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Pulse Oximeter UsingPhotoplethysmography and IOT

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ABSTRACT: COVID-19 has hit the earth like a hurricane and undermined health systems and the rest of the economy. In the IoT era, there has been an increase in the use of connected sensors for many daily activities. The Medical Device Internet or IOMT is an IoT subsidiary that can alleviate pressure in the medical facility during this epidemic and allow remote patient monitoring at low cost. This paper will focus on the Android App that will measure Heart rate and oxygen saturation (also known as SPO2) for COVID-19 patients and the general public using photoplethysmography and IoT. The edge offered by our proposed model is the wider availability of a larger range of sensors and smaller controls and is less expensive compared to the current structure used. Another benefit of our approach is generating data that can be used for further understanding and research. The app will then be upgraded to connect to multiple sensory devices connected to the same microcontroller module and receive data from them, thus creating a fully functional interface for complete patient and general health monitoring at minimal cost.

KEYWORDS: IOT, IOMT, COVID-19, Photoplethysmography, Android, Pulse Oximeter, Vital Signs, SPO2.

I. INTRODUCTION

The COVID-19 epidemic has hit the world hard and it has crippled the global economy due to the damage done to businesses that are not well suited to work at home. India ranks second in the number of cases reported behind the USA. Delhi faces serious challenges in managing CASs and patients due to a shortage of Testing Labs and Leaders and staff. There are also many cases where isolated patients infected with the virus do not receive phone calls from the authorities which is why people with little knowledge of the virus often do not receive effective treatment immediately. Basic medical equipment used to monitor and treat COVID-19 patients at home such as pulse oximeters is also widely available, and available.

in diagnosing, treating, and controlling the spread of the disease. Therefore, there has been an ongoing need for reliable, affordable, simple, and at the same time practical technology for public clinical settings and primary care. The wide availability of small and inexpensive semiconductor components, and advances in computer-based pulse wave analysis techniques provide a great platform to achieve this.

This also highlights the fact that there should be a reliable patient care and monitoring system in place to inform authorities about the importance of COVID-19 patients. Therefore, it is important to take practical steps and at the same time provide accurate information to COVID-19 patients, both active and discharged and their family members to track their health and recovery by identifying priorities using medical data. But to get easy access to such a device becomes a requirement of that. IoT (Internet of Things) and PPG (Photoplethysmography) and data analysis can help speed up the recovery process, retrieve important information and improve a patient monitoring system that can help both authorities and patients. While IoT can assist in connecting sensor modules and is easily controlled via a central system.

IoT refers to a network of connected objects, ranging from simple items like pillows to complex and difficult to use objects such as cars, with the ability to communicate wirelessly. These interactions can then be automated to minimize or eliminate human intervention, thus minimizing human error. Photoplethysmography (PPG) is a simple, non-invasive, visual technique used to detect blood volume changes in peripheral circulation. Make measurements on the skin.

Our goal is to address the problem of remote patient monitoring that includes the implementation of an Android App that can measure key signals such as Heart Rate and Oxygen Saturation (SPO2) using a method known as

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Photoplethysmography with a smartphone camera. It will also be a forum for physicians to register and admit patients and to follow their measure of the most important of the latest symptoms and information that the patient is an active or recovering patient to manage their treatment.

II. LITERATURE REVIEW

The Medical Device Internet or IOMT integrates medical tools and applications linked to other devices using network technology to share data with each other over a wireless network without the need for human intervention. They can provide assistance to patients to reduce the need for hospital visits and at the same time reduce the burden on the national health system. The market for medical devices including IOMT includes smart tools such as clothing, as well as monitors that are particularly important for timely, telephone-assisted health care. A growing number of connected medical devices are able to generate, collect, transmit and analyze health data or images, at the same time connecting to healthcare providers and managing network storage and network control. success of IOMT. Finally, IOMT delivers standard performance management and develops in a critical environment, either within the walls of a building, home or remote area. Your goal is to use IOMT in a wider range and help patients monitor their priorities at home in less time. IoT limits limits on user capacity as solutions focus on intermediate solutions. To enable you to use cloud solutions via IoT, a highly dynamic data collection is presented as crowd-sourcing. Provided better computational speed with better efficiency, accuracy and precision [15].

