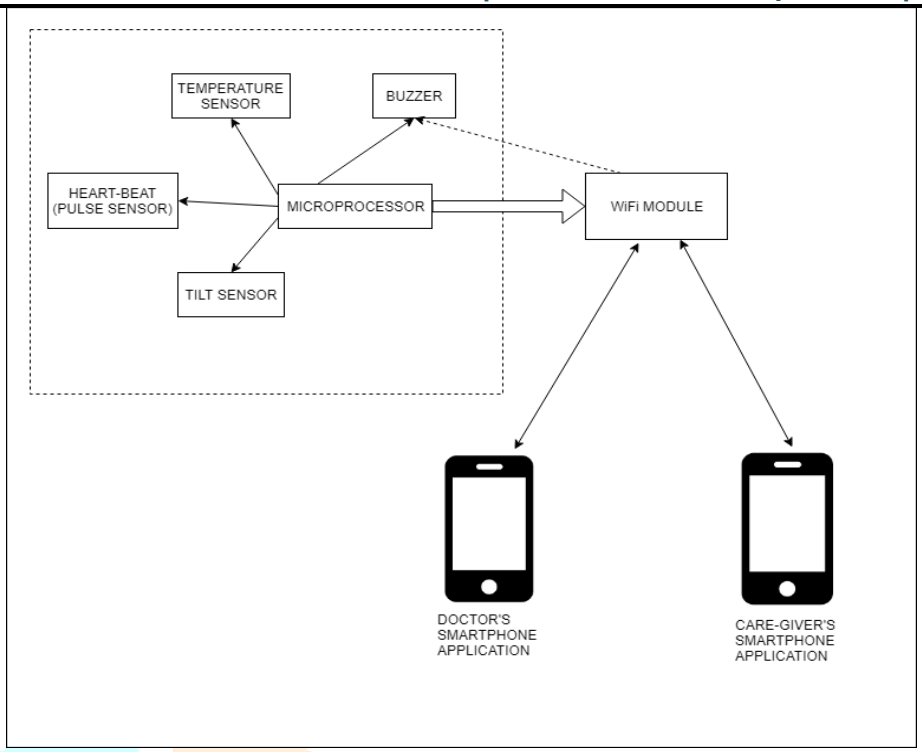

FIGURE 3.1: Block diagram of Proposed system

The diagram shown above is the schematic block diagram of how the proposed system would work. The system consists of a wearable device with a microprocessor as the brain and the sensors such as the heart-beat, temperature and tilt interfaced with it. This device will also have a buzzer which alerts the people near the patient if the patient needs attention. This buzzer though is not very helpful when the patient is in isolation, it may help if there are people around. The pulse sensor detects the pulse of the patient and have noise cancellation circuitry as well on board, and hence it can provide reasonably accurate data to the microprocessor. The temperature sensor detects the body temperature of the patient and notifies if the patient is running a fever. The tilt sensor is another important addition to this device as it can detect if a patient is falling down from a position and hence a buzzer as well goes off intimating both the care-giver via the app, and also alert any people passing by.

The microprocessor uses Wi-Fi module that can be interfaced and helps in communicating the data to the application, this Wi-Fi module is interfaceable with the microprocessor and allows the data sensed from the three sensors to be communicated to the mobile application. The mobile application displaying the values of all sensors and also notifying the care-givers and/or the doctor through an e-mail as well as an app notification. This notification will help the care-giver take necessary action, such as calling an ambulance in an emergency situation, or calling someone to take care of the patient or go and take care of the patients themselves.

When the proposed system is turned on and all sensors is working ideally, the sensors collect the data which includes the body temperature, pulse and tilt. These sensed values are computed and displayed on the mobile application and checked for any deviations from the normal i.e. deviations from the preset value. If there is in fact an abnormal reading, the notification is forwarded to the mobile application of the care-giver and also the designated doctor with necessary details like his body vital parameters. This sensing and communication happens in an infinite loop provided the device is powered on and all sensors are working ideally. The security of the data is maintained with a key provided to pair only the mobile application and the proposed device. This ensures that the critical data is kept confidential, and not accessed by any unauthorized person.

IV. EXPERIMENTAL SETUP

The device was tested every 30 minutes in a day on a person in room temperature and under normal circumstances.

SENSOR VALUES TESTED FOR EVERY 30MIN			
No of Observations	Heart Rate	Temperature(in celsius)	Tilt Sensor Reading
1	83	32	0
2	84	32	0
3	84	32	0
4	80	33	1
5	13	35	1
6	89	35	0
7	85	32	0
8	86	32	0
9	83	34	1
10	82	34	0
11	85	35	0
12	98	33	0
13	103	33	0
14	82	32	0
15	82	32	1

FIGURE 4.1: Experimental values observer for each sensor

The patient was made to wear the device in a room with room temperature 30-degree Celsius. The data was read from the mobile application every 30 minutes throughout the day and the results were noted for analysis. The pulse sensor showed a wrong reading 13 in a day and this was confirmed to be a anomalous reading. The other readings were as expected. The tilt sensor shows "0" when it detects no tilt and "1" when the patient was tilted forward, I other words bent forward. These readings provided us with the actual values for the patient and hence monitoring was done throughout the day.

The heart-beat(pulse) reading is considered to be normal when between 70 BPM (Beats per Minute) and 100 BPM (Beats per Minutes) and the temperature value varies between 35-37 when the person has normal temperature which is said to be 97.5F to 99.0F. The patient had no fever throughout the day as confirmed by the monitoring device he was wearing. At the time of reading if the tilt sensor detects a tilt of the body it records the value as 1 and if not, then the patient is said to be in an upright position.

V. CONCLUSION

The proposed system can be used to monitor heart rate and temperature of patient along with tilt sensor which is used to detect if a patient is falling from a position and notify the care-givers. The proposed system is expected to monitor the heart rate and temperature of the patient from remote location. It also enables features for the aged persons who want only a monitoring device that can detect a fall or other interruption in every day activity and report it to emergency responders or family members. There are many advantages of this proposed system which include reduces clinic visits, Lower health expenses, and length of stays in hospitals. The proposed system has few challenges as well along with the advantages such as position of sensors plays important role, if the sensors are not placed in proper location it might give anomalous reading. Therefore, this system will surely provide the healthcare domain with a solution to the challenges of health monitoring systems.

As part of future work, the design of the system could be improved. We can enhance the design by adding more sensors such as motion sensor, blood pressure monitor and other devices which measures various body parameters. This makes the system more advanced.

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