

Development of an IoT Based Health Monitoring System for e-Health

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Abstract—Healthcare monitoring system in hospitals and other health institutes has increased significantly. In recent days healthcare monitoring systems with new technologies are becoming of great concern to countries all over the world. Nowadays IOT (internet of things) is such an emerging technology. Iot consists of various sensors and communication devices which are necessary tools for IOT based health monitoring systems. Among the various applications that Internet of Things (IoT) facilitated to the world, Health care and Health monitoring applications are most important. It also responded if any medical emergency was needed. IoT (Internet of Things) has brought a remarkable approach in healthcare during the global pandemic. The remote health surveillance monitors certain parameters of a patient using digital technology and allows a correct evaluation of health right at home. This brilliant internet revolution has not only minimized patient movement during COVID but also ensured smart healthcare for all ages. IoT heads to set up a strategic connection between the patient & the doctors. The goal is to track the important health parameters such as – Blood pressure, heart rate, blood glucose level etc. and evaluate the data to figure out any sort of medical emergency. From diagnosing heart disease to finding ICU bed availability in the nearest hospitals, digital technology is all set to assist. Using certain medical sensor devices & web-based apps, the health data is passed to the portal from where concerned doctors can provide medical assistance. The data collection, transmission & visualization can use a smartphone as a hub, thus making the operation smooth & flexible. It is the most practical & economical solution to people of all ages while avoiding direct contact & preventing the spread of the virus. The wearable real-time health tracking devices privilege the elder citizen through continuous monitoring while ensuring immediate measures in case of emergency.

In this paper, a review of IoT based smart health monitoring systems is presented. The latest innovative technologies used for IoT based smart health monitoring systems with their benefits and challenges have been discussed. This review's goal is to effectively and continuously monitor the multiple patients in a hospital ward and as well as remotely located patients so that it will ultimately reduce hospital operating costs, all other communication costs and improve the quality of health service.

Keywords—IoT, Sensors, patient monitoring, medical devices

I. INTRODUCTION

Not just the absence of illness, but a complete condition of physical, mental, and social well-being can be defined as health. People's basic demand for a better existence includes their health. However, the global health crisis is worsening by the day due to a number of fundamental issues, including poor health services, widespread discrimination between rural and urban areas, rich and poor, and the lack of doctors and nurses at critical times.

Cardiac diseases, lung failures, and heart-related ailments are on the rise, along with a variety of other illnesses. It is vital to monitor the health of elderly individuals at home or patients in hospitals and other medical facilities, but doctors and nurses must maintain regular watch.

IoT and various sensor-based health care and monitoring systems have been quickly growing in popularity in recent years. The prototype device [1] provides user-friendly voice recognition and alert functionality by utilizing a smartphone as the data computing platform. IoT-based health monitoring systems are becoming more widespread all over the world, thanks to the advancement of technology. These devices can be used to capture real-time health data and provide patients and medical specialists with immediate feedback. It also enables everyone to test their health status and be alerted to take appropriate action in the event of an emergency. This warning could lead to the person's life being saved. Medical fees and other medical costs can be reduced by using these health monitoring solutions. Due to the widespread availability of mobile internet connection, combining mobile internet with a health-care system based on an open-source Android architecture has become quite simple. [2].

In recent years, the Internet of Things (IoT) has ushered in a technological revolution, and it is widely seen as the next big thing that will make people's lives more intelligent, efficient, and convenient. Smart health monitoring system [3], smart parking [4], smart home [5], smart city [6], smart climate system [7] are some examples of IOT-based smart applications. The healthcare industry, which provides 24 hour health care and monitoring facilities, is one of the most significant uses of IoT.

Electrocardiography (ECG) has become a standard medical procedure for all patients. An ECG can determine the heart's functionality by measuring the difference in voltage created by the cardiac muscle [8]. Doctors and others can use IoT devices to monitor the heart rate while also receiving accurate data and taking action to avert serious harm. Heart rate and body temperature are also vital characteristics of the human body, and they can play a significant part in establishing a patient's health status. By using sensors, IOT-based Smart health monitoring devices can identify the health state, such as the rate of the pulse, core body temperature, breathing rate, blood glucose rate, ECG, EEG, and other things [9]. In [10-21], different IoT based patient monitoring systems have been presented.

