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Research Article

Modern Health Monitoring And Analysis Using Iot Technology

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Abstract

The Internet of Things is evolving constantly and rapidly by connecting devices and interacting with people. It is very important to apply effective, safe and secure solutions to encourage people to enroll for services in the IoT network. Electronic signatures, smart encryption, and robust laws are needed to control the use of private data by hospitals and third parties.In this paper, we will discuss on how to acquire the SPO2 concentration, Heart-Rate and Temperature of a person to monitor the variations in its value and update accordingly to the doctor or the caregiver using Raspberry PI 3 which acts as a mini-computer as the processor and displays the measured values in the form of graph with assigned threshold value limits on the web-page or Thingspeak that has been created for this specific purpose so that the doctor gets a clear idea on where the condition of the patient holds and also on how to treat patients when their severity increases .

Keywords – IoT, Internet of Things, future scope, healthcare system, hospitals, health sector, data privacy, security, challenges , Raspberry PI 3, Thingspeak.

1. Introduction

Internet of Things (IoT) which consists of micro-controllers, sensors and transceivers to interact with the web and initiate communication. It is designed with protocol stacks to connect devices together and interact with the users. A lot of applications have been developed on the basis of IoT where every object uses sensors to connect to the web. We explored some of the latest research and discoveries made about security and privacy of IoT devices. We discussed several legal, ethical, and security challenges related to IoT. IoT personalizes healthcare solutions by keeping digital identity for all patients. With the help of non-invasive, pervasive, and effective IoT systems, it is possible to monitor and analyze patient data. A lot of distributed devices analyze, collect, and pass medical information in IoT healthcare to the cloud in real-time. This paradigm of innovation enables ubiquitous and consistent data acquisition in medical devices over the web (Kodali et al., 2015).

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A Body Sensor Network (BSN) is a special network which has been programmed to operate automatically to connect several implants and sensors placed outside and inside the body. Putting it in monitoring will make cost-saving options and operations flexible to both patients and healthcare professionals. Cases are monitoring, tracking patients in hospital, keeping track of physiological input, and drug management in hospital settings (Khan & Yuce, 2010).

Vitals can help in monitoring overall health and measuring basic functions of the body. It can be made possible in an economic and patient-friendly. It’s important to improve monitoring patients to improve the efficiency of patient care. patients are limited to bed and connected to heavy machines and care providers and doctors have to be around the patients (Vippalapalli & Ananthula, 2016).

All mechanical, computing, and digital technologies are interconnected by the IoT. IoT is the technology booming especially during COVID era for healthcare monitoring. Many casualties have happened because of delays and lack of health information in this age (Singh et al., 2018). This technology uses the sensors to alert the providers and patients. Daily activities of the patient are recorded and alerts are sent to the care providers if any problem persists (Kumar et al., 2020).

IoT is highly capable to make operations successful and analyze surgical improvements. The IoT and its applications can provide better treatment to patients with different conditions during this pandemic. IoT ensures real-time monitoring successfully and can save lives from various issues like heart failure, diabetes, blood pressure, asthma attack, etc. It is possible to connect the smartphone and track the important health records. (Rath & Pattanayak, 2019; Javaid & Khan, 2021).

It will bring a drastic rise in sensors from end users to hospitals. These valuable and vital devices are going to be integrated by patients and doctors in medical records. But there are some challenges that have come up over the years. New security policies will be required by millions of IoT devices related to legal requirements and challenges (AboBakr & Azer, 2017).

There are some ethical and moral challenges related to IoT in terms of social behavioral standards. Ethical behavior basically needs enforcement of privacy, access, and integrity of data. In the field of IoT, here are some ethical issues –

