IOT-based Big Data Wearable Sensors for Analysing Symptoms and Predicting Illnesses in the Healthcare Sector

S. Aysha Asra, M.S. Faathima Fayaza, and F. Fathima Farhath

Abstract Technological innovation has always shaped the evolution of healthcare. Nowadays, this relationship has significantly become inseparable with the influence of the Internet of Things (IoT) such as increased use of wearable technology. However, existing IoT-based healthcare systems face challenges in efficiently processing the massive amount of patient data to provide accurate illness prediction. This study proposes an IoT–big data integrated system using wearable sensors for real-time symptom analysis and disease prediction. Experimental evaluation demonstrated that the proposed model improves prediction accuracy and reduces response time compared to conventional systems. The result of expanding access to treatment and enabling unprecedented levels of personalization is customized healthcare. This research suggests an IoT wearable sensor and a big data-based system for illness prediction where the wearable sensors are used to record the patient's physiological signals. These kinds of data are frequently referred to as "big data". By providing doctors with useful information, big data analysis employing effective technology may assist them in making quicker, more informed decisions and in taking proactive measures for better health management. This analysis section is read by a doctor or healthcare adviser, who then provides advice to the patient's caregiver. Moreover, the findings of this study will aid academics, experts, and designers in the development of improved health information systems.

***Index Terms*— Big data, Healthcare, Internet of Things, Wearable Sensors**

I. Introduction

THE goal of the smart city concept [1][2] includes maximizing the use of home assets [3], reduce traffic congestion, provide high-quality healthcare [4], provide environmental convenience, predict the weather, control power and water consumption [5]. The Internet of Things (IoT) [6] offers numerous services to everyone to enhance the day-to-day lifestyle along with other emerging technologies, such big data [7][8], cloud computing, as well as surveillance [9]. This paradigm shift has influenced the healthcare sector as well [10] [11]. Although these disciplines are young, they also pose new difficulties, particularly when they are aimed at the healthcare industry, which is a complex system that calls for answers that are reliable, appropriate, secure [12][13][14], adaptable, and energy efficient [15]. Though these disciplines are in their incubation stage, they face many challenges when it comes to the healthcare sector in terms of reliability, appropriateness, security, adaptability and energy efficiency.

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Big Data has the ability to forecast illnesses, avoiding preventable casualties in the process. A person's full profile is instantly drawn using the big data pipeline once data from various sources, including insurance and medical records, has been processed. In the perspective of IoT healthcare, where patient medical histories are accumulated on cloud platforms and analyzed using big data analyzing tools, big data becomes highly important. IoT systems with big data pipelines present platforms for managing applications, doing analytics, as well as saving and protecting medical records. Geographical locations and IP addresses are used to describe the safety model for healthcare data. The notion of constant key length encryption approach has been employed in this study to protect healthcare data on cloud systems [16]. The data will be created by IoT devices and subsequently analyzed through big data pipelines to generate insightful findings. Since technologies such as biosensors and mHealth are utilized, the volume of data gathered in healthcare systems is currently expanding immensely. This contains information obtained from different software programs, electronic health records (EHR), as well as results from Electronic Patient Records (ePRO). One goal of big data in healthcare schemes is to lower computing time by processing huge quantities of data quickly.

Convergence of big data and IoT is a novel model in healthcare systems. Smart administration of healthcare processes and procedures has been made possible by this convergence. Prescriptive, predictive and autonomous study of healthcare patterns and trends are now possible because of big data analytics. Therefore, a novel intelligent paradigm has been created in which

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big data analytics and IoT are combined as complimentary technologies to upend the healthcare sector [17].

Objectives

- To design an IoT-based wearable sensor system that captures real-time health data.
- To implement a big data analytical model for illness prediction using fuzzy rule-based neural classification.
- To evaluate the performance of the proposed system using simulated or real patient datasets.

This study suggested a system that uses IoT wearable sensors and big data to detