

IoT and Machine Learning

Subjects: **Others**

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Machine learning (ML) is a powerful tool that delivers insights hidden in Internet of Things (IoT) data. These hybrid technologies work smartly to improve the decision-making process in different areas such as education, security, business, and the healthcare industry. ML empowers the IoT to demystify hidden patterns in bulk data for optimal prediction and recommendation systems. Healthcare has embraced IoT and ML so that automated machines make medical records, predict disease diagnoses, and, most importantly, conduct real-time monitoring of patients. Individual ML algorithms perform differently on different datasets. Due to the predictive results varying, this might impact the overall results. The variation in prediction results looms large in the clinical decision-making process. Therefore, it is essential to understand the different ML algorithms used to handle IoT data in the healthcare sector.

IoT

ML

health prediction system

classification

prediction

supervised learning

1. Introduction

Health prediction systems help hospitals promptly reassign outpatients to less congested treatment facilities. They raise the number of patients who receive actual medical attention. A health prediction system addresses the common issue of sudden changes in patient flows in hospitals. The demand for healthcare services in many hospitals is driven by emergency events like ambulance arrivals during natural disasters and motor vehicle accidents, and regular outpatient demand ^[1]. Hospitals missing real-time data on patient flow often strain to meet demand, while nearby facilities might have fewer patients. The Internet of Things (IoT) creates a connection between virtual computers and physical things to facilitate communication. It enables the immediate gathering of information through innovative microprocessor chips.

It is worth noting that healthcare is the advancement and preservation of health through the diagnosis and prevention of disorders. Anomalies or ruptures occurring below the skin periphery can be analyzed through diagnostic devices such as SPECT, PET, MRI, and CT. Likewise, particular anomalous conditions such as epilepsy and heart attack can be monitored ^[2]. The surge in population and the erratic spread of chronic conditions has strained modern healthcare facilities. The overall demand for medical resources, including nurses, doctors, and hospital beds, is high ^[3]. In consequence, there is a need to decrease the pressure on healthcare schemes while preserving the quality and standards of healthcare facilities ^[4]. The IoT presents possible measures to decrease the strain exerted on healthcare systems. For instance, RFID systems are used in medical facilities to decrease medical expenses and elevate healthcare provision. Notably, the cardiac impulses of patients are easily monitored by doctors via healthcare monitoring schemes, thus aiding doctors in offering an appropriate diagnosis ^[5]. In a bid to offer steady transmission of wireless data, various wearable appliances have been developed. Despite the

advantages of the IoT in healthcare, both IT experts and medical professionals worry about data security [6]. Consequently, numerous studies have assessed the integration of IoT with machine learning (ML) for supervising patients with medical disorders as a measure of safeguarding data integrity.

The IoT has opened up a new era for the healthcare sector that enables professionals to connect with patients proactively. The IoT with machine learning evaluates emergency care demands to make a strategy to deal with the situation during specific seasons. Many outpatient departments face the problem of overcrowding in their waiting rooms [7]. The patients who visit hospitals suffer from varying conditions, with some requiring emergency medical attention. The situation is further exacerbated when patients with emergency care needs have to wait for a lengthy queue. The problem is aggravated in developing countries with under-staffed hospitals. Many patients commonly return home without receiving medical treatment due to overcrowding at hospitals.

Yuvaraj and SriPreetha created a wearable medical sensor (WMS) platform made up of different applications and utilities [8]. The authors comprehensively analyzed the application of WMSs and their advances and compared their performance with other platforms. The authors discussed the advantages brought about by the applications of these devices in monitoring the health of patients with conditions such as cardiac arrest and Alzheimer's disease. Miotto et al. proposed a monitoring system that relies on a wireless sensor network (WSN) and fuzzy logic network [9]. Specifically, the researchers integrated micro-electro-mechanical systems (MEMS) set up with WSN to create a body sensor network (BSN) that regularly monitors abnormal changes in patients' health. Notably, the authors developed a clinical data measuring system using devices such as a microcontroller, pulse, and temperature sensor [10]. Additionally, the proposed system was integrated with base station appliances to remotely regulate the pulse and temperature of patients as well as convey the patient's data to the medical practitioner's phone. Notably, the system can send an SMS to both the patient's relatives and medical experts in emergency scenarios [3]. Therefore, the patients can acquire a remote prescription from medical practitioners using this system.

Moreover, the IoT application has made it possible for hospitals to monitor the vital signs of patients with chronic conditions [11][12]. The system uses such information to predict patient health status in different ways. IoT sensors are placed on the patient's body to detect and recognise their activity and to predict the likely health condition. For example, the IoT sensors system monitors diabetes patients to predict disease trends and any abnormal status in patients. Through the health prediction system, patients can receive suggestions of alternative hospitals where they might seek treatment. Those who do not want to visit other facilities can choose to stay in the same facility but face the possibility of long waiting queues or returning home without treatment. Rajkomar et al. [13] proposed a Zigbee Technology-hinged and BSN healthcare surveillance platform to remotely monitor patients via clinical sensor data. In particular, they utilized standards such as Zigbee IEEE 802.15.4 protocol, temperature signals, spirometer data, heart rate, and electrocardiogram to assess the health status of patients [14]. The acquired data are then relayed via radio frequencies and displayed on visual appliances including desktop computers or mobile devices. Therefore, the proposed platform could monitor attributes of patients including temperature, glucose, respiratory, EEG (electroencephalogram), ECG (electrocardiogram), and BP (blood pressure), and relay them to a database via Wi-Fi or GPRS. Once the sensor data are offered to the Zigbee, they are conveyed to a different network, permitting their visualization on appliances such as emergency devices and the mobile phones of doctors

and relatives [10]. Accordingly, the integration of IoT with machine learning eases the management of healthcare in patients by enhancing the connection between patients and doctors.

