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Smart Healthcare System Based IoT with Frequency Analysis of Heart Rate Data across FFT Algorithmto be used During Covid-19 Pandemic

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Abstract : Io T in healthcare system became the major player in providing better medical facilities to patients and doctors. The end purpose of this research is to build a healthcare system dedicated to provide better and faster medical aid to the patients. The suggested system is designed to initially record the patient's temperature, heart rate pulses and oxygen percent through appropriate medical sensors and circuits. Moreover, it will also provide immediate analysis of the data of the heartbeat rate using FFT algorithm and then compare the results with standard stored data. The outcome of this medical information will be fed to a raspberry-pi controller and then relayed to the appropriate health center destination through the mobile or web-based application, via existing networks, or the internet. The transmitted data is then recorded and monitored and with the help of a doctor's advice, the patient can then receive fast medical help. The collected data can also be used to help predict chronic disorders or diseases and accordingly preventive measures can be recommended. In the event of sudden heart attacks the situation can immediately be addressed in its preliminary stage based on the actual data and the stored data as past history.

KEYWORDS: **:(**Healthcare, Heart Rate, COVID-19, Fast Fourier Transform "FFT")

Introduction

IoT plays a vital role in different fields such as the most efficient industries, smart cities, intelligent agriculture, health care, logistics, etc.It can connect things to the Internet, and then transmit or receive the dataover the Internet. The main concept of IoT has developed into and from more technologies like embedded systems,sensors, real-time analysis,and machine learning. The data havebeen collected and shared through smart devices in daily life to achieve the demanding task[1].

Various sensors and medical devices are central to IoT implementation in the biomedical field. IoTcan inter-relate all digital technologies and computing to send the data without human intervention through the Internet. It is more successful in healthcare monitoring during the pandemic of COVID-19. It can quickly notify us about any individual health state as it can collect the basis of patients and send alerts about their health status, daily. Monitoring in real-time is successfully done with IoT technology and can save lives from different health problems ascritical temperature, asthma attack, heart failure, etc.[2].

FFT algorithm is a simple method of measuring the heartbeat rate. The advantage of FFT is the ability for detecting the signal frequency from the recorded signal. By using FFT, the correct heartbeat rate measurement can be achieved once the signal frequency is obtained[3].

With the growing rate of senior citizens, remote healthcare has become a vital service. Health monitoring, rehabilitation, and assisted living for the elderly and medically challenged humans is an emerging challenge because they require seamless networking between people, medical instruments, and social service providers. This motivates the need for affordable, low-power, reliable, and wearable devices that will improve the quality of life forelderly and physically challenged people [4].

This paper proposes a modified healthcare system that monitors the heartbeat rate, pulse oxygen rate and body temperature of patients via sensors and then transmits the data through wireless communication that helps doctors get data from the server. The developed system also analyzes the heart rate using FFT algorithm then, compare the results with standard values initially stored in PC, and transmit the result to the website via Wi-Fi module using IoT,and in the case of any abnormalities, a message will be sent immediately to the specialist doctor to take appropriate measures.

2.RELATED WORK

In [5]:The author proposed a system that shows the design and Implementation of an IoT based smart doctor kit for a critical medical problems. The microcontroller Arduino is used to collect the data from different sensors and send it to raspberry-pi through wireless communications, and then the raspberry-pi send the data to users and doctor using IoT to help doctor follow-up the patients' state at any time.

In [6]: The authors proposed a system that discusses that intelligent robotics and autonomous systems, as well as smart wearable, can play a positive role. They can facilitate the prevention, containment, and mitigation of COVID-19 and provide general support for patients and medical professionals, alleviating the non-COVID-19 burden placed on healthcare systems during this crisis.

In [7]:The author proposed a system that can monitor the patient's basic health signs as well as room conditions where the patient is now in real-time. ESP-32 (Node MCU) is used as a microcontroller to collect the data from sensors and process the data to send to the gateway server to help the doctor follow patients easily.

3.DESIGN AND IMPLEMENTATION OF PROPOSED SYSTEM

FFT is used for frequency analysis, it converts the time domain into frequency domain of a signal. It is a faster version of the DFT (Discrete Fourier Transform) which can be applied for the number of samples in the signal is a power of two[3]. The equation of FFT can be computed using equation (1).

$$X_n = \frac{1}{N}\sum_{k=0}^{N-1} X_k \,.\, e^{\frac{j2\pi kn}{N}} \qquad (1)$$

Where X_n is the discrete-time signal with a period of N.