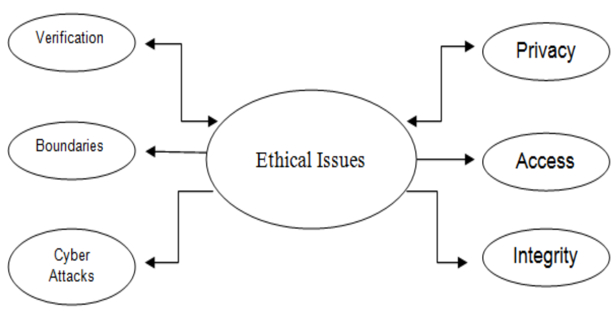


Fig. 1 – Ethical Issues

- **Verification** – It is not easy to determine the right verification of data in the usual IoT system. Data usage has always been a matter of concern without the consent from patients.
- **Private/Public Boundaries** – It is believed that IoT is going to remove the boundaries between public and private life of users, without defined limits for user data.
- **Cyber Attacks** – Virus or cyber attacks can further cause physical and data loss of the systems. The loss will also directly affect the lives of people. Even a small change in data may affect the life of a patient with wrong treatment or medication in case an attacker accesses the IoT application.

It is very important to have proper technical implementation to encourage people to adopt this novel technology. Advanced encryption, strong legislations, e-signatures, etc. are some of the solutions to prevent unauthorized access to the data (AboBakr & Azer, 2017).

Common access and networking can boost sharing clinical information and records of patients over the web. IoT is the best tool for observing patients remotely (Hameed et al, 2016). **Swaroop et al. (2019)** present real-time health monitoring solution for storage of basic patient's data and vitals. Medical practitioners can access the data as an alert and monitor through several means. Currently, only single communication mode is available in healthcare systems, i.e. either web application or GSM. The proposed solution can provide healthcare solutions through GSM, Wi-Fi and BLE mobile applications.

Krishnan et al. (2018) propose an innovative solution to avoid deaths due to heart problems with patient health monitoring that is based on internet and sensors to alert the family of patients in case of any issue. The proposed system uses a heartbeat and temperature sensor to track a patient's status. This sensor shows live data of heartbeat and temperature with timestamps.

Wan et al. (2018) propose a novel solution for personal health tracking, Wearable IoT-cloud-baSed, hEalth (WISE) monitoring solution. The body area sensor network (BASN) framework is used in this system for real-time tracking. It has several sensors like body temperature, heartbeat, and blood pressure monitoring. BASN gathers data and WISE transfers data directly to the cloud. It provides quick insight to health status through a light wearable LCD device.

Different prototypes are already proposed to keep track of patients' health using IoT. **Rahaman et al. (2019)** proposed a smart health monitoring solution based on IoT technology. They have discussed all the pros and cons of this solution and highlighted implementation and design patterns of smart devices.

Pinto et al. (2017) propose an IoT solution for providing care to elderly people by monitoring and registering their vitals and triggering alerts in case of emergency. It is an affordable and power-efficient wireless device that is easy to use and can be used remotely as a cozy and discreet wristband. They obtained up to 306 hours of battery backup (i.e. around 12 days) with a single charge and found decent system performance.

Current Scope of the Internet of Things in the Healthcare Sector

According to Statista (2016), the connected IoT devices are expected to cross 75 billion's mark by 2025. There are several benefits of the IoT paradigm, such as wireless body area networks (WBANs), cloud computing, fog computing, edge computing, technological advances, autonomic computing, and sensors to create new opportunities and horizons that have various applications (Naresh et al., 2020).

1. **IoT Application in Healthcare** – Naresh et al. (2020) identified many applications and categorized them with similar themes and scope, such as (1) Real-Time Alerts and Monitoring, (2) Telemedicine, (3) Detection and Prevention of Chronic Diseases, and

(4)Elderly Healthcare (Fig.2).

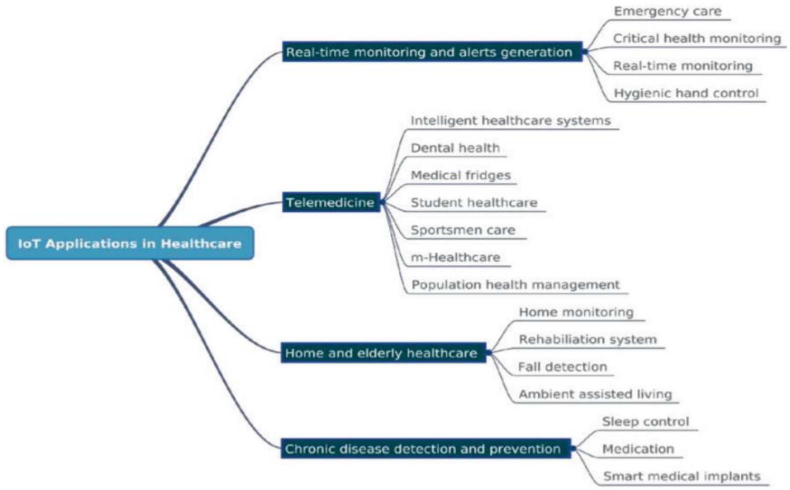


Fig.2. IoT Applications in Healthcare (Naresh et al., 2020)