The IoT offers systems for supervising and monitoring patients via sensor networks made up of both software and hardware. The latter includes appliances such as the Raspberry Pi board, blood pressure sensors, temperature sensors, and heart rate sensors. The software process entails the recording of sensor data, data cloud storage, and the evaluation of information stored in the cloud to assess for health anomalies [15]. Nonetheless, anomalies usually develop when there exist anonymous activities in unknown body parts. For instance, the heartbeat tends to be elevated when seizures occur in the brain [16]. As a result, machine learning techniques are applied to integrate the heart rate sensor with Raspberry Pi boards to display abnormal results via either an LCD or a serial monitor. Due to the vast volume of data, cloud computing is applied to store the information and enhance data analysis [17]. Various open-source cloud computing platforms are compatible with the Raspbian Jessie and Raspberry Pi board [18]. These devices utilize machine learning algorithms to assess the stored data to recognize the existence of any anomalies [19]. Therefore, the application of machine learning in IoT helps in predicting anomalies resulting from unrecognized activities in different body parts.

It is paramount to note that machine learning is an artificial intelligence (AI) discipline. The primary objective of machine learning is to learn from experience and paradigms. In contrast to classical techniques of simply generating code, big data are input to the generic algorithm and analysis conducted using available data [20]. Big data allow the IoT and machine learning systems to easily train a system by applying simple data for predicting medical anomalies. The accuracy of predictions is directly proportional to the quantity of big data trained [21]. Therefore, big data enhance the prediction ability of machine learning techniques utilized in healthcare prediction platforms.

Fortunately, patient load prediction models are based on machine learning for prompt patient load information sharing among hospitals. In a hospital, the historical data are captured and used to forecast the future patient load to ensure adequate preparation. IoT devices with embedded machine learning methods are used to train a classifier that can detect specific health events such as falls among elderly patients. The clustering algorithms can effectively identify abnormal patterns of behaviour among patients and send out alarms to healthcare providers. Similarly, the daily activity of a patient is monitored through daily habit modelling with IoT microchips. The information is utilised for detecting anomalies among older adults.

2. IoT and Machine Learning Applications in Healthcare Systems to Predict Future Trends

As previously discussed, the IoT and machine learning AI have enhanced the health sector in that patients can wear devices like premium jackets and smart bands that are used to monitor their condition and send regular reports to a database accessed by doctors and medical practitioners [22]. The devices can monitor the vital signs and organs of a patient and send out a progress report to a specific database. The system also collects and reports

pathogen presence and manifestations [23]. This is a crucial advance that helps the healthcare system deliver best practices.

The availability of smart pills, sensors, and wearable monitors in healthcare adds value to the sector. These tools help with monitoring and predicting signs and future trends in disease patterns. The essence of automating the patient and disease monitoring tasks saves time and steps in when all doctors are occupied—for example, in a crisis [24]. The use of smart technology in this sector is vital for saving lives during pandemics like COVID-19. The wearable monitoring devices capture and send data to a database for a doctor can analyse and then diagnose the patient or send a prescription.

Patients can be fitted with smart pills and smart bands (IoT) that monitor and collect specific data to feed a database during pandemics. These devices help doctors and other machines (machine learning) to learn disease patterns and symptoms, giving doctors a chance to understand symptoms and analyse the symptoms to develop quick and safe diagnostics [25]. During times of quarantine, such strategies can enhance safety for both the patient and health practitioners as machine learning technology prevents physical contact with patients infected with deadly airborne viruses.

Cloud computing is also an efficient part of the IoT sector. It helps to connect a wide variety of machine learning AI devices to understand data through analysis and storage. Another important feature of cloud computing is that it can store a huge amount of data and, therefore, sustain the needs of the healthcare system. Due to its data-sharing capabilities, cloud computing can also allow different devices to access the information. On the other hand, cloud computing currently faces some challenges that need to be addressed. These challenges could open up new research opportunities for scientists and researchers seeking to improve ML and IoT's usability in the healthcare industry. One of these challenges is data privacy and security. Medical records in the healthcare industry are highly sensitive and need to be carefully protected as they contain individuals' protected health information (PHI). Therefore, strict regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) [26], have been introduced to regulate the process of accessing and analysing these data. This creates a significant challenge for modern data mining and ML technologies, such as deep learning, which typically require a large amount of training data. Sharing this type of sensitive information to improve quality-of-care delivery can compromise patient privacy. Several solutions for preserving patient privacy with ML technology have been introduced.

One solution is called federated learning (FL). This new ML paradigm uses deep learning to train and enable mobile devices and servers to build a common, robust ML model without sharing data [27]. FL also enables researchers to address critical issues such as data security, data access rights, and heterogeneous data access. Storing data in a centralised cloud computing is an additional issue for ML because using the same server to collect shared information from different devices and maintaining a generic model can make the server vulnerable to server malfunction and bias. This might also result in having an inaccurately trained model that will negatively influence the accuracy of the predicted outcome. Therefore, decentralised data storage is currently one of the best practices. One technology that has decentralised data storage capabilities is blockchain.

There are devices capable of monitoring body temperature, blood pressure, and heart rate. They are useful for collecting and storing data about patients and hence can contribute to diagnosis. IoT and machine learning can help keep healthcare professionals abreast of changes, which is important for a healthy society. The storage of diagnostic data and COVID-19 symptoms is key to ensuring that a disease is wiped out or a vaccine is found since data can be stored in a central database and accessed by scientists and medical practitioners for cross-examination, analysis, and real-time sharing of results.

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