FFT iscalculated and analyzed to determine the frequency of heart rate. When the signal frequencyis obtained from the spectrum, the heart rate (HR)can measure from equation (2).

$$HR = Frquency * 60 \qquad (2)$$

IoT-based healthcare monitoring can provide biotech information of elderly patients, who avoid a long hospitalization. The embedded wireless sensors collect and transmit the important signals and a raspberry-PI is programmed to receive the data [8]. In this research, sensor data such as heartbeat rate, pulse oxygen rate, and body temperature are considered as important signals. The block diagram of the proposed system is shown in figure 1.

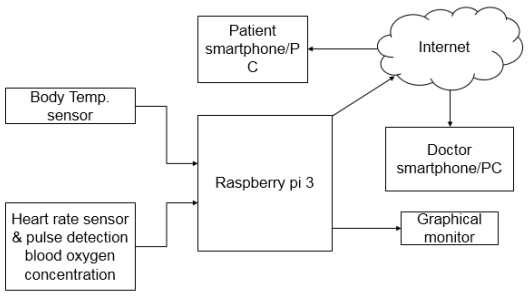

FIG 1: Block diagram for the proposed system

The proposed system analyzes the inputs and checks the condition, whether the heartbeat, oxygen rate, body temperature are normal or abnormal, then displays on the webserver.

- Monitoring the heartbeat, pulse oxygen rate, and body temperature using the heart rate & pulse detection blood oxygen sensor (MAX30102) and temperature sensor (DS18B20).

- The data are collected and transmitted through Wi-Fi to the web server, and it can be viewed wirelessly based IOT.
- In case of abnormal change in the heart or oxygen rate or body temperature, buzzer in the system alerts the nearby person and sends a message to the doctor.
- Doctor can monitor the patient's health condition, continuously from anywhere at any time through the patient's database stored in the web server.
- Moreover, analyze the heart beat rate with FFT algorithm using MATLAB that helps us to know the main spectrum of frequencies to compare the patient's statue with standard values that are already stored in the PC, and transmit the result to the web via Wi-Fi using IoT, if there are any abnormalities, a message will be sent immediately to the specialist doctor to avoid critical situations.

The analysis of heart frequency will be carried out using the FFT algorithm, through the spectrum, the shape of the normal and abnormal pattern of heartbeat rate will be seen.Figure 2 shows the flow chart diagram for the proposed system.

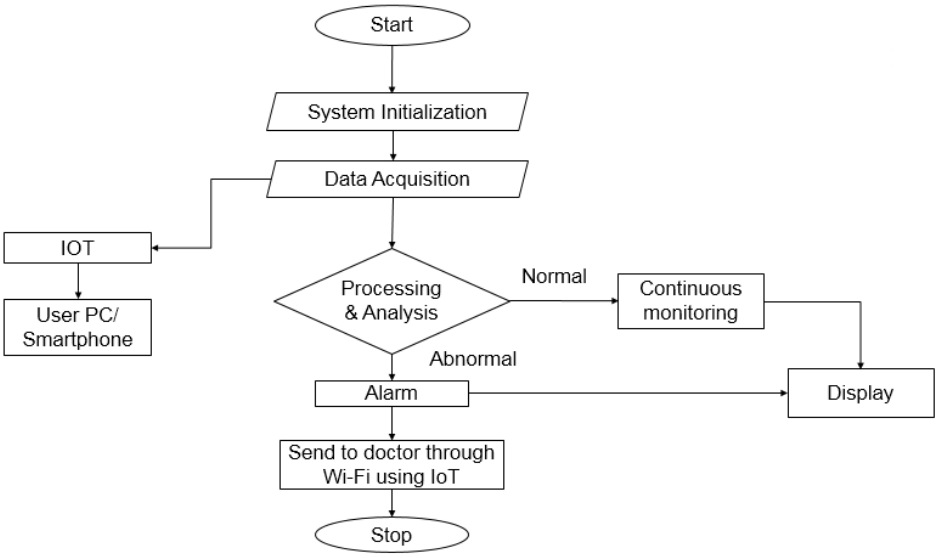

FIG 2: Flow chart diagram for the proposed system

Figure 3 shows a photographic view of the actual circuit implementation built to practically carry out the proposed system.

