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Review Paper

Healthcare Monitoring System using IoT and Machine Learning Approaches

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Abstract: The Internet of Things (IoT) is a new technology that is rapidly advancing in the health arena with numerous new developments. IoT devices are evolving with cutting-edge resources and technology to meet new problems. The health status of in- and out-patients can be routinely and periodically monitored with IoT devices. The field of machine learning is rapidly advancing and has the potential to completely transform the healthcare system in several ways, including patient care, treatment, and diagnosis. In order to create an advanced automation system, we concentrate on developing an IoT application framework for the Healthcare Monitoring System that is coupled with machine learning (ML) approaches to handle healthcare problems. This system will link, monitor, and make decisions for an accurate patient diagnosis. To validate and authenticate our proposed work, we obtained patient data from IoT devices and applied Machine Learning for analyse and prediction. We developed User Interface for patient and doctor communication.

Keywords: Internet of Things, Machine Learning, Healthcare.

1. Introduction

The healthcare industry is undergoing a profound transformation with the integration of cutting-edge technologies, such as the Internet of Things (IoT) and Machine Learning, combined with the power of cloud computing. This convergence has opened up new avenues for healthcare monitoring, diagnosis, and treatment, leading to improved patient care, reduced costs, and more efficient healthcare systems.

The Internet of Things (IoT) has emerged as a disruptive force in healthcare by enabling the interconnection of medical devices, wearables, and sensors, allowing real-time data collection and communication. This interconnected ecosystem offers a wealth of health-related data, from vital signs to medication adherence, which can be collected, processed, and analyzed to monitor patient health and inform medical decision-making.

Machine Learning, a subset of artificial intelligence (AI), plays a pivotal role in healthcare monitoring. It can analyze vast volumes of healthcare data, detect patterns, make predictions, and assist medical professionals in diagnosing diseases, predicting patient outcomes, and recommending personalized treatment plans. Machine Learning models are continuously learning from new data, which leads to improved accuracy and effectiveness over time.

The cloud has become the backbone of this technological revolution. It provides the infrastructure, storage, and computational power required to process and store the massive amounts of healthcare data generated by IoT devices and applications. Cloud-based solutions offer scalability, flexibility, and security, allowing healthcare providers to access and share information securely and cost-effectively.

This integration of IoT, Machine Learning, and cloud computing has far-reaching implications for healthcare monitoring. It enhances patient care by enabling continuous remote monitoring, early disease detection, and timely interventions. It reduces the burden on healthcare professionals, automating routine tasks and providing decision support. It also improves patient engagement and empowers individuals to take control of their health, ultimately leading to better health outcomes.

This paper will delve into the various aspects of healthcare monitoring using IoT and Machine Learning with a focus on cloud-based solutions

2. Literature Survey

Mohammed, B. G (2023) Author developed an IoT-based smart healthcare monitoring system that tracks and monitors crucial health parameters, including body temperature, heart rate, and SPO2 (oxygen saturation), and provides real-time data to both doctors and patients through a cross-platform mobile application. Their system uses a Raspberry Pi 4B microcontroller, DS18B20 temperature sensor, MAX30100 pulse oximeter, and a 4G GSM, GPRS, and GNSS HAT module for communication. Abnormal parameter values trigger SMS alerts to doctors and patient's relatives, facilitating remote healthcare management and life-saving decisions. They tested system on a group of individuals, demonstrating its effectiveness in real-time health monitoring and alerting.

Malathi, M (2023) [2] The Authors Malathi, M., Muniappan, A., Misra, P. K., Rajagopal, B. R., & Borah, P. focuses on developing a health monitoring system using an Arduino Mega 2560 microcontroller, various sensors (such as blood pressure, body temperature, and heart rate sensors), and IoT technology. Their system continuously monitors patients' health parameters and send notifications to caretakers, nurses, and doctors. It is useful in the pandemic like covid-19 to reduce the need for in-person doctor visits and maintain social distancing. They include ECG sensors for heart-related monitoring

Raju, K (2023) [3] Authors developed health sensor network system for Internet of Things (IoT) applications, for monitoring the safety and health of ICU patients in a hospital setting. They incorporate various wearable sensors to monitor environmental and physiological parameters, such as heart rate, temperature, and motion. Data from these sensors is processed by an Arduino module and displayed on an LCD screen. Additionally, the data is transmitted to an IoT-based server for storage and visualization. Their proposed system aims to provide real-time monitoring and alerts for critical health parameters.

G. Saranya (2022) [4] In their Research, authors G. Saranya, N. Dineshkumar, A. S. Hariprasath and G. Jeevanantham designed and developed Contactless IoT-enabled cloud-assisted health monitoring system to monitor and detect the severity of Covid-19 in patients. They uses unobtrusive sensors to measure vital parameters such as heart rate, temperature, oxygen level, and pulse rate, which are critical for Covid-19 monitoring. The data collected by the sensors is transmitted to a cloud server via a microcontroller and Wi-Fi module in real-time. The data is then processed using Convolutional Neural Network (CNN) algorithms to predict the severity of the patient's condition, and healthcare providers are alerted to any abnormalities. Their system is cost-effective, scalable, and efficient, enabling timely responses to critical situations. Their Experimental results show the accuracy and effectiveness of the proposed architecture in monitoring Covid-19 patients.

M. N. Bhuiyan et al (2022) [5] Authors discusses the context and significance of healthcare monitoring systems in the face of the COVID-19 pandemic and the challenges faced by healthcare providers. they highlights the system's integration of IoT technology and cloud-based storage to monitor critical health parameters and enable remote patient care, especially in rural and urban areas. They used hardware components, including Arduino Uno, Node MCU ESP8266, and various sensors, as well as the implementation of the Google Firebase platform for data storage. They developed mobile application 'HSMART' as a user-friendly interface for accessing patient data and monitoring health.

M. I. Abdullah (2022) [6] Author introduces a Covid-19 Patient Health Monitoring System based on IoT technology. Their system allows medical staff to remotely monitor crucial health parameters, including blood saturation, heart rate, pulse rate, body temperature, humidity, and room temperature. They utilizes sensors such as MAX30100 for heart rate and blood saturation, DS18B20 for body temperature, and DHT11 for humidity, all processed by an ESP32 Arduino. They developed a web server to acess data on smartphones or PCs, making it an efficient tool for monitoring multiple patients simultaneously while reducing the risk of infection among healthcare workers.

H. K. Bharadwaj (2021) [7] In their work they provide a comprehensive overview of the intersection between machine learning and Internet of Things (IoT) in the context of healthcare. Their paper explores the utilization of machine learning techniques to enhance IoT-based healthcare applications, emphasizing their role in improving the efficiency, accuracy, and effectiveness of healthcare systems. The authors discuss various aspects of machine learning, including data analytics, predictive modeling, and decision support systems, and how they can be integrated with IoT devices to monitor patients' health in real-time, diagnose medical conditions, and facilitate remote healthcare services. Their work insights into the challenges and opportunities in healthcare domain and highlights the potential for machine learning-driven IoT solutions to revolutionize healthcare delivery.

E. T. R. Babar (2021) [8] In their work E. T. R. Babar and M. U. Rahman presented a system that has been designed to address the need for automated patient monitoring in under-resourced hospitals, focusing on neonatal and infant care. The system uses a wearable glove with sensors for measuring vital signs, including heart rate, temperature, and oxygen saturation, and communicates the data wirelessly to a central server. The system includes an alarm generation system with LEDs and a buzzer to alert healthcare providers in case of abnormal vital sign values. A web-based dashboard allows medical staff to visualize and monitor the vital signs in real-time, and it provides a security feature to protect patient data. The system was tested for accuracy in measuring temperature, oxygen saturation, and pulse rate, and the results showed minimal error, making it a viable solution for remote patient monitoring in resource-limited settings. Their system offers a cost-effective and scalable solution to improve patient care and reduce medical errors

T. H. Hafsiya (2021) [9] Author presented an IoT-cloud-based health monitoring wearable device for COVID-19 patients. With the global crisis of the COVID-19 pandemic, the need for accessible and continuous health monitoring has become critical. Their proposed wearable device continuously monitors the patient's heart rate, temperature, blood oxygen level, and blood pressure, as these are key indicators of COVID-19 symptoms. The data is transmitted to the IoT cloud using Wi-Fi, making it accessible to healthcare providers through mobile applications and web browsers. Their system aims to facilitate early detection, monitoring, and intervention for COVID-19 patients, improving healthcare outcomes and reducing the risk of exposure for healthcare workers.

J. Riyazulla Rahman (2021) [10] Author discusses a Health Monitoring and Prediction system utilizing the Internet of Things (IoT). They collected patient data from various sensors, processing the data through an Arduino microcontroller and transmitted to a remote server via an ESP8266 Wi-Fi module. they used Thing Speak Remote server for data visualization and analysis. They also incorporates Machine Learning algorithms for accurate predictions. IoT technology offers significant advantages in healthcare, enabling remote health monitoring, emergency notifications, and tracking vital signs. They highlights the potential of IoT in various applications, from smart cities and homes to industrial efficiency.

A. Das (2021) [11] Author introduces comprehensive health monitoring system that utilizes IoT and cloud computing to continuously track individuals' vital signs, send data to cloud servers, and alert doctors to potential health threats. They employs machine learning to analyze the data and predict health risks. The authors present an experimental setup involving the collection of health data and the use of algorithms like Support Vector Machine and Convolutional Neural Network for risk prediction. They also discuss the integration of cloud computing for data storage and analytics. Their system aims to improve early disease diagnosis and remote health monitoring, ultimately helping save lives,

B. Godi (2020) [12] described the integration of IoT and Machine Learning in the field of healthcare, specifically focusing on the development of an E-Healthcare Monitoring System (EHMS). It highlights the challenges posed by unhealthy lifestyles and the need for continuous patient monitoring. The EHMS utilizes IoT wearable devices to collect patient data, which is then processed and analyzed using machine learning algorithms to facilitate better decision-making and diagnosis. User collected diabetes dataset and applied Support Vector Machine (SVM) algorithm and, it gives an accuracy of 80.51%. EHMS framework offers the potential for improved healthcare services and paves the way for future enhancements in IoT-based healthcare monitoring systems.

H. Pandey (2020) [13] The authors, H. Pandey and S. Prabha addresses the use of IoT and machine learning to predict cardiovascular diseases, which are a leading cause of death worldwide. They utilize a pulse sensor with Arduino to collect real-time data, which is then processed and analyzed using various machine learning algorithms, including logistic regression, support vector machine, K-nearest neighbor, decision tree, and random forest classifier. They concluded that the support vector machine algorithm provides the highest accuracy, with an 86% prediction rate. Their approach can be valuable for early detection of heart diseases, especially in areas with limited access to healthcare facilities.

Islam, M.M (2020) [14] Authors Islam, M.M., Rahaman, A. & Islam, M.R. introduces a smart healthcare system that monitors a patient's vital signs, including heart rate and body temperature, as well as the condition of the patient's room, such as humidity and the levels of CO and CO2 gases. They employ sensors connected to an ESP32 processor, which sends data to a web server for access by medical staff. Their work system's accuracy is quite high, with error rates generally below 5%. They developed real-time monitoring system that has the potential to improve

healthcare by providing remote access to patient data, making it valuable for managing epidemics and crises, like COVID-19.

H. T. Yew (2020) [15] authors designed Internet of Things (IoT)-based real-time remote patient monitoring system to address healthcare challenges in rural areas with limited access to doctors. The system utilizes an electrocardiogram (ECG) sensor and the Message Queuing Telemetry Transport (MQTT) protocol to transmit real-time ECG data to a webserver. Doctors can monitor patient data through smartphones or computers, and the system has been tested in both local and wide area network environments, demonstrating no packet loss or packet errors. They provide remote healthcare services and early detection of disorders, particularly for patients in underserved areas with limited access to medical professionals.

K. A. Moid (2020) [16] The Authors addresses the need for affordable and effective health monitoring solutions in this paper. They introduces a system that utilizes Raspberry Pi and Internet of Things (IoT) technology to continuously monitor a patient's temperature and pulse rate. The acquired data is transmitted to a data center and can be accessed remotely through a website or an Android application. Abnormalities trigger SMS alerts to authorized personnel. Their system aims to bridge the communication gap between doctors and patients, providing an inexpensive and efficient health monitoring solution. The hardware components include Raspberry Pi, an ADC (ADS 1115), LM-35 temperature sensor, and a pulse sensor. Their results demonstrate real-time monitoring of temperature and pulse rate, with data accessible via a website. Their proposed system offers a portable, scalable, and cost-effective solution for health monitoring.

A. Rahman (2019) [17] In their paper they describes an IoT-based patient monitoring system using an ECG sensor. They designed system to continuously monitor a patient's health condition, primarily by extracting ECG data using an ECG sensor. This data is processed using a Raspberry Pi and stored in the IoT cloud. Doctors, nurses, or relatives can remotely check the patient's condition and receive notifications if the condition becomes critical. Additionally, their system allows for video calls and live streaming of the patient's condition. In their work they included hardware components like Raspberry Pi, ECG sensor, temperature sensor, while the software components involve Python, Arduino programming, and web technologies. They designed cost-effective and efficient solution for patient monitoring, especially for bed-ridden patients. they utilizes cloud computing for data storage and remote access.

Jie Wan et.al. (2018) [18] described wearable IoT used for health monitoring are supported designed with device, sensor network, data processing centre and APIs. RFID, 6Low PAN and ZigBee are short-range of communications connected to disease-based diagnoses devices. Using Wireless Body Area Network (W-BAN) EMG, ECG, EEG and blood pressure can be observed. The biomedical device will collect the information regularly. Patient condition identification, tracking and monitoring and controlling the system can be displayed in LCD embedded devices. Information will be uploaded to wise cloud Database servers.

M. S. Uddin (2017) [19] In this paper, the authors propose an intelligent patient monitoring system designed for remote healthcare monitoring. The system relies on Internet of Things (IoT) technology to automatically monitor patients' health through sensors. These sensors collect data on various biological parameters, which is then transmitted to the IoT cloud. Their system can detect critical patient conditions and send push notifications to doctors, nurses, and hospital personnel. This allows healthcare professionals to monitor patients remotely, improving efficiency and patient care. Their designed system can be applied to various healthcare scenarios and can benefit patients and their relatives.

Gaurav Raj et.al. (2017) [20] described IoT-based EMG (electromyogram) detects the upset in nerves, muscles and tissues and dislocation. Worker comfortless, heavy load lifting, restlessness work, maximum and minimum weighing capability in a work environment can be identified. EMG systems are deployed at work stations to detect any upsets in weighing the cargo by workers. By using three major techniques mainly Fast Fourier transform (FFT) uses magnitude and frequency transformation of signal for fast signaling, Short-time Fourier transform (STFT) uses spectral transformation of signal and Time with low rate of signal transformation, Frequency representation (TRF) uses time frequency for simpler wave transformation analysis of EMG signal. ESP8266 Wi-Fi module is added for signal transformation to the EMG system.

3. Conclusion

In conclusion, the research papers presented a wide range of innovative healthcare monitoring systems based on IoT technology. These systems leverage various hardware components, including microcontrollers, sensors, and communication modules, to continuously monitor critical health parameters such as body temperature, heart rate, SPO2, and more. The findings from these studies have demonstrated the effectiveness and potential of IoT-based healthcare monitoring systems in improving patient care, especially in remote and under-resourced healthcare settings. They also highlight the role of machine learning in enhancing the accuracy and efficiency of these systems. Additionally, several of the systems have proven valuable in addressing the challenges posed by the COVID-19 pandemic. Overall, these research papers have contributed to the advancement of healthcare technology and hold promise for the future of remote patient monitoring, early disease detection, and improving healthcare outcomes.

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