PPG uses low-intensity IR light. IR light is absorbed by the bones, skin tissues and blood in the arteries and veins as it travels through our biological tissues. As blood absorbs more intense light than surrounding tissues, changes in blood flow can be easily detected by PPG sensors. The PPG provides a waveform that represents changes in blood flow consisting of both AC and DC conductors that represent variations in blood volume in sync with signals and signals that are reflected or transmitted by body tissues. There are various factors that affect PPG such as hearing, cardiovascular and biological. Mutations that occur spontaneously or spontaneously can cause flexibility and flexibility leading to light gain.

A Intangible PPG also known as Imaging Photoplethysmography (IPPG) is a technique that was developed in 1996 that creates a remote sensory space and reduces physical limitations, thereby contributing to its potential contact [10]. Nowadays, many PPG wearables have become popular due to advances in hardware and signal processing but research has to be done on wearable PPG-enabled pulse oximeters and pulse rate monitors [11].

The big IoT data challenges come from a huge number data collection done on the IoT environment using sensors and radio frequency devices. In IoT, based on application different types of sensors operate on IoT structures that produce different types of targeted data as a challenging process. Security and privacy issues are an important challenge to large IoT data. Voice-to-channel data is processed using a wireless device that addresses privacy and security issues [14].

According to a study by Medical Buyer, it was found that Approximately 51.75% of the patient monitoring program was as low as Rs.541 Crore as a cost, and approximately 70.18% of the total value of 57,000 units according to the study. created by ADI Media Research published at www.medicalbuyer.co.in.As noted in the data provided, the costs incurred in importing IOMT devices are significant. There is a great need for a cost-effective and accessible patient care system in general, as well as ease of use. [1]

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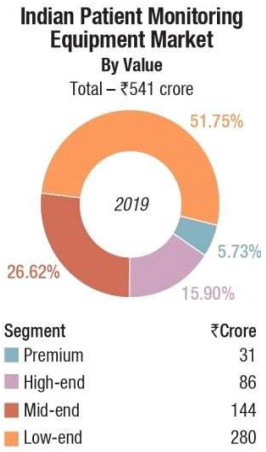

Fig 1. Indian Patient Monitoring Market

IOT generally comprises of 3 main elements:

- **Sensors:** The sensor can be a device, module, or machine, your purpose is to detect natural phenomena or changes in it and send signals to the processing device.

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- **Data Storage:** Data generated for processing the device can be saved for analysis. Data can be stored in local memory or in the cloud. If data is to be stored in the cloud the processing device must be connected to the internet

- **Client:** Client refers to the end user who works with system components such as patient, physician etc. This interaction between the client and the system can be facilitated through the use of websites, mobile applications etc. the question of combining these elements and providing an inexpensive model that uses the most readily available and inexpensive components. This is what they tried to do in this paper.

[2] As a previous study, it was found that HR, HRV, and heart rate were among the various symptoms associated with cardiovascular function such as, which may be the first indication of COVID-19 infection when changes are detected. HRV, measured as the median difference between heart rate, provides a better understanding of life, function, and stress. Decreased HRV levels indicate poor and physical stress. Human heart function can be monitored using Electrocardiogram (ECG) and photoplethysmography (PPG) as a wearable technology. Many of the physical changes that are measured can be detected by the wearables before the user experiences any significant clinical signs of illness. As considering, there are 2 major ways to test and diagnose COVID-19 infections:

- **Invasive Method:** The method in which physical contact is required to some degree to check for presence examination. A great example of this approach is the RT-PCR Highly accurate test performed to confirm the presence of the virus in the body. Swabs are taken inside the nose and throat to expose the person to the virus and to increase the risk of contracting the virus by being at risk of contracting the virus

Advantages: This method is faster and more accurate as research has gained over time.

Disadvantages: It is sometimes expensive, for example RT-PCR tests are performed for Rs. 2500 in India before its prices were set by the Government. Getting tested at a free community camp increases your risk of getting the virus rather than being infected at first because there will definitely be people living with the virus in your area. Physical contact is required to collect samples. Results are late. The risk of contamination of the sample lab is high. It is more prone to human error while taking samples. It can only be done by trained professionals.

- **Non-Invasive Method:** It is an unobtrusive, IT-based approach that revolves around data production and segmentation that gains popularity due to its fast nature. There is no risk of infection or spread of infection if you do

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tests that can at least warn you of the disease before taking the offensive approach to confirm the suspicion. Many researchers have found a close relationship between SPO2 levels and COVID-19 infection.

Some examples of this approach are:

- **Using Deep Convolutional Generative Adversarial Networks for Enhanced Medical Data Classification:** An effort to amplify samples of rarely available medical conditions, and to use these generated samples to amplify existing data and perform the required phases using DCGAN in-depth structural learning. [3]

- **Keeping track of cardiovascular status of a person using PPG:** [4] Non -invasive techniques can be used to keep track of the condition of the heart and blood vessels. Pulse wave propagation can be traced using PPG, which is actually the central concept of PPG. The PPG was rated using a customized system and SA participants underwent a State-Trait Anxiety Inventory (STAI-Y) test. A positive correlation between STAI-Y points is indicated by a cross-country verification framework. Previous results suggested that PPG could be a promising sensory recognition tool, ideal for interactive human machine applications.

- **Using Fitness Bands as a tool to track influenza like infections which is highly similar to and more lethal than to COVID – 19:** Scripps Research Institute (US) published a study in early 2020 that showed the potential to predict "hot spots" with resting heart rate and sleep data. from a smartwatch or fitness band [5]. More than 47,000 Fitbit users living in 6 major regions were screened over a period of 2 years. It was noted that when a group of people in one area presented an increase in heart rate, a subsequent increase in ILIs was found. [5].

- **Using PPG and IOT for creating a cost effectiveremote patient monitoring system**: Our proposed method..

Advantages: It is a non-invasive method. It does not require lab testing. It is not subject to human error as it is always spontaneous. The results are quick and accurate if you use good quality sensors. Cloud capacity can be reflected in data availability everywhere you go.

Disadvantages: Depends on the quality of the sensors used. Requires some form of connection to the data source. It needs some Information Technology information to get started

III. PROPOSED MODEL

Our solution for dealing with remote patient monitoring involves the implementation of an Android system that can measure important symptoms, such as Heart Rate and Oxygen Concentration (SPO2) using a method known as Photoplethysmography with a smart phone camera. serves as a forum for physicians to register and admit patients almost exclusively and to follow their measure of the most important of the latest symptoms and the knowledge of an active or recovering patient patient in order to manage effectively.

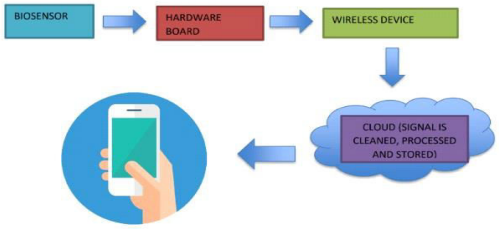

Fig 2. Working Model

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- *SPO2 Watcher Android App:*

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The app offers 2 login options: As a User and As a Doctor. Both Users and Doctors can sign in to the app using their email, phone number or google account. Doctors need to fill out a short form to register on the platform and users must fill in their environmental information which helps with PPG rating, namely age, gender, height and weight.

It has 2 ways to measure key signals:

- *Using Smartphone Photoplethysmography:* The user needs to place his or her finger lightly on the smartphone camera covered with a flash and lens completely as shown on the on-screen instruction for at least 30 seconds. The app captures a short video and then analyzes it using image processing to collect the Red, Green, Green Light Detected by the camera and used in complex mathematical calculations as detected by researchers in PPG over the years to measure the heart rate and oxygen level of the user. It is done in the following ways:

- *Measurement of Heart Rate:* The array stores the intensities of Red and Green light. Fast Fourier Transform is applied to the same members. The highest rate in the resulting system obtained after ignoring the sound from the first few stored data will contain the frequency of the heartbeat per second, after which the heart rate may be estimated. [6-8]
- *Measurement of SPO2:* AC and DC signals obtained from PPG signal. DC signal is the average Red and Blue intensity of all time. The standard deviation calculated by the following formula is the AC signal. [6]

The vital results are stored in the patient database hosted on Firebase that is visible to the patient to keep track of his/her vital signs. The app has a built-in mechanism that can detect consecutive abnormal readings for a user and warn him/her about the same. The threshold for consecutive abnormal readings using PPG is 3 and for the Pulse Oximeter Sensor (IoT approach) is 2

IV. ADVANTAGES OF USING OUR PROPOSED SOLUTION

- The advantages offered by our app are its availability and low cost. Anyone with a smartphone and camera can use the app to check their priorities, both for health or recovery in a comfortable environment and their doctor can track their continued recovery without physical contact or contact with them with just one click. phones. Although smartphone photoplethysmography has its own inaccuracies such as physical oximeter devices and depending on the capability of the smartphone camera, it is still very helpful in warning existing patients of their deteriorating vital signs without using any expensive pulse oximeter device and giving the infection a chance to be considered. by healthy people. Sensors can also be used remotely with the app.