- **Real Time Alerts and Monitoring** – It is possible to deploy the sensors on the human body and check various parameters using IoT. Doctors can analyze this data and suggest the right medication and treatment when needed. Shanin et al. (2018) introduced an e-health monitoring system to keep track of temperature, heart rate, foot pressure, and ECG. It is a flexible and power-efficient system which tracks GPS location of patients for emergency care, RFID to track patients, and Thingspeak and Arduino Uno for data analysis as middleware and MCU (Microcontroller Unit), respectively.
- **Telemedicine** – Zouka & Hosni (2019) developed a smart healthcare monitor which uses fuzzy systems and neural networks to analyze data with sensors like ECG, temperature, pressure, heartbeat monitors, and pulse oximeter. The data is processed by “Fuzzy-based Inference System (FBIS)” and Azure IoT Lab using the GSM module. It helps doctors to provide emergency care with a remote health monitoring app and M2M system for patient monitoring.
- **Detection and Prevention of Chronic Illnesses** – Chronic diseases like depression is one of the most serious complication. Kumar & Bairavi (2016) proposed a health monitor for patients with autism. This system gathers data with neurological sensors and reads EEG waveforms, and sends alerts to care providers if any abnormal readings are recorded. It sends notifications to doctors through email.
- **Elderly Healthcare** –Abdelgawad et al. (2017) proposed a health monitoring solution for assisted and active living. They created a prototype to test the system, which uses six different types of sensors, viz. sensor interface circuits, BLE-powered indoor positioning, Wi-Fi transceivers, Raspberry Pi2 (microcontroller) and cloud server.

2. Smart Healthcare Monitoring System

Smart health monitoring systems are able to determine the pulse rate, respiratory rate, body temperature, body position, blood glucose, EEG, ECG, and other vitals with sensors. The sensors are controlled and connected with several micro-controller devices like Raspberry Pi and Arduino Uno. The data is collected by these micro-controllers with sensors. The servers store the biomedical data which has been collected. The device diagnoses the condition of the patient with the collected data.(Rahaman et al., 2019).

Future of the Internet of Things in the Healthcare Sector

The Healthcare sector was quite slower in adopting IoT initially than other industries. However, the Internet of Medical Things (IoMT) has arrived as a new concept to change the game. It is all set to turn the ways people ensure safety and health in a cost-effective manner. In 2015, IoT healthcare was a $28.42 billion market. With a CAGR of over 28.2%, it is predicted to grow up to $534.27 billion by the end of 2025 (Singh, 2019).

