

Design of a Portable Ventilator and Health Monitoring System Using IOT

Prof. Arti Tekade

Ayush Gaikwad, Tanvi Sarda, Vishnu Pratap Singh

Prof. Maithili Andhare, Prof. Vijayalaxmi Kumbhar

Department of Electronics and Telecommunication Engineering

Pimpri Chinchwad College of Engineering and Research, Ravet, Pune

Abstract: A smart health monitoring system that is based on the Internet of Things (IoT) allows for round-the-clock patient monitoring. IoT is transforming the technological infrastructure of the modern world. One of the most noteworthy uses of IoT is in health monitoring systems. Numerous ideas and patterns have previously been put into practice to use IoT to monitor a patient's health. An overview of Internet of Things-based smart health monitoring systems is provided in this study. The most recent cutting-edge technologies created for Internet of Things-based smart health monitoring systems have been examined, along with their benefits and drawbacks. The goal of this review is to draw attention to the common design and application patterns of intelligent IoT-based patient smart health monitoring devices. Fever, or body temperature, blood oxygen level (Spo₂), and heart rate are the common symptoms of COVID-19 that are easy to identify. These three parameters are crucial in the pandemic and are the main symptom that are needed to look for in order to identify the virus. In addition, these parameters are used to determine a person's health conditions on a daily basis. Therefore, this article can be helpful if the patient or individual cannot see the doctor or needs frequent monitoring to address all issues. The plan was to design a system that can be monitored at any time, with all monitor data being kept on cloud servers. Additionally, this system can be utilized to maintain customer information and monitor the health conditions of patrons at the entrance to different shops, D-Marts, and clinics.

Keyword: Internet of things, temperature, pulse, humidity, motion, and oximeter sensors; smart health monitoring.

1. INTRODUCTION

Currently, the Internet of Things (IoT) is extensively researched and serves as a reliable technological standard. Sensors are ubiquitous, present in everyday items and industrial monitoring setups. Increasingly, IoT and sensor-based intensive care systems are

employed, enhancing convenience, intelligence, and productivity in our lives. A prototype model, utilizing smartphones as data computing platforms, offers convenient voice recognition and alert features. These IoT-based systems facilitate the monitoring of life-

threatening conditions, particularly cardiovascular diseases, which contribute to a significant portion of global mortality. The ongoing information and technological revolution has spurred the popularity of smartphone-based health monitoring systems, capable of real-time health data collection and feedback provision to both patients and medical professionals. Empowering individuals to assess their health and prompt them to seek medical attention promptly can potentially save lives and reduce national medical expenditures over time. Integration of mobile internet with open-source Android health service systems is now straightforward due to widespread mobile internet access. Electrocardiography (ECG) services have become increasingly accessible, aiding in the accurate assessment of cardiac function. Continuous monitoring of vital signs such as heart rate and body temperature is crucial for overall health assessment. Heart rate, expressed as beats per minute, varies with age, gender, and health status, making it a critical indicator of well-being. Diabetes, a prevalent global ailment, affects millions worldwide, prompting the development of smart health monitoring devices equipped with various sensors to track vital health parameters. These devices, managed by microcontroller-driven platforms like Arduino and Raspberry Pi, contribute to the growing network of IoT devices, which are projected to reach 26-50 billion by 2020 and 100 billion by 2030. Raspberry Pi, a cost-effective Linux-based device, has emerged as a popular IoT platform, revolutionizing healthcare systems by enabling the creation of mini-clinics equipped with sensors for comprehensive health monitoring. While microcontroller units (MCUs) have traditionally served as primary controllers, their limitations in handling parallel data have paved the way for field-programmable gate arrays (FPGAs), known for their real-time performance and parallel data processing capabilities, to gain prominence in IoT applications. This shift has led to new developments utilizing FPGA for multisensor data processing in IoT contexts. The general architecture of smart health monitoring systems involves sensors collecting patient data transmitted to a processing unit, which compares it with stored cloud data to assess the patient's health status and provide feedback. This paper will focus on IoT-based healthcare systems utilizing sensors, cellphones,

and microcontroller-based approaches, detailing their functionalities, working principles, and limitations. Furthermore, the integration of IoT in healthcare extends beyond individual health monitoring to encompass remote patient monitoring, telemedicine, and predictive analytics. Remote patient monitoring allows healthcare providers to track patients' health in real-time, leading to early detection of potential health issues and timely interventions. Telemedicine enables healthcare professionals to remotely diagnose and treat patients, improving access to healthcare services, particularly in underserved areas. Predictive analytics leverages the vast amount of data collected from IoT devices to forecast disease outbreaks, optimize treatment plans, and improve healthcare delivery efficiency. As IoT continues to evolve, its applications in healthcare are expected to revolutionize patient care, disease management, and public health initiatives globally.

II. LITERATURE REVIEW

Sr.No	Journal Name	Advantages	Limitations
1.	IoT-Based Healthcare Monitoring: Applications, Challenges, and Future Directions.	Offers a broad perspective on IoT applications in healthcare. Identifies key challenges, which can inform future research directions.	Lacks specific implementation details or technical depth. Focuses on general trends rather than detailed case studies.
2.	A Survey of Internet of Things (IoT) in Healthcare: The Security and Privacy Threats.	Focuses on critical security and privacy issues, which are essential considerations in healthcare IoT. Raises awareness about potential risks.	Emphasizes security concerns and may not provide a comprehensive view of IoT applications. May lack in-depth technical analysis.
3.	Internet of Things (IoT) in Health Care: A Comprehensive Survey.	Offers a comprehensive view of various IoT applications in healthcare. Covers multiple aspects of IoT healthcare systems.	Due to its comprehensiveness, may lack in-depth technical details. Might not capture the latest developments in IoT healthcare.

4.	IoT-Based Wearable Smart Healthcare Systems: A Review of Critical Design and Implementation Aspects.	Provides valuable insights into designing and implementing wearable health monitoring systems. Focuses on a specific subset of IoT healthcare applications.	Primarily emphasizes wearable devices, potentially neglecting other IoT healthcare aspects. May not cover broader IoT applications in healthcare.
5.	A Review on Internet of Things (IoT) in Healthcare: Applications, Challenges, and Security Concerns.	Discusses a wide range of IoT applications in healthcare. Highlights critical security and privacy concerns.	Tends to focus more on security and privacy issues and may not provide detailed implementation information. May not cover all aspects of IoT-based healthcare.

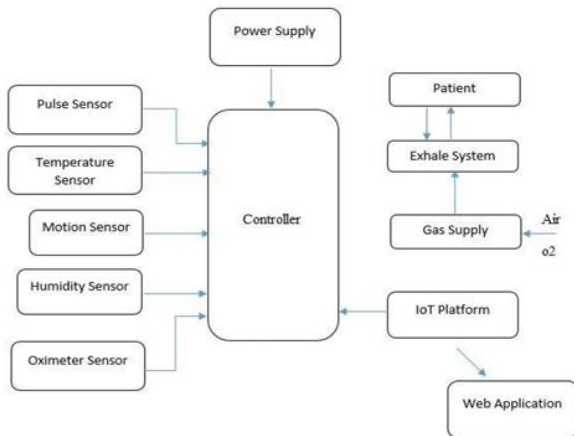
III. GAP IDENTIFICATION

From the literature survey following gaps are identified :

1. Inadequate security measures for data transmission and storage could expose sensitive health information to unauthorized access .
2. Short battery life in portable health monitoring devices can lead to inconvenience and disruption in continuous monitoring.
3. A complex user interface can discourage users from consistent engagement with the monitoring system
4. poor network connectivity can hinder the system's ability to support a growing user base.
5. IoT sensors can be susceptible to noise and environmental factors that may lead to inaccurate health data readings.

III. METHODOLOGY

In this research paper, the authors propose the development of an automated system designed to monitor various vital signs of patients, including blood pressure, body movements, heart rate, and temperature. Furthermore, they aim to enhance the existing system by incorporating additional health parameters and symptoms to facilitate the prediction of potential chronic illnesses or diseases in patients. Unlike conventional ventilators that solely regulate oxygen levels, the proposed system also monitors heart rate, temperature, humidity, and other relevant parameters, enabling remote monitoring by healthcare professionals via cloud-based transmission. Through the utilization of diverse accessible sensors, the system measures an array of patient parameters, such as ECG, temperature, heart rate, and pulse, among others. The biometric data collected by these sensors is transmitted to an Arduino Atmega328p microcontroller and subsequently relayed to a server, where it is stored in a secure database accessible through a restricted website.



Access authorization is granted to individuals such as patients, family members, doctors, or medical officers (RMOs). The system facilitates easier access to patients' historical medical records for physicians by utilizing stored data. Remote health monitoring through physiological data acquisition can significantly benefit elderly patients or those with chronic illnesses who prefer home-based care over prolonged hospital stays. Wireless sensors are employed to gather and transmit signals of interest, which are automatically received and processed by a configured processor. Selection of appropriate sensors and algorithm development are crucial aspects of the project to enable accurate detection, such as fall detection and monitoring of heartbeat signals. The research presents an approach to remote health monitoring, extending healthcare beyond traditional clinical or hospital settings to patients' homes, utilizing a single-parameter monitoring system. Data collected by the system include temperature, fall detection, heartbeat, and other relevant parameters, enabling remote detection capabilities. Design considerations for upcoming medical applications include integration with modern medical technology, adherence to contemporary medical practices, long-lasting real-time device functionality, support for chronic and elderly patients, remote monitoring capabilities, utilization of small wearable sensors, and extended battery life. The proposed gadget is envisioned to feature minimal buttons and straightforward operation for user convenience.

IV. SYSTEM DESIGN

The automated health monitoring system comprises the Arduino Atmega328p controller along with various sensors such as temperature, motion, humidity, and oximeter sensors. The system architecture delineates the interconnection of these components, as illustrated in Figure 1. Patient health parameters can be monitored by the doctor through a simple website or URL. Moreover, there is a surge in the development of IoT applications nowadays. Through the Android application, doctors or family members can track or monitor the patient's health. The devices monitor an extensive range of patient vitals, including oxygen saturation, heart rate, body temperature, ECG, respiration, and non-invasive blood pressure. The primary objective of this project is to design and deploy a smart patient health tracking system, as depicted in Figure 1, providing an

overview of the proposed system. Sensors are implanted on the patient's body to detect temperature and heartbeat, while two additional sensors are placed at home to monitor humidity and room temperature. These sensors are connected to a control unit, which computes the values from all four sensors. These calculated values are then transmitted to the base station via an IoT cloud. The doctor can access these values from any location through the base station. Consequently, by analyzing temperature, heart rate, and room sensor values, the doctor can evaluate the patient's condition and take necessary actions, thereby managing multiple patients simultaneously.

V. WORKING

This paper discusses the hardware design of a lab model ventilator, aiming to address respiratory issues, especially in resource-poor countries. The prototype model is cost-effective, using a potentiometer and needle valve in place of a flow analyzer. The ventilator operates with compressed air through a regulator, solenoid valve, and T-connector, controlling airflow with a flow control valve and needle valve. The system includes a test lung bag to demonstrate inhalation and exhalation. The paper emphasizes the need for affordable ventilators in developing countries due to the high costs and sensitivity of existing models.

The literature survey covers various aspects of ventilator control, including closed-loop control of tidal volume, physiological lung ventilation models, and adaptive control strategies. The hardware description outlines the components and connections involved in the ventilator setup, including the use of an Arduino board for control. The results and discussion section presents calibration data for the needle valve, showing the relationship between resistance, digital voltage, and airflow.

The paper concludes with the development of a cost-effective lab model ventilator with a focus on simplicity and reliability. The authors have successfully replaced expensive components with more affordable alternatives, contributing to the accessibility of ventilators in healthcare.

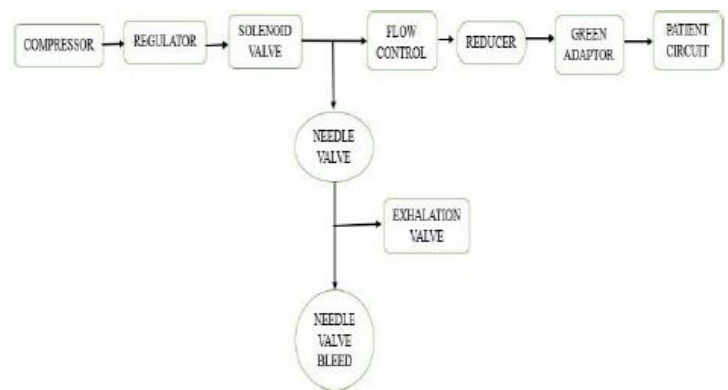


Figure 1. Block diagram of a Ventilator

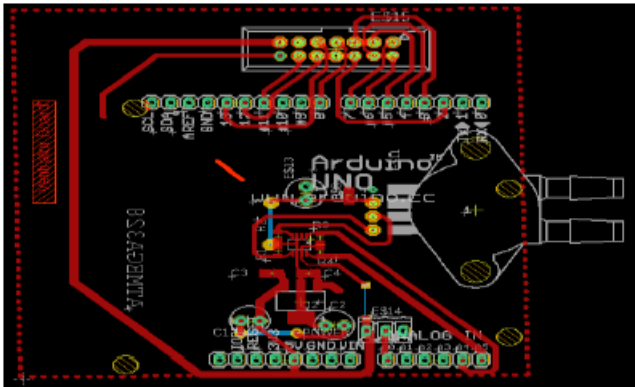


Figure 2. Pressure Sensor Board

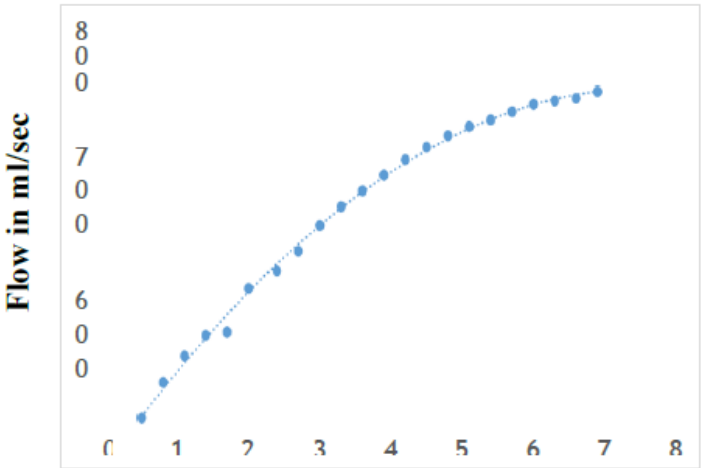


Figure 4 . Calibration Graph

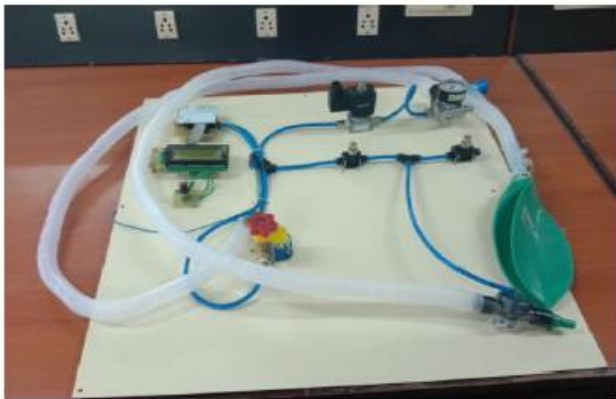


Figure 3. Hardware setup

Table 1. Position of the control valve and flow

Position Of Needle Valve in term of resistance (KOhm)	Flow in Digital Voltage	Flow in LPM	Flow in ml/Sec
9.95	5	0.5	8.33
9.92	8	4.8	80.0
9.89	11	8.0	133.3
9.86	14	10.5	175.0
9.83	17	13.9	181.67
9.80	20	16.2	270.0
9.77	24	18.3	305.0
9.74	27	20.7	345.0

VI. RESULTS

The results and discussion section outlines the calibration process of the needle valve. Adjustments were made to its position, and corresponding digital voltage and flow values were recorded and presented in Table 1. The calibration graph in Figure 4 depicts the relationship between the position of the control valve, measured in terms of resistance (KOhm), and the corresponding flow rates in liters per minute (LPM) and milliliters per second (ml/Sec). The curve fitting process was employed to derive an equation relating flow and digital voltage. The graph and table showcase the correlation between the needle valve's position and the resulting flow rates in a detailed manner.

VII. CONCLUSION

Researchers have been diligently addressing the myriad challenges stemming from the COVID-19 pandemic since its onset. One recent endeavor that has garnered attention is the development of affordable, open-source mechanical ventilators. This initiative is driven by the global shortage of these life-saving devices crucial for treating COVID-19 patients. The present study adds to this initiative by detailing the construction of a functional, low-cost, open-source mechanical ventilator. The authors' objective is to alleviate the impact of the ventilator shortage, particularly in underserved regions. Additionally, the paper introduces a numerical method for real-time assessment of a patient's pulmonary condition, which can be easily integrated into other ventilator designs. In summary, this work contributes to both theoretical understanding and practical implementation. Furthermore, it suggests the incorporation of alarms into the ventilator project, utilizing either a dedicated screen or speakers, akin to those employed in clinical settings to alert healthcare providers of critical conditions such as blood pressure fluctuations.

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