V. IMPLEMENTATION AND RESULTS

The results were astonishing as the app always shows exactly the same or closest readings taken by a real pulse oximeter from the market. Comparisons were made with 2 fellow authors using pulse oximeters found in their homes and reported a small number of errors only when comparing the app readings with the oximeters. There have been a few instances where the reading has been bizarre due to violations of the limits set by PPG technology itself such as measuring in a dark room, keeping the finger slightly pressed, standing balance, etc. which has a profound effect on mathematics. And sometimes, the app was like a real pulse oximeter.

The app has also been successful in finding consecutive randomized measurements and that is why it alerts users to the risk of possible infection in certain test cases designed by us (Fig. 6).

An Illustration of Patients monitoring their vitals: Users can track their health via the dashboard (Fig. 3). They can use the app to rate key singing using PPG and get results in 30 seconds and be notified if their reading arrives abnormally more than 2 consecutive times (Fig. 4,6).

1. An Illustration of Doctors remotely monitoring their patients: Doctors can provide consultation with their patients by following their visual appointments (Fig.9) and tracking their patients with their latest significant diagnostic

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results (Fig.10), either using PPG or IoT. It therefore helps the idea of monitoring the patient away with minimal effort and expense.

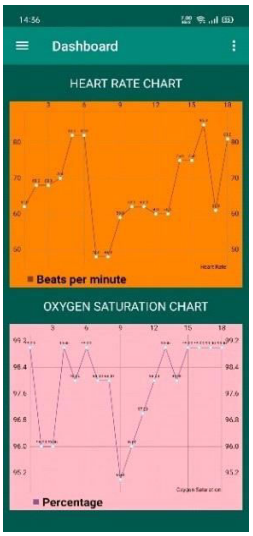

Fig 3. The app dashboard

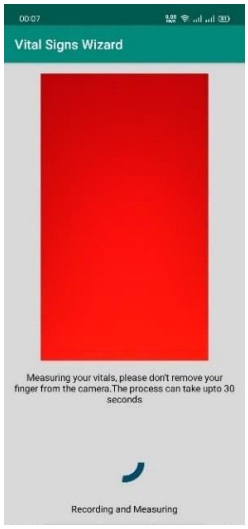

Fig. 4. Measuring vitals via PPG

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Fig. 5. Vital signs result screen.

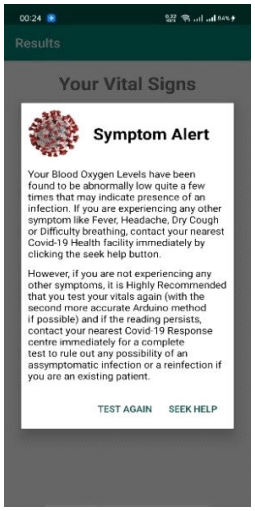

Fig. 6 Warning Screen displayed to the user in an event of abnormal reading.

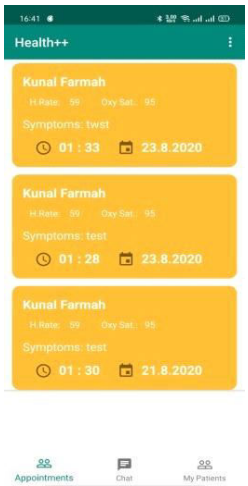

Fig. 9. Doctors Viewing

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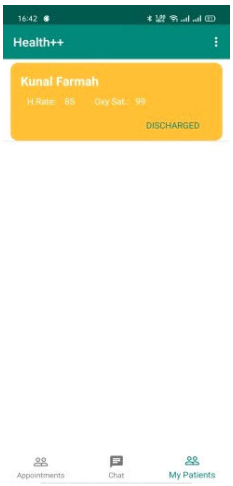

Fig. 10. Doctor viewing his their virtual appointments patients list with their most recent vital signs measurement.

- *Graphs obtained from the app measurements:*

The following graphs are derived from the application taken by the application using PPG. Fig.11 shows the graph obtained by testing the SPO2 readings taken by the app with 2 low readings as our experiments. Fig.12 shows the same level of heart rate with 2 reading of 48 which is a direct result of breaking PPG limits.