Various microcontroller-based systems, such as Arduino, Raspberry Pi, and others, link and control the sensors used in IoT devices. Sensors are used by the microcontroller to collect data. This medical data obtained by IoT devices is kept on servers for future use. The device can determine the current state of the patient's health after

gathering data. It can tell whether a patient's condition is normal or atypical. These internet of things gadgets also provide doctors and medical assistants with real-time health care observation that they can utilize anywhere and at any time. The key benefits of these devices are their low power consumption,

ability to provide higher performance than standard medical equipment, high sensitivity, and dependability.

In this study, we will look into IoT-based healthcare systems, which comprise sensors, smartphones, and microcontroller unit-based techniques, as well as the systems' working procedures, problems and constraints, and operating capability. Our major goal is to offer a technological and economic model for an IoT-based medical system for easier and more comfortable medical services for all types of patients, as well as the impending problems and complications in adopting IoT in the real world medical area. The paper's main purpose is to use IoT to find real-time medical data and statistics about a patient. To be able to predict any sickness or disorder in its early stages in order to cure it. Our goal is also to examine the advantages and disadvantages of IoT-based devices, as well as people's perceptions of IoT-based devices, survey results, and how we can give IoT-based healthcare solutions to a variety of patients at any time and from any location. In section 2, we describe numerous sensors, devices, Arduino, and other components, their applications, and how they work in IoT-based medical devices. Section 3 contains the results and analysis of IoT devices, as well as comparative tables and research data on people's attitudes toward IoT. After that, the review comes to a close in Section 4.

II. METHODOLOGY

Directing IoT-based healthcare and health monitors The framework and sensors will be examined, which monitor the patient's heart rate and core body temperature and then send an email/SMS alert if the values deviate from basic attributes. MySQL database is used to store heartbeat rate and body temperature information so that this system can be controlled from anywhere on the earth over the internet. It also contains a mechanism that may send email/SMS to their family, doctors, and medical specialists in the event of a crisis. Secure data communication is required if we are to develop this connection. This connection's key issue is not only data transmission, but also privacy. A cloud server is also required. This cloud server can be shared by several verified users upon request. After 10-15 minutes, records will be updated on a regular basis. It updates its data every minute in emergency and critical mode. The results will be sent to the phone using Bluetooth or NFC technology from the wireless device. When you connect to cloud servers, you can get results where each patient is assigned a unique address. As a result, transmitted data in the cloud can identify and authenticate the correct patient before delivering the requested information to the patient.

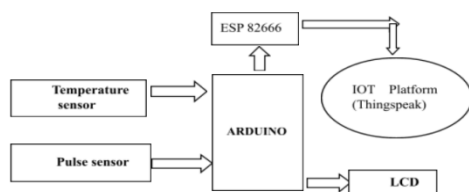


Fig 1: Flowchart of Health monitoring system [10]

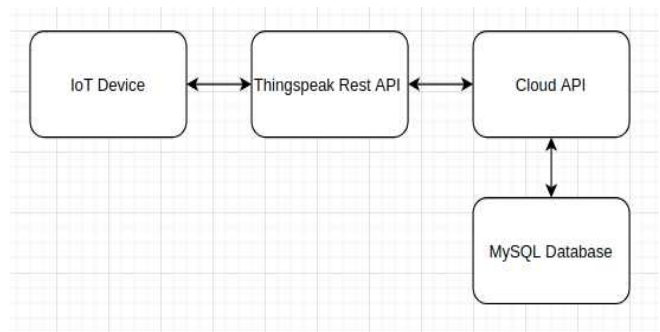


Fig 2: System Architecture

From the above Fig-3 it can be seen that the IoT Device is sending the data to the cloud api. API processes those data and stores them to the MySQL database. The api checks if all the data are in normal range, If the api finds any abnormality in the data, it immediately sends an alert message to the patient and hospital's phone number.