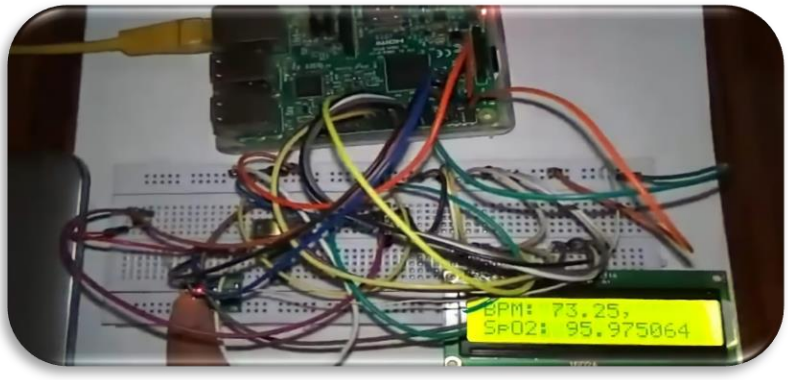

FIG 3: Depicts the actual circuit configuration

4.RESULTS AND ANALYSIS

The proposed monitoring system is divided into two levels:

1) Measures some physical cases, practically like body temperature, pulse oxygen rate and heartbeat rate as shown in figure 4_(a,b), then send the data through the Wi-Fi module to the website that can enable doctors and relatives to know the patient's health case if it is normal or not.

(a) Readings of heart and oxygen rate sensor (b) Readings of body temperature sensor

FIG 4_(a, b): Practical readings of physical cases

The output readings shown in web server "Firebase" consists of heartbeat rate, pulse oxygen rate, and body temperature can be shown in figure 5.

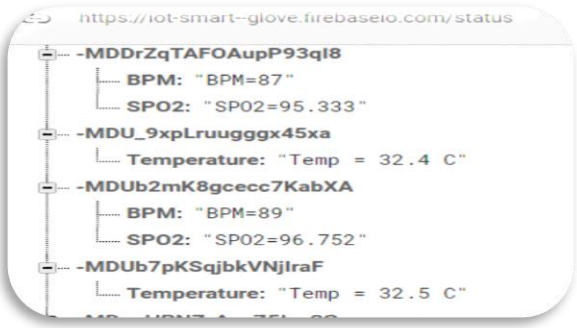

FIG 5: Practical sensors readings in web server "Firebase"

Notice that there are normal ranges for measuring these human physical cases such as for heartbeat rate normal range is from 60 BPM to 100 BPM (beat per minute), for pulse oxygen rate normal range is from 95% to 100%, and for body temperature normal range is from 32˚C to 35˚C when the temperature measured from fingers [6].

2) Analyze the data of heartbeat rate using FFT analysis to determine if the patient's heartbeat is normal or another case. Figures from figure 6 to figure 9 show FFT analysis using MATLAB for four cases of heartbeat rate listed as Normal Sinus Rhythm (NSR), Long-term ECG, ECG Compression and Supraventricular Arrhythmia (SVA), respectively.

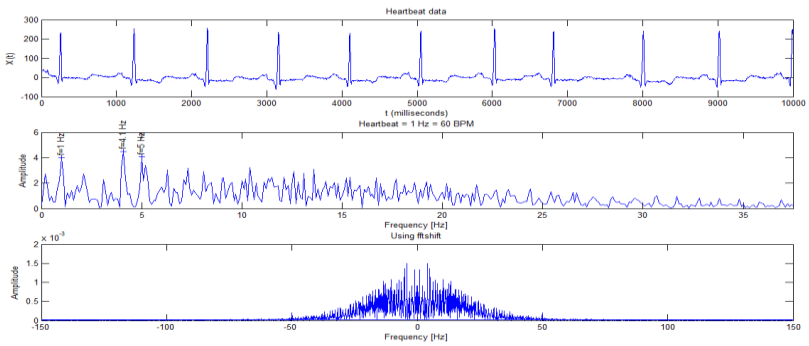

FIG 6: Normal Sinus Rhythm FFT Analysis

Analysis of the spectrum reveals a high-frequency (>1 Hz) and a low-frequency (<0.10 Hz) component. The high-frequency peak or respiratory sinus arrhythmia is a reliable indicator of parasympathetic efferent activity. The low-frequencycomponent of the heart rate variability spectrum is often used as an accurate reflection of sympathetic activity.

