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Sensor Involved Self Intelligent Health Acquisition System using Raspberry Pi Controller

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Abstract— **The medical disorders such as cardiovascular diseases, respiratory disorders, and age-related health complications have created an immerging area in health tracking systems. Recently, the use of various sensors in Internet of Things (IoT) has emerged as an attractive technology in the healthcare domain through 24×7 patient observation system. This paper introduces an IoT-based intelligent health diagnostic technique using Raspberry Pi as the core processing unit. The proposed system will continuously monitors essential parameters like heart rate, and body temperature through biomedical sensors. The acquired data is transmitted via Wi-Fi in the form of a message to the hospital and patient's near member for secure storage and real-time observation and service provision (if needed). The proposed works increases healthcare efficiency, ensures early disease detection, and improves accessibility for aged and remotely located persons.**

Keywords— Internet of Things (IoT), Intelligent Health Acquisition, Raspberry Pi, Biomedical Sensors, Cloud Computing

I. INTRODUCTION

The busy schedule of young generation and physical problems in old aged population requiring continuous attention and the increasing widespread of persistent illness such as cardiovascular disorders, Bronchital illnesses, and cardiac anomalies have placed serious demands on present day healthcare structure. Regular observation of patient's mental as well as physical parameters is necessary for early detection, timely support, and effective illness management. However, long established healthcare systems depends prominently on personal take care and regular clinical appointments, which are often not sufficient for sufferer requiring constant examination, particularly those living in far distant or facilities deprived areas.

Latest progress in the field of sensor technology have brought up more chances for betterment of these healthcare remittance by enabling instantaneous observation and long distance access to patient's illness details. IoT-based medical care programs make use of biomedical sensors, embedded technical units, and wireless data transfer techniques to gather, control, and send back anatomical physical data on the internet. These methods assist medical care professionals to regularly observe essential criteria in patient such as blood sugar level, pulse rate, fever conditions, and SPO2 levels, thus enhancing diagnostic precision and speeding up the aid time during medical difficulty.

Amidst various embedded programmes, the Raspberry Pi has proved itself a powerful and economical solution for the start of smart health management systems. Its compressed size, low watt guzzling, and in built assistance for long distance communication make it suitable for real-time medical aid assistance usaage. By the combination of biomedical sensors with the Raspberry Pi, patient well being data can be observed and analysed locally and safely transmitted fast to internet for future reference and study. This method ensures extensibility, data adaptability, and system dependability.

In urgent conditions, on time alerts play an important role in moving towards reduction of life-risk conditions. IoT-based health tracking systems can impulsively judge abnormal anatomical body conditions and initiate instant alert systems by the use of email or messaging assisstance to intimate healthcare providers and family calamity repliers. Such automated alert procedures reduce the delay between serious health conditions and providing quick medical support to a great extent.

This paper presents an IoT-enabled efficient healthcare monitoring system built on a Raspberry Pi platform that supports regular patient observation, safe data communication, and distant support for approved medical professionals. The proposed system is designed to enhance healthcare quality, improve patient well being, and offer a dependable solution for old aged assistance and distant health supervision. By integrating IoT techniques, the system overcomes the shortcomings of traditional health support approaches and supports the advancement of smart, approachable, and modern healthcare framework.

The use of the smart sensors in medical support system has attracted considerable interest owing to its capability to enable continuous patient's health observation, distant medical support, and enhanced quality of care. Numerous studies have investigated IoT-based health care techniques by employing different sensors, data transfer techniques, and embedded technologies.

Dohr et al. [1] introduced an IoT-driven Ambient Assisted Living (AAL) framework aimed at aiding elderly and chronically ill individuals by enabling ongoing observation of both health-related and environmental conditions. Their study emphasized the role of integrated sensor networks in enhancing independent living and strengthening healthcare assistance.

Mohammed *et al.* [2] developed an IoT-enabled remote patient observation framework which integrates cloud computing and web services to support real-time health data acquisition and remote access. The findings of their study highlighted the effectiveness and scalability of cloud-based solutions in modern healthcare systems.