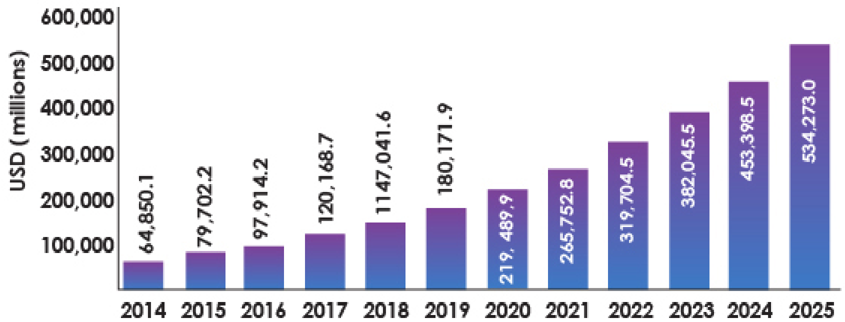


Fig.3 – **IoT Healthcare Global Market Projection (Singh, 2019)**

Here are some of the ways and possibilities for IoT in future advancements -

- **Post Covid-19 (wearable healthcare system) -** COVID-19 pandemic has literally made human lives tougher, especially for patients, healthcare and front-line workers (WHO, 2020). Across the world, in third world countries to be specific, there have been many reports proving infection in common people when they visited hospitals during COVID-19. Some hospitals were even turned into COVID-19 care centers and many diagnostic centers, clinics, and hospitals were closed for elective procedures. This way, wearable devices and sensors like 'e-skin' or 'electronic skin' are developed for 24x7 monitoring of overall health. Generally, these e-skins are transparent, flexible, stable, and stretchable (Takei et al., 2010; Kaltenbrunner et al., 2013; Sekitani & Someya, 2010). Wearable sensors are directly touched by skin. So, these sensors and devices should be made with care. These sensors should be highly flexible without causing any pain to the skin.
- **Cloud Computing, IoT Driving Healthcare Digital Transformations -** In 2021, telehealth will witness significant growth in planned investment to 75% from 42% in 2020. Adoption of telemedicine platforms enables healthcare organizations to improve in several aspects. For example, appointments can be made by 63% of patients using an official portal. In addition, 34% patients can access medical records, 61% can pay and view bills online, and 33% can interact with doctors securely through online mode.Machine learning and AI will provide automation and compassionate care to the patients and save their money and time in billing cycles (McGrail, 2021).

3. Securing Medical Devices

There is always a high risk in healthcare organizations from ransomware attacks, especially because of some connected devices using obsolete programs. These networks use IoMT, IoT and OT devices and they often have various operating owners which further complicate things.It is important to have a common platform to secure all devices.This platform helps in discovering all devices and keeping track of security vulnerabilities. It can also send alerts on weak passwords,

product recalls, etc. Healthcare providers can determine and mitigate risks with monitoring and visibility (Vickers, 2021).
It is vital to have proper know-how of actually what is connected to the network to deal with such security issues. These devices have some common and particular networking patterns like medical devices requiring a central server or cameras requiring a camera management program. It is possible to define the unique patterns of each device to profile the exact behavior of them (Vickers, 2021).

2. Methodology

2.1 Block Diagram:

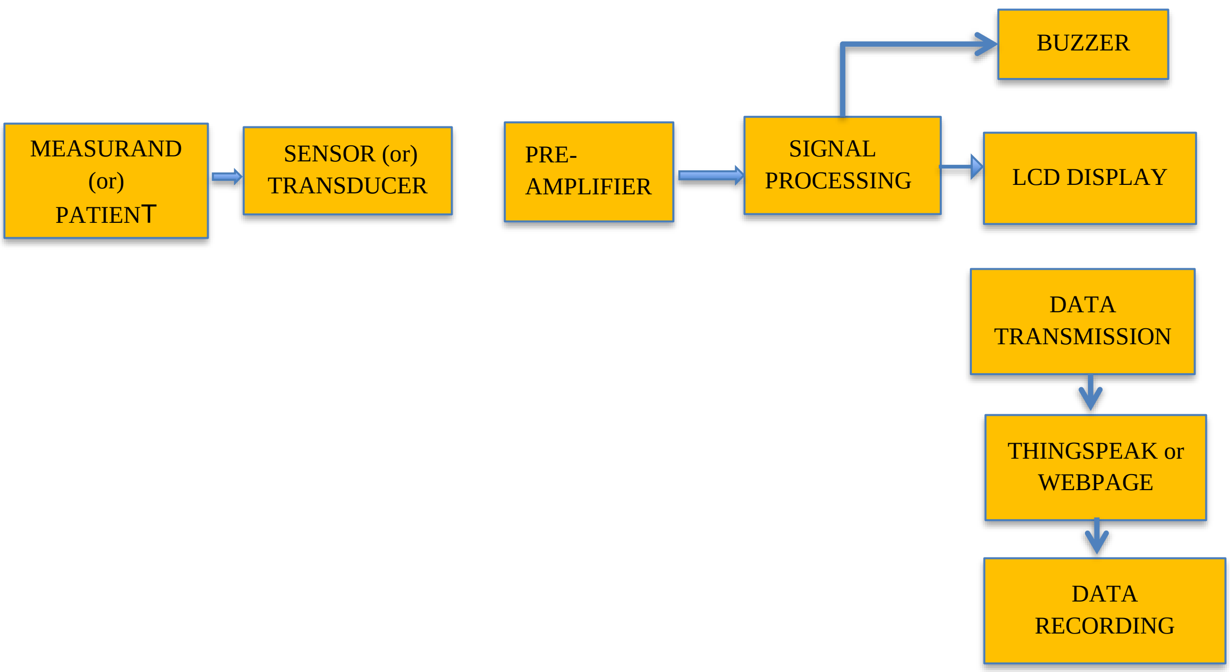


Fig.4. Basic block diagram

2.1.a) Measurand /Patient: the physical quantities and dimensions of the system to measure it are measurable value. The human body is the source of the measurement and bio-signatures are created. For instance: bodily surface or heart blood,

2.1.b) Sensor / transducer: a transducer, generally electrical, that transforms one type of energy into another form. For instance, a piezoelectric signal translates electric signal changes. Depending on the measurement measurement, the sensor is also useful. Sensor to utilize feeling that the source of the signal is receiving. It is utilized for the combination of human signals.

2.1.c) Pre-amplification and Signal Processing: the power output signal of the sensor is converted into an electric value via a signal generator circuit. This system specifies the screen or recording system quantity. The process signal conditioner often comprises amplification, filtering, digital to analogue and digital to analogue conversion. The air conditioning signal improves sensitivity.

2.1.d) Display: Use to visually represent the estimated values of an asset or quantity. For example: chart recorder, Electron beam oscilloscope (in addition). Sometimes use an alarm clock to hear a beep. For example, the signals generated in an ultrasound Doppler scanner that is used to monitor fetal health.

2.1.e) . The storage and transmission of data, storage of data are employed for the storage and usage of data. An electronic health card has been utilized in the previous few days in a hospital environment. Data transfer, usage of telemetry systems where information may be delivered at a distance from one point to another.

2.2 Process Flow:

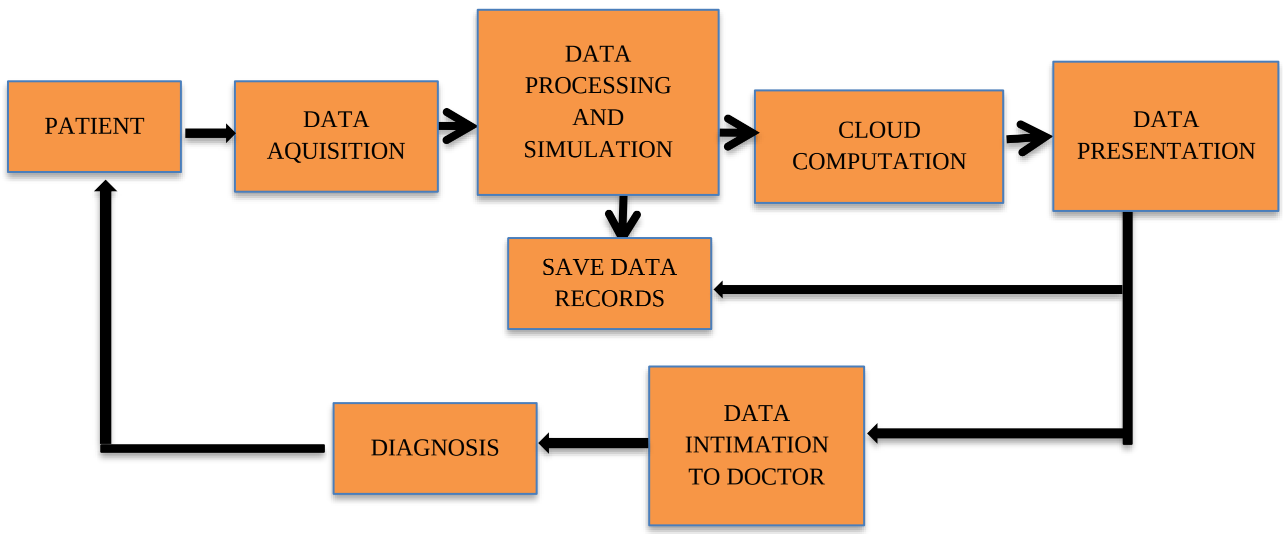


Fig.5.Process flow diagram

The working of the design is classified into the following levels:

2.2 .a) Approach Level:

This level explains how individual data is being acquired though each sensor that is in contact with the patient and how the bio-signals are transmitted for further processing such as transforming, rectifying,filtering and regulating .It is also called as Data Acquisition and Signal processing level.