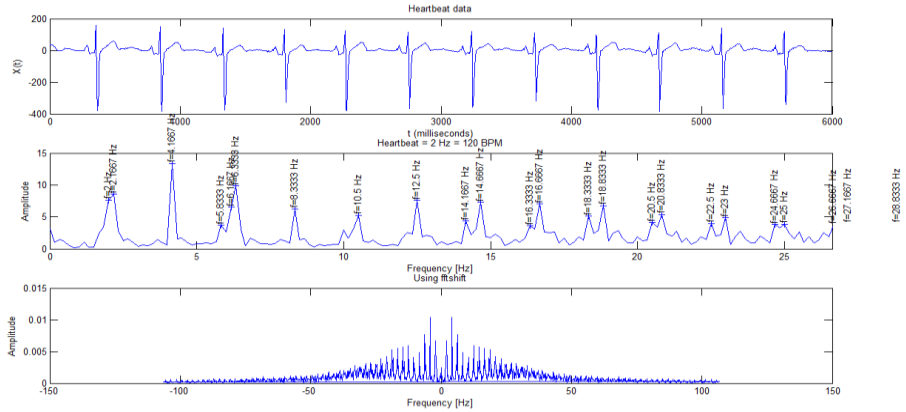

FIG 7: Long-Term ECG FFT Analysis

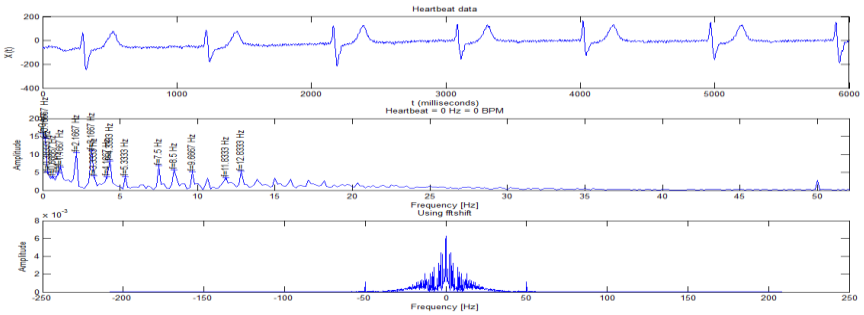

FIG 8: ECG Compression FFT Analysis

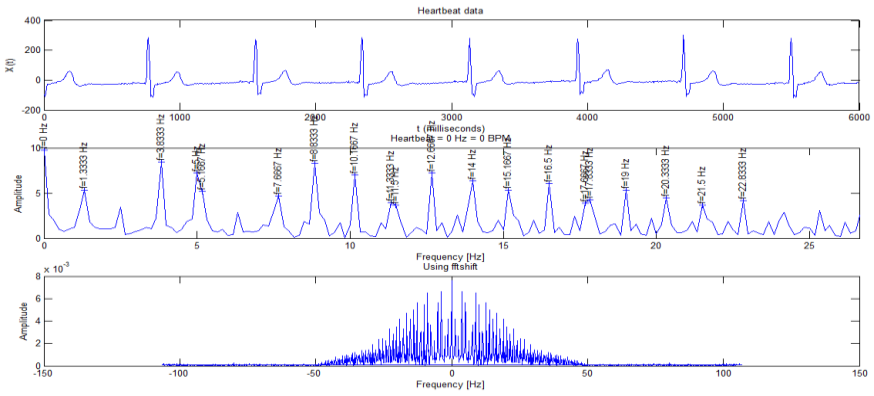

FIG9: Supraventricular Arrhythmia FFT Analysis

It can be seen from figures 6-9, the dominant frequency for the normal case is in the range of 1 - 4.16 Hz while for abnormal is in the range 0.06 - 0.1Hz.

5. CONCLUSION

This research presented a smart healthcare system to monitor the basic important signs of patients as heartbeat, pulse oxygen rate,and body temperature with an accuracy greater than 95%. Doctors can track and monitor the data in a real time even though the patients are outside of the hospital. The system can also analyze the heart rate by using the FFT algorithm and compare with standard data and give alarm if there are threshold cases. This prototype is easy to design and use. The proposed system is very helpful in the case of infectious disease as the novel coronavirus (COVID-19) treatment. It will improve the current healthcare system that may prevent lots of lives from death. It can be set up in hospitals and a massive amount of data can be obtained and stored in the online database.