Component	Normal Range
Blood Pressure	80-120 mm Hg
Body Temperature	36.5-37.5° C
Heart Rate	60-120 beats/min

Fig 3: Normal Range of Blood pressure and Heart Rate

The cloud api checks for the above Fig-3 data range. If it doesn't get the values from the IoT device in this range, it triggers an alarm.

For data security Public Key Cryptography / Asymmetric Encryption is used. This encryption makes the data safe from Man In The Middle Attack.

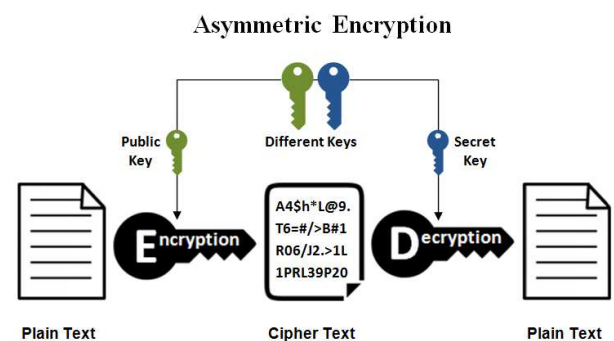


Fig 4: Asymmetric Encryption

While sending the data the IoT devices encrypt the data using the public key of the teamspeak and if needed to the cloud api. Then only cloud api can decrypt the data using its own private key. Similarly if cloud api needs to return the data to the IoT devices it encrypts the data using IoT devices public key. To encrypt and decrypt the data BearSSL library in arduino has been used.

A. Temperature Sensor

Not only is data transfer a major concern with this link, but so is privacy. You'll also need a cloud server. On request, numerous confirmed users can share this cloud server. Records are updated on a regular basis every 10-15 minutes. In emergency and critical mode, the data is updated every minute. From the wireless gadget, the results will be communicated to the phone using Bluetooth or NFC technology. When you connect to cloud servers, you can acquire results that provide each patient their own address. As a result, before delivering requested information to the patient, received data in the cloud can identify and authenticate the proper patient.[11].

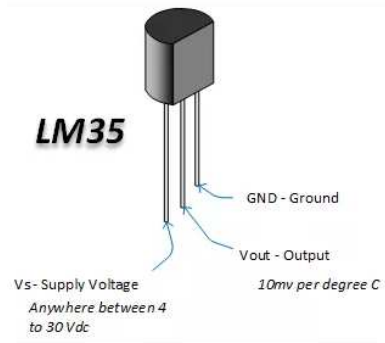


Fig 5: Temperature Sensor

This sensor has the following features:

- It has an analog output voltage which is proportional to the temperature
- Any calibration isn't required for this sensor
- Provides the output voltage in celsius
- If the temperature increases, the output voltage also increases.

B. Pulse Sensor

A pulse/heartbeat sensor is another essential sensor for IoT devices. Pulse Sensor is an Arduino heart-rate sensor with a well-designed plug-and-play design. Students, artists, sportsmen, makers, and game and smartphone developers can all utilize it to incorporate real heart rate data into their work. With some jumper cables, the sensor attaches to a fingertip or earlobe and connects to the Arduino. It also comes with an open-source monitoring app that displays your pulse graph in real time. Both sides of the sensor are visible. On one side, the LED is paired with a light sensor, while on the other, circuitry is present. On the front, the LED remains. The sensor is also regulated and placed over a vein in our bodies. Regardless of whether it's a fingertip or an ear tip, the top of the vein should be placed. The Pulse Sensor is a plug-and-play heart rate detector for Arduino enabled devices. [12].

This sensor has the following features:

- Very easy to use. Plug and play type sensor.
- 4mA current utilisation
- It has its own noise cancellation



Fig 6: Pulse Sensor

Pin-1 is for ground, Pin-2 is for VCC and Pin-3 is for the pulse signal.