Jassas *et al.* [3] designed an intelligent e-health framework that links biomedical sensing devices with cloud-based platforms to ensure efficient data management and remote availability. The proposed approach enhanced healthcare monitoring by supporting real-time data processing and secure access for authorized personnel.

Mansor *et al.* [4] work had a focus on remote monitoring of fever conditions and validated the effectiveness of biomedical sensors in delivering accurate and reliable temperature measurements for healthcare applications.

Istepanian et al. [5] proposed a concept of mobility based Internet of Things (m-IoT) for non-intrusive blood sugar monitoring, emphasizing the role of IoT technologies in chronic disease management through non-intrusive sensing methods.

Mathan Kumar and Venkatesan [6] developed an intelligent health monitoring solution that leverages Android-based mobile devices to provide instantaneous display alongwith the mobile access to patient medical information. Their study highlighted the significance of smartphones in improving usability and accessibility within IoT-enabled healthcare systems.

Malhi *et al.* [7] presented a wearable health observation system that make use of ZigBee technology that enables reliable short-range communication while maintaining low power consumption. Their work demonstrated the suitability of ZigBee for efficient physiological parameter monitoring in wearable healthcare applications.

Jain *et al.* [8] introduced an embedded, GSM-enabled patient monitoring solution capable of tracking multiple physiological parameters in real time and generating timely alerts, making it suitable for use in intensive care unit (ICU) environments.

Roy and Gupta [9] designed a centralized cardiac monitoring framework employing ZigBee-based short-range communication to ensure efficient data transfer and effective centralized oversight of patient health.

Piyare [10] presented a omnipresent IoT-based monitoring and control framework integrated with Android smartphones, showcasing the flexibility of IoT architectures across multiple application areas, including healthcare.

Mukhopadhyay [11] presented an extensive survey of wearable sensing technologies for health and human activity monitoring, discussing key challenges including measurement accuracy, power consumption, and data reliability.

Chen *et al.* [12] examined IoT applications from a global standpoint, outlining key challenges and future opportunities while emphasizing concerns related to scalability, security, and system compatibility.

Stankovic [13] identified key future research avenues in the field of IoT, stressing the importance of developing systems that are reliable, secure, and capable of scaling effectively. Zanella *et al.* [14] investigated IoT deployments within smart city environments, illustrating how intelligent infrastructure frameworks can be leveraged to enable and support healthcare monitoring services.

Karthick *et al.* [15] designed an embedded real-time patient monitoring system capable of efficiently acquiring and tracking physiological parameters. Their study highlighted the significance of embedded platforms and real-time data processing for healthcare applications.

Based on the reviewed literature, it is clear that while many IoT-based healthcare monitoring solutions have been developed, issues such as continuous real-time monitoring, secure data communication, and prompt emergency alerting still persist. These challenges highlight the need for a Raspberry Pi–based smart health monitoring system aimed at improving remote healthcare supervision and ensuring greater patient security and well being.

II. PROBLEM DEFINITION

The universal health support sector is covering a challenged system to insufficient medical framework, the limitation of trained healthcare staffs, and restricted access to standard medical facilities. Simultaneously, the prevalence of crucial health conditions, particularly cardiovascular and respiratory diseases, continues to grow. Many patients—especially the old aged and those demanding continuous care—often miss on time medical treatment due to the lack of continuous health observation and rapid response systems. Conventional healthcare approaches depend mostly on direct supervision by medical personnel, which is frequently impractical and unskillful, especially for patients in far distant or multiple locations. Existing monitoring systems often fall short in providing real-time data access, accurate patient tracking, and timely emergency alerts. This underscores the need for a sensor dependent intelligent health tracking system which can be responsible for continuous remote observation, secure data access for authorized users, efficient patient localization, and automated alert generation to ensure prompt medical intervention and enhanced patient care.

III. PROPOSED SYSTEM

The proposed system employs IoT-enabled sensors to continuously track the health parameters of elderly patients and individuals with cardiac conditions, with the collected data securely stored on a cloud-based server for real-time access and analysis.