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REFERENCES

[1] Kadhim Takleef Kadhim, Ali M. Alsahlany, Salim Muhsin Wadi and Hussein T. Kadhum, "An Overview of Patient's Health Status Monitoring System Based on Internet of Things (IoT)" © Springer Science+Business Media, LLC, part of Springer Nature 2020, Wireless Personal Communications (2020) 114:2235–2262, https://doi.org/10.1007/s11277-020-07474-0

[2] MohdJavaid and Ibrahim Haleem Khan, "Internet of Things (IoT) enabled healthcare helps to take the challenges of COVID-19 Pandemic" Journal of Oral Biology and Craniofacial Research 11 (2021), Published by Elsevier B.V. https://doi.org/10.1016/j.jobcr.2021.01.015

[3] N. H. MohdSani, W. Mansor, Khuan Y. Lee, N.AhmadZainudin, S. A. Mahrim"Determination of heart rate from photoplethysmogram using Fast Fourier Transform", 2015 International Conference on BioSignal Analysis, Processing and Systems (ICBAPS).

[4] Ahmed Abdelgawad, Ahmed Khattab, Kumar Yelamarthi, "IoT-Based Health Monitoring system for Active and Assisted Living" Conference Paper in Lecture Notes of the Institute for Computer Sciences · July 2017, See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/318426723

[5] Tamilselvi V, Sribalaji S, Vigneshwaran P, Vinu P and J.GeethaRamani, "IoT Based Health Monitoring System" 2020 6th International Conference on Advanced Computing & Communication Systems (ICACCS).

[6] Mahdi Tavakoli, Jay Carriere, and Ali Torabi, "Robotics, Smart Wearable Technologies, and Autonomous Intelligent Systems for Healthcare During the COVID-19 Pandemic: An Analysis of the State of the Art and Future Vision" © 2020 The Authors. Published by WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. DOI: 10.1002/aisy.202000071

[7] Md. Milon Islam, Ashikur Rahaman and Md. Rashedul Islam, "Development of Smart Healthcare Monitoring System in IoT Environment" © Springer Nature Singapore Pte Ltd 2020, SN Computer Science (2020) 1:185, https://doi.org/10.1007/s42979-020-00195-y

[8] KonguvelElango and KannanMuniandi, "A Low-Cost Wearable Remote Healthcare Monitoring System" G. R. Kanagachidambaresan (ed.) Role of Edge Analytics in Sustainable Smart City Development: Challenges and Solutions, (219–242) © 2020 Scrivener Publishing LLC

[9] Ahmed Kassem, Mohamed Tamazin, and Moustafa H. Aly, "An Intelligent IoT-Based Wearable Health Monitoring System" © Springer Nature Switzerland AG 2020, https://doi.org/10.1007/978-3-030-39847-7_29

[10] MeenakshiSaji, Madhusudhan Sridhar, AnithaRajasekaran, Rohan Akshai Kumar, A. Suyampulingam, and N. Krishna Prakash, "IoT-Based Intelligent Healthcare Module" © Springer Nature Singapore Pte Ltd. 2021, P. Suresh et al. (eds.), Advances in Smart System Technologies, Advances in Intelligent Systems and Computing 1163, https://doi.org/10.1007/978-981-15-5029-4_66

[11] NeelamSanjeev Kumar and P. Nirmalkumar, "A Novel Architecture of Smart Healthcare System on Integration of Cloud Computing and IoT" International Conference on Communication and Signal Processing, April 4-6, 2019, India.

[12] Mohamed Abdel-Basset, Victor Chang and Nada A. Nabeeh, "An intelligent framework using disruptive technologies for COVID-19 analysis" Technological Forecasting & Social Change, 0040-1625/© 2020 Elsevier Inc., https://doi.org/10.1016/j.techfore.2020.120431

[13] Dahlia Sam, S.Srinidhi, V. R. Niveditha, S.Amudha and D. Usha, "Progressed IOT Based Remote Health Monitoring System" International Journal of Control and Automation Vol. 13, No. 2s, (2020), pp. 268-273

[14] Ms. Ramya Devi, Sri Bargavi V and Yuvarani V, "E Health Glove using IoT" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 7 Issue III, Mar 2019- Available at www.ijraset.com

[15] Harleen Kaur, Mohd. Atif, and Ritu Chauhan, "An Internet of Healthcare Things (IoHT) - Based Healthcare Monitoring System" © Springer Nature Singapore Pte Ltd. 2020, https://doi.org/10.1007/978-981-15-2774-6_56

[16] KhelilGuizani and SghaierGuizani, "IoT Healthcare Monitoring Systems Overview for Elderly Population" Authorized licensed use limited to: East Carolina University.

[17] Aya Abdelmoghith, RewanShaaban, ZeinabElsheghri and Loay Ismail, "IoT Based Healthcare Monitoring System: Bedsores Prevention" Authorized licensed use limited to: Auckland University of Technology.