C. Wifi Module

The ESP8266 WiFi Module is a self-contained SOC with an inbuilt TCP/IP protocol stack that can provide WiFi access to any microcontroller. The ESP8266 may host an application or outsource all WiFi networking functionality to another processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, so you can just plug it into your Arduino and get about as much WiFi functionality as a WiFi Shield (right out of the box)! The ESP8266 module is a low-cost board with a large and growing community.

This module offers sufficient on-board processing and storage capability to allow it to be integrated with sensors and other interface devices via its GPIOs with moderate development and load during operation. Its high on-chip module enables for minimum external circuitry, and the front-end module is designed to take up as little PCB coverage as possible. The ESP8266 features APSD for VoIP applications and Bluetooth coexistence interfaces, has a self-calibrated RF that allows it to work in any environment, and doesn't require any extra RF parts.[13].

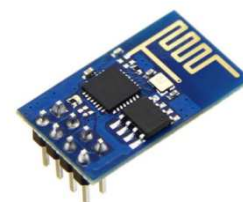


Fig 7: Wifi Module

D. Arduino

Arduino is an unrestricted tool for making electronic projects. Arduino is made up of a mechanical programmable circuit board (also known as a microcontroller) and an application called an IDE (Programming Language) that allows computers to write and transmit code to the physical board.

With good reason, the Arduino platform has risen in popularity among individuals who are just starting with

electronics. The Arduino, unlike most previous programmable integrated circuits, does not require an external device (known as a programmer) to load fresh code into the board; instead, all that is necessary is a USB cable.. Additionally, the Arduino IDE simplifies programming by employing a simplified version of C++. Finally, Arduino has a standard form factor that divides the microcontroller's functions into more understandable chunks. [14].

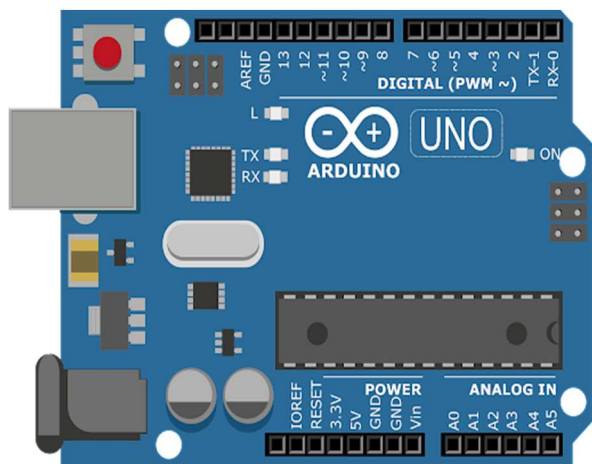


Fig 8: Arduino Uno

E. IoT Platform

ThingSpeak is a cloud-based IoT analytics tool for aggregating, visualizing, and analyzing live data streams. Using online services like Twitter® and Twilio®, you can transfer data from your devices to ThingSpeak™, generate live data visualizations in real time, and issue alarms. You may conduct preprocessing, visualizations, and analysis using MATLAB® analytics within ThingSpeak. Many devices and platforms are used in the Internet of Things system, and Thingspeak is one of the finest platforms for data transfer in IoT-based health monitoring systems. It works by allowing data to be delivered and received from any device with an internet connection. It also has a warning system built in. This system relies heavily on real-time information [15].

F. LCD

A 16×2 character LCD is used. The operating voltage of the LCD is 5v and 80 x 36 x 12 mm is the module dimensions. In total it has 16 pins. To connect it with Arduino physically the specification of the LCD was followed and to give command to LCD from arduino programmatically a arduino library 'liquidcrystal.h' was used.

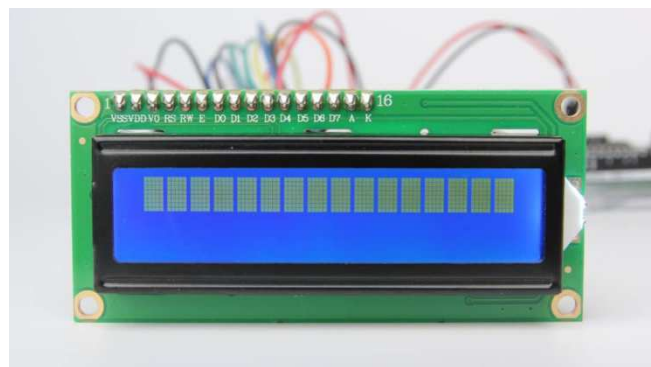


Fig 9: LCD

III. DISCUSSION AND ANALYSIS

We can connect iot-based gadgets to the medical system using the above sensors. We may use this type of system to create a Health Monitoring System that calculates pulse rate and body temperature and monitors the patient's body in real time. This device is capable of sending emergency signals to doctors or patients' relatives. It also helps us save time and money. The review paper's major goal is to connect all types of people with smart healthcare surveillance systems that will provide them with hassle-free medical treatment. Individual modules utilized in an IoT system, such as pulse detection, temperature detection, and others, yield the following results:



Fig 10: Result of Heat Beat Detection [16]



Fig 11: Result of Panic Detection [17]

The above two figures show the heartbeat rate that is collected from the IoT device. In Fig 7 the heart beat rate is between 80-100, which is a normal heart beat rate.

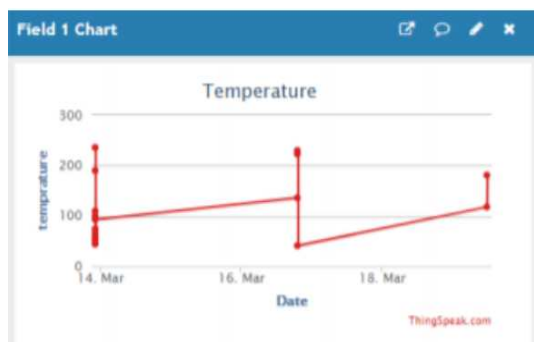


Fig 12: Result of Temperature Detection [18]

the Internet of Things (IoT) is seen as a way of living a smarter and safer life and its application is highly encouraged in medical establishments. Do u agree with this?

19 responses

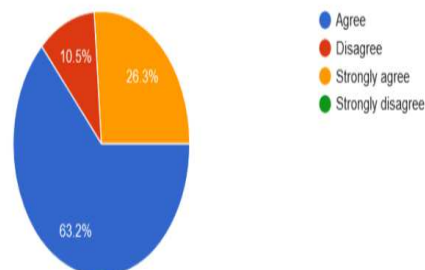


Fig 15: Survey Response-3

IV. SURVEY AND RESULTS

As part of our review article, we conducted a survey on IOT (internet of things) based health monitoring systems in Bangladesh, as well as their benefits, drawbacks, and limitations. We received a variety of viewpoints from many individuals. We got their thoughts, recommendations, and opinions on an IoT-based health monitoring system. Our internet of things questions and findings are shown below.

lot based health monitoring system is especially important for preventing the spread of infection in COVID-19 pandemic. What could be main reason?

19 responses

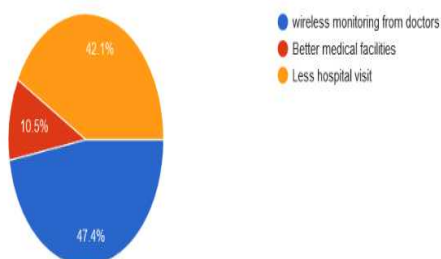


Fig 13: Survey Response-1

What are the main benefits of IoT in healthcare?

19 responses

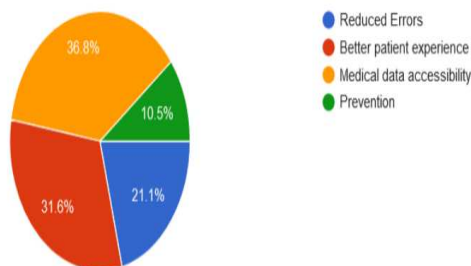


Fig 14: Survey Response-2

What are the main benefits of IoT in healthcare?