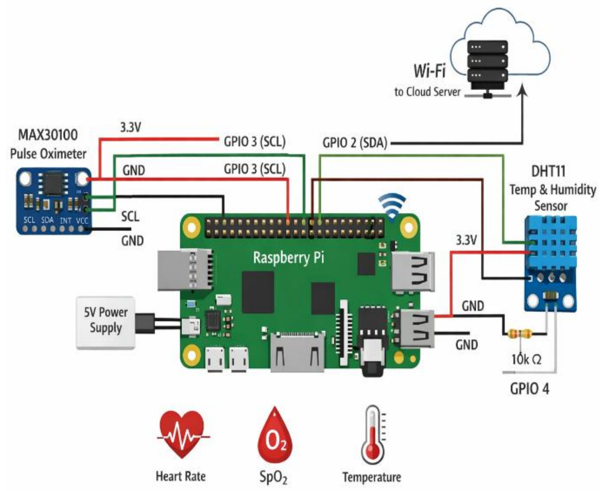

Figure 1: Circuit Diagram for interfacing Rasberry pie and network

A. Objective system Approach

- To offer technical support for enhancing healthcare delivery efficiently and effectively.
- To obtain precise measurements of a patient's physiological condition.
- To guarantee online availability of essential health information.
- To accelerate the assessment process and the administration of timely treatment.

B. Proposed System Approach

The four main phases of the proposed system's operation are data analysis, storage, communication, and information gathering.

C. Architecture of System

In the proposed system workflow, the primary function is to collect patient data using monitoring devices, capturing various health problems such as pulse rate, patient's body fever, etc. Low-power sensors have been incorporated to acquire this information efficiently. Regular collection of these data is essential for monitoring each patient's health status and enabling appropriate treatment decisions. The gathered data is transmitted to a web server connected to the NodeMCU board, where it can be processed if necessary before being stored in a database. Following the standard client-server model, authorized users can access the stored data, which is shared on demand among all peers within the IoT system.

According to the system architecture, sensors attached to the NodeMCU continuously collect patient information, which is then organized by patient IDs on the web server and forwarded to the hospital database for further analysis. Healthcare personnel use this data to evaluate patients' conditions accurately and make informed medical decisions. Data communication and transfer are facilitated through the Wi-Fi module, employing protocols such as HTTP, MQTT, and CoAP depending on the network requirements. CoAP is preferred for optimal network performance, while HTTP and MQTT are adapted for sensor-based applications to meet specific operational needs.

C. Implementation

The proposed system is designed using a three-tier architecture that integrates multiple technologies to achieve its intended objectives. The system involves three layered architecture system: firstly, the hospital system, second will be the web server systems, and the third will be at the sufferer system, as illustrated in Fig. 2 and described below.

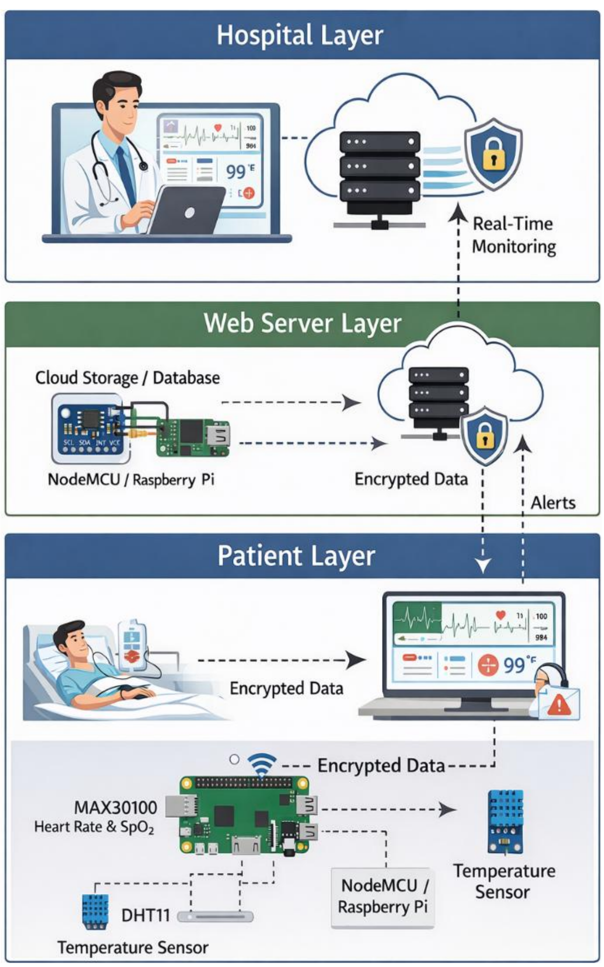

Figure 2: Three layered architecture of IoT based Health care System

A. The sufferer system

The sufferer system includes the so called patient and a sensor based module equipped with various biomedical sensors that monitor the pre feeded vital parameters and its danger zone level, including body fever level, pulse rate, and blood oxygen levels. The collected data is processed by a Wi-Fi–enabled microcontroller, which encrypts the information using the AES algorithm before transmitting it securely over Wi-Fi to the web server database.

A high-sensitivity pulse oximeter, the MAX30100 [14], is deployed to keep a track for blood oxygen SPO2 level and pulse rate, as shown in Fig. 3-a. This can be worn around the wrist of the sufferer.

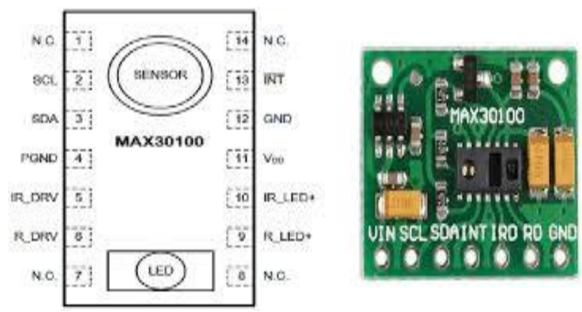

Figure 3-a: MAX30100 Pulse Oximeter

Body temperature is monitored using a DHT11 sensor [15], illustrated in Fig. 3-b.

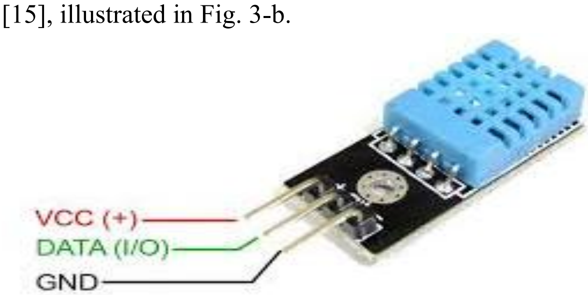

Figure 3-b: DHT11 Temperature Sensor

Both sensors are interfaced with the ESP8266 Node MCU microcontroller [16], which handles data processing, transmission, and overall system control (Fig. 3-c).

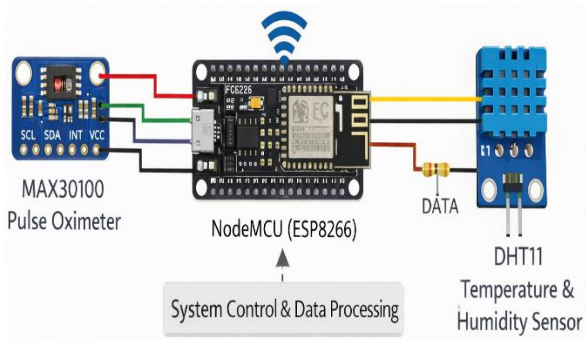

Figure 3-c: Interfacing Sensors with Node MCU

The ESP8266 NodeMCU is widely used due to its compact size, low cost, integrated Wi-Fi capability, fast processing, and ability to operate as a standalone device.

B. Web Server

The web server architecture system is capable of providing a secure storage environment that can preserve sensitive patient health data for future reference (if needed). Data collected from the patient layer is transmitted to the cloud and stored in an encrypted format, enhancing protection against both external threats and potential internal breaches, including those from the web service provider. The cloud layer then forwards the data to the subsequent layer in its original form without performing any processing, ensuring data integrity and security.

D. Hospital Layer

Through this layer, healthcare professionals at certified medical facilities can monitor a patient's vital data in real time. This capability allows specialists to detect abnormal patterns early and implement preventive measures to avoid potential health incidents. The received data is retrieved, encrypted, and transmitted to the monitoring dashboard using backend processes. To ensure secure access, medical personnel must authenticate via a web interface before reaching the dashboard. The user interface with the web is designed with the help of ASP.NET, Bootstrap, JavaScript, and HTML5.

The development as well as the implementation of the hardware of the suggested remote medical monitoring system are presented in this part. The IoT module's hardware implementation is depicted in Figure 3, wherein the microcontroller and pertinent sensors are linked together.

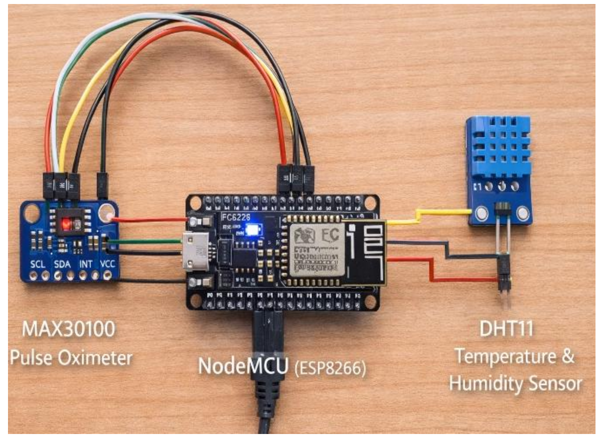

Figure 3: Implementation of IoT Module

1. Sensor Module: The primary purpose of this module is to collect physical problematic data from the sufferer and send it to a medical facility for analysis. It integrates two types of sensors: a body fever reading sensor and a heartbeat measuring sensor. The MAX30100 oximeter is used to measure heart pulse rate and oxygen saturation (SpO_2) level in the sufferer's blood, providing accurate readings through its built-in photodetectors, optical components, and noise-reduction circuits with ambient light cancellation. Additionally, the DHT11 is employed to continuously track the sufferer's skin temperature for fever analysis.

2. IoT Module: The entire patient layer is coordinated by the IoT module. The process flow of this module involves the following steps:

- Collecting the physical parameters of sufferer continuously noted by sensors with the help of suitable interfaces such as I²C or 1-Wire.
- Converting the acquired data into numerical values to calculate parameters that the patient is suffering from like heart pulsating rate, oxygen level in blood (SpO_2), and body fever, etc.
- Encrypting the normal or danger signals using the AES programming to ensure data security.
- Connecting to the cloud database via a Wi-Fi network.
- Storing the encrypted data securely in the cloud.
- Sending email alerts in case of emergencies or when critical parameters fall outside normal ranges.

These operations are facilitated by the programmable NodeMCU development board, which is similar to an Arduino but offers additional features, including 802.11 b/g/n Wi-Fi facility, a built-in TCP/IP protocol coverage, 3.3 V battery support, less power usage ranging from 10 µA to 170 mA, expandable 16 MB flash memory, and a high-speed processor running between 80 and 160 MHz. The NodeMCU is programmed using the free Arduino IDE 1.8.5 to perform its designated tasks efficiently.

3. Arduino Nano: The compact Arduino Nano development board, equipped with the ATmega328 microcontroller, offers a wide range of technological features. It provides 6 PWM support digital I/O pins along with 8 extra digital I/O pins making it suitable for many applications. The board also includes 8 analog input pins, 2 KB memory capacity for SRAM, 1 KB memory of E2PROM, and 32 KB flash memory thus providing with suitable memory capacity for data storage of sufferer. The operating clock crystal frequency is 16 MHz, the digital logic level of Arduino Nano is 5 V as logic 1 and 0 V as logic 0. The system can accept an input ranging in a voltage level of 7–12 V.

4. Web Server: Web server functions as a centralized storage system for patient information, enabling efficient transmission of data from the patient to the healthcare facility. This setup allows medical professionals to monitor and evaluate patients' vital signs remotely, at any time and from any location.

5. Hospital Database: This component is mainly intended to fetch the sufferer's physical medical data from the Web server, encrypt this data using a relevant decryption model, and subsequently message the details of the data to the usable medical record. Two tables—one for patient data and the other for login credentials—are maintained in a SQL database that is likewise maintained. By authorising users based on the rights they have been granted, this database manages user access to the system.

6. Doctor Terminal: This component serves as the final destination for patient data, where healthcare professionals analyze critical health information to diagnose the problems of the sufferer and thus provide suitable medication or suggestion to improvise the health conditions and thus use preventive measures against the conditions of emergencies. Initially, some medical expert must be authenticated for their identity using secure login credentials. Once verified, they can access and interact with real-time patient data through the monitoring dashboard. The dashboard continuously synchronizes with updates from the cloud database to ensure that the expert always has access to the most current information.

Software used:

1. Arduino Software (IDE) Code can be easily written and uploaded to microcontrollers over USB with the help of the open-source Arduino integrated development environment (IDE) editor. It can be used with a number of controllers, including Due, Pro Mini, Mega, Uno, and Arduino kits. Furthermore, this programme works with Linux, Mac OS X, and Windows. Built on top of the Processing/Wiring foundation, the Arduino IDE is written in the Java programming language. Its libraries are compiled with AVR-GCC and AVR Libc, and are written in C and C++. These software has been used to write the "Smart Health" code and expands interoperability to include more sophisticated controllers such as Blynk, ESP, Onion Omega, Raspberry Pi, STM32, NodeMCU, and Arduino Nano. Controllers that use Bluetooth, such the ESP32, provide effective energy consumption for closed circuit communication.

IV. EXPERIMENTAL OUTCOMES

Here we wish to presents the results of our experiments on the proposed sensor based Intelligent Health Acquisition System. This model offers a reliable and secure method for real-time tracking of a patient's vital physiological parameters. Initially, these critical parameters are collected from the patient using IoT-enabled biosensors. The data is then processed, encrypted, and transmitted to the server via an IoT microcontroller. Access to the patient's data is restricted to authorized medical professionals or certified healthcare facilities that possess the appropriate decryption credentials, ensuring privacy and secure sharing over networked systems. Additionally, the system functions as an alert mechanism, automatically notifying the attending physician via email if any vital signs fall outside the normal range. The monitoring dashboard, illustrated in Fig. 3, provides real-time visualization of all physiological parameters, allowing both patients and healthcare providers to track vital information continuously.

The ECG is employed to detect both common and significant cardiac rhythm abnormalities, analyzing the intensity of R peaks and the gaps occuring between repetitive two simultaneous R peaks, commonly called as the RR interval. Figure 4 illustrates the email alert sent to the nearest hospital when sensor readings exceed predefined threshold values stored in the cloud database. This alert mechanism ensures that healthcare facilities are promptly notified of critical conditions, enabling timely medical intervention and patient care.

V. CONCLUSION

S. No.	Parameter	Sufferer's Parameter	Message
1.	Fever	97°	Ok.
2.	Fever	101°	Fever. Give Paracetamol.
3.	Fever	103°	High Fever. Contact doctor.
4.	BP	79, 120	Ok.
5.	BP	90, 135	High BP
6.	BP	65, 105	Low BP

Intelligent Health acquisition systems are essential for the timely judgement of physical health issues in the healthcare system and provide a way to lower the costs of medical care related to frequent hospital stays and consultations. Systems that allow patients to send their health information to family members or medical professionals are becoming more and more necessary. This research introduces a cloud-based, sensor driven, reliable, and secure health acquisition system featuring a real-time available data bank for tracking sufferer's health pointers under a safe and secure condition. Vital signals collected by sensors are encrypted by the system using the AES method before being stored in the cloud. A NodeMCU microcontroller handles the encryption and processing, allowing Wi-Fi communication to the server. Moreover, if vital indicators deviate from normal ranges, the system's alarm feature will send an email to coordinating specialists or patient family.

SCOPE FOR FUTURE WORK

Additional metrics, like blood sugar levels and respiration rate, could be measured as part of the proposed project's extension. The system may precisely ascertain the patient's position based on obtained latitude and longitude data via integrating GPS modules with IoT tracking devices using Arduino Mega. Afterwards, by utilising the Wi-Fi module, this position data can be sent to the server. As a result, the patient's whereabouts can be found in an emergency using the hospital database. Furthermore, to provide a more complete picture of patients' health and wellbeing, future improvements may involve collecting highresolution datasets that may contain patient movements as well as facial expressions.

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