2.2.b) Data Processing and Simulation level:

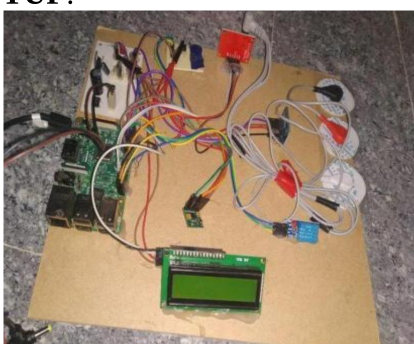
The data received is then ultimately analyzed to determine whether the acceptance value is junk. The Raspberry PI is used for data processing. The Raspberry Pi 3 Model B is the third edition of the Raspberry Pi. A powerful computer of the same size as the original Raspberry Pi models B+ and Raspberry Pi 2 model B . At the same time, Raspberry Pi Model 3 B includes a more powerful processor, 10 times faster than the Raspberry Pi of the first generation. It also incorporates Bluetooth and Wireless LANs, making it a good alternative for robust communication designs.

2.2.c)Cloud Computation level:
In this level, the processed data is transferred to Thingspeak through the wi-fi module of the Raspberry PI. .The computation is done on the processed values so that the measured values are compared with the threshold limits that are specified for each individual sensor.

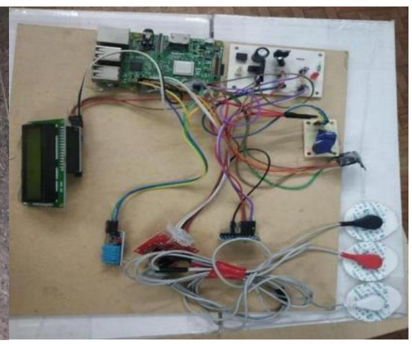
2.2.d)Data Presentation level:
In this level, the final computed and processed data output is sent to the Thingspeak application where the digital data of each physiological parameter is represented in graphical format along with its specified threshold limits(both upper and lower).If the parameter exceeds the threshold limit values, an alarming sound is produced by a beeper.

2.2.e)Data Intimation and Diagnosis level:
After the data is presented , it generates a link which is shared to the doctor . Depending upon the values , the alert action is initiated like if the measured values are too over the edge of the threshold limits then immediately an emergency call is initiated along with the message to the doctor.Based on the observations , the doctor immediately responds with a suitable diagnosis or treatment.

2.3 MODEL SETUP:



A.Front-View



b.Top-View

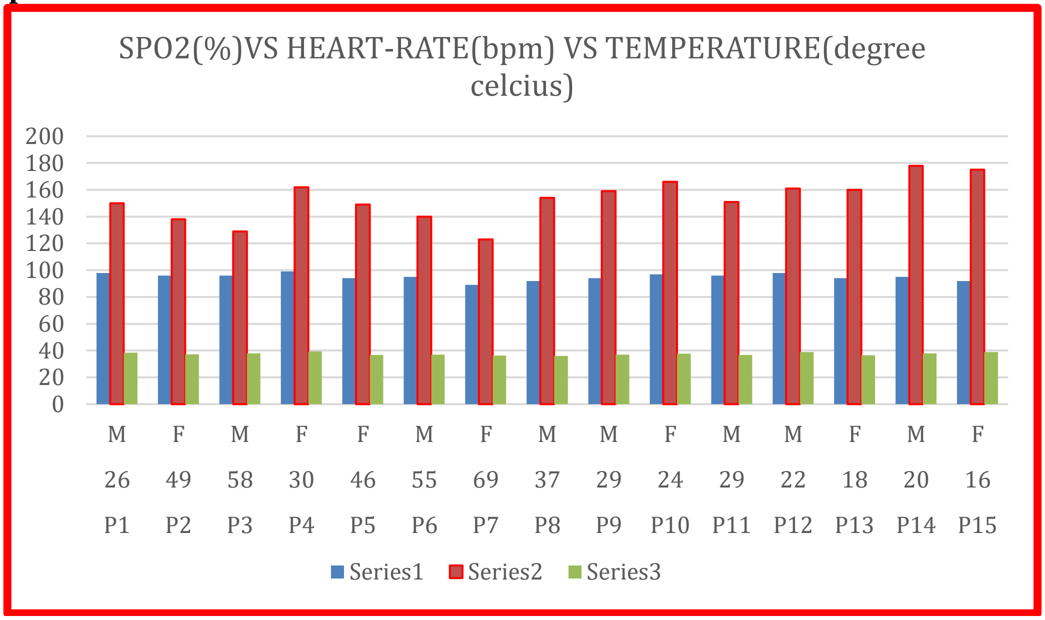
3. Results:

S.NO.	**NAME**	**AGE**	**GENDER**	**SPO2 (%)**	**HEART-RATE (bpm)**	**BODY TEMPERATURE**
1.	P1	26	M	98	150	38.4
2.	P2	49	F	96	138	37.3
3.	P3	58	M	96	129	38
4.	P4	30	F	99	162	39.4
5.	P5	46	F	94	149	36.7
6.	P6	55	M	95	140	37
7.	P7	69	F	89	123	36.3
8.	P8	37	M	92	154	36
9.	P9	29	M	94	159	37
10.	P10	24	F	97	166	37.7

11.	P11	29	M	96	151	36.8
12.	P12	22	M	98	161	39
13.	P13	18	F	94	160	36.5
14.	P14	20	M	95	178	38
15.	P15	16	F	92	175	39

Table 1. Sample tabular results

3.1.Graphical Results:



A sample testing of this kit is performed on 40 people out of which the medical parameters of 15 people (8 male & 7 female) are tabulated for analyzing the characteristics of the instrument as they explain the accuracy, precision, sensitivity, precision, resolution etc.. The table represents the heart-rate(bpm), temperature (celsius) and spo2 concentration levels(%) values of 15 persons of different age groups .These values show a similarity for the people of the same age group for eg. Person1 and Person9 whose age is 26 and 29 respectively have spo2 levels 98 and 94 respectively, heart-rate values 150 and 159 respectively and temperature values 38.4 and 37 respectively.This shows that when people of same age group both healthy and unhealthy are taken into consideration, then the medical parametric values are known to be bound within specific threshold limits (upper and lower) .

In this study, the values have been taken with the model setup and after the values have been recorded and displayed on the LCD screen , a fixed Thingspeak link for observing these values in the graphical format is provided for each specific user.

Fig.7.a)Temperature (degree celcius) b) SPO2 Concentration (%) c)Heart-rate (bpm)

The above graphical representation of the measured parameters (spo2,heart-rate and temperature) shows the change in variation of the readings from time-to-time .The threshold limits have been set up in case the measured parametric value goes out-of-bound region.The interval for taking measurements are fixed by the doctor .When any of the parameter exceeds the threshold , the beeper alarms immediately and it gives a sign for the doctor to look into the case immediately and suggest suitable diagnosis or treatment.

4.Conclusion

In this COVID-19 scenario, IoT has brought a lot of changes to the healthcare system in terms of improvements and facilities. It improves proper management and digitization of medical facilities in hospital settings. It opens new horizons in the field of medical science where equipment and devices can work together over the internet.

With the data gathered by IoT devices, healthcare organizations can distribute the right equipment among the patients. Wastage can be reduced in hospitals with proper information systems. By recording information properly, IoT can also reduce the risk of providing wrong treatment in hospitals.

More clarity of the patient's data is automatically evaluated and updated using this initiative. The hurry and anxiety can be minimized using the warning system utilized in this project. Due to the current pandemic situation and the lack of doctors available at the required time, the doctor can teach certain suggested Do-It-Yourself(DIY) diagnostic measures to the patient or his caretaker at home, such as what medicinal procedures he should follow when his physiological parameters deviate from the specified threshold limits.

This project can be improved further by adding video and audio sensors via a USB camera, allowing for more accurate patient results to be recorded, or by adding an EEG sensor, which allows for continuous monitoring of the heart's cardiac activity, lung’s breathing capability, and brain's electrical activity.

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