19 responses

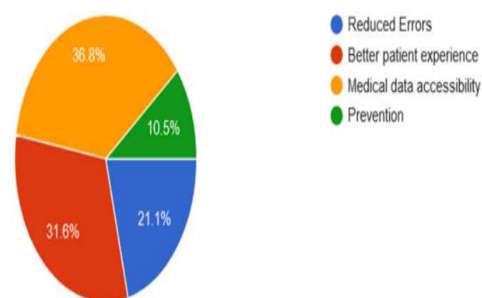


Fig 16: Survey Response-4

Do u think using iot devices could reduce cost in medical sector?

19 responses

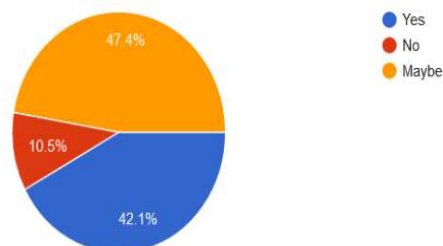


Fig 17: Survey Response-5

Is it will be a problem for availability in iot driven devices Such as Sensors and tracking devices in Bangladesh?

19 responses

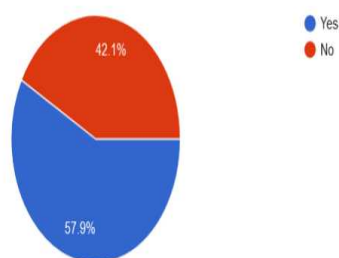


Fig 18: Survey Response-6

Do You know about iot in healthcare?

12 responses

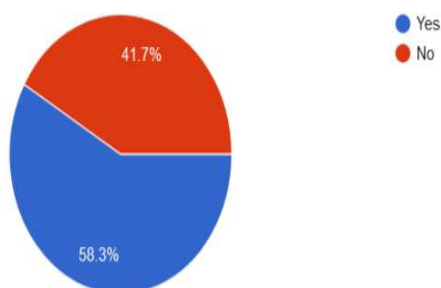


Fig 19: Survey Response-7

Do you think iot based health monitoring system can Improve treatment management?

19 responses

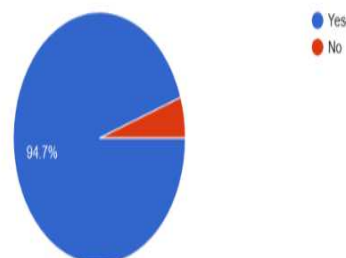


Fig 20: Survey Response-8

According to the results of the poll, the majority of respondents believe that an IoT-based health monitoring system can improve enabled service in Bangladesh. However, many people are unaware of the internet of things and its benefits, and the lack of IoT-based sensors and other communications equipment is also a huge worry. They are unsure whether IoT-based devices can help them save money on medical bills. They also believe that implementing IoT devices will reduce errors and improve medical services. According to some, during the Covid 19 Pandemic, IoT devices will have a significant impact in the medical sector due to fewer hospital visits and wireless remote monitoring.

V. CONCLUSION

This article provides an overview and synopsis of the IOT-based health monitoring system. This article discusses several IoT-based Health Monitoring technologies and applications. The complete process of an IOT-based Health Monitoring system is described and analyzed in this study, which includes methodologies, applications, implementation, and procedures. Every new and old technology has its own set of advantages, disadvantages, and difficulties.

The Internet of Things (IoT) has the potential to make a significant difference in the health-care system through health-monitoring technology. A global pandemic is threatening the planet. Health monitoring systems based on the Internet of Things can monitor real-time health data, which doctors can review at any time. The data is given to the Doctor, and they are free to utilize it whenever they want. Patients and medical specialists can receive comments from doctors at any time. This will take time and energy, but it will result in higher performance and be beneficial to all. Doctors' supervision is particularly important during the COVID 19 crisis, and the IOT-based health monitoring system has brought a notable approach in the global pandemic. The summary of this research instructs us on which techniques and procedures to employ in order to increase the quality of IoT-based Health Monitoring systems..

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