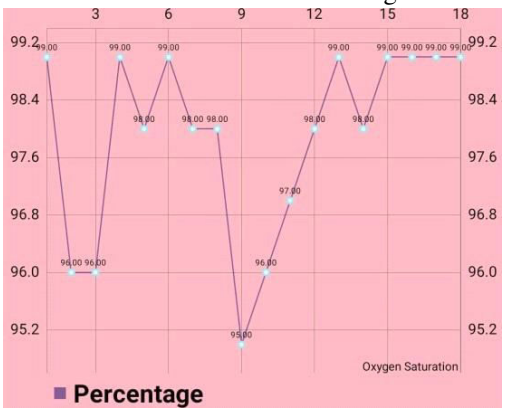

Fig 11. Graph of Oxygen Saturation (SPO2) per reading obtained by the app with two test cases of low reading (95 and 96%)

Fig 12. Graph of Heart rate obtained along with SPO2 by the app with 2 test cases of low readings (48 bpm)

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TABLE I. Vital signs data of Yash Patil while violating at most 2 ofthe constraints over a week

Reading No	SPO2 Watcher App Readings (PPG)	
	Heart Rate (bpm)	SPO2 (%)
1	65	99
2	68	96
3	68	96
4	70	99
5	82	99
6	82	99
7	48	98
8	48	98
9	59	95
10	62	96
11	62	87
12	75	99
13	75	99

- *Resulting data generated so far:*

As seen in Table I, the app is able to calculate key signals using the PPG even though all obstacles can be strictly tracked. Since Yash Patil broke 2 multiple barriers while taking the study periodically over a week, it was noted that the heart rate was not accurately calculated twice (see reading 7.8) while SPO2 was negatively calculated only once (see reading 11).

In Table II obtained by Shubham Sawant for a PPG reading taken mostly after dusk, not a single miscalculation was observed.

TABLE II. Vital Signs data of Shubham Sawant taken mostly after evening over 3 days

Reading No	SPO2 Watcher App Readings (PPG)	
	Heart Rate (bpm)	SPO2 (%)
1	61	99
2	61	99
3	59	99
4	47	99
5	75	99
6	78	98
7	81	99
8	66	98
9	60	98

VI. CONCLUSION

In an effort to create a low cost and easily accessible remote patient monitoring system, we have successfully implemented a cost-effective, non-invasive method of controlling key signals that have been found to be helpful in obtaining COVID-19 through our SPO2 Watcher. the app and its interaction with IoT sensors to provide clean, accurate, reliable and real-time data that can be used for research and development and at the same time to alert users to potential risks.

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For example, an ECG sensor can be added to the board to operate near the Oximeter Sensor. Also, the same device can work with a Wi-Fi module or a GSM module, therefore, it adds another layer of flexibility and makes it easier to work in different communication environments.

- *Merits of our approach:*
- Low cost remote monitoring method.
  - Non-invasive, no risk of exposure to the infected person.
- Readings can be taken remotely as well.
  - All the benefits of cloud technology can be used here as well. One application is enough to find unusual in important signs and warn users about it
  - It can be very helpful in analysis and research due to the amount of data produce
- *Demerits of our approach:*
  - Measurement taken using PPG requires certain restrictions to be followed, i.e., dark area, finger should be well pressed, measurement should be taken standing.
  - PPG technology also depends on the quality of the smart camera but the reading is very accurate.
  - An internet connection is required to keep reading in the cloud if only the sensor is used to synchronize data from the website.
  - The current prototype cannot be used as an alternative to certain preconceived notions for a fatal phase or serious illness such as a severe SARS-like infection caused by COVID-19 in some rare cases.
- Not recommended for detection of COVID-19 but for warning about the possibility of disclosure based on declining SPO2 values and monitoring of patients' health remotely.
- Despite its disadvantages, our approach has been successful in fulfilling the concept of patient monitoring using PPG and IoT in the recent years of COVID-19.
- *Novelty of our Approach:*

In India, the Aarogya Setu App exists but with only Contact Tracing that does not work well to track patients as it relies on visual input from the community. There is currently no independent application that can help measure critical symptoms and remotely monitor patients with COVID-19 which reduces the need for physical presence of patient care, especially in soft and invisible cases where the patient is unaware of the severity of the disease. situation. Our approach is aimed at providing that facility to relieve the burden on doctors and health care facilities and to provide patients with in-home care, priorities can be followed and the necessary steps taken in time to detect deteriorating health. As the distribution of medicines continues, patient monitoring becomes more important as well as monitoring any side effects. Our app can be used for that purpose as well.

Also, as an example only the final product can be very useful and versatile by adding new components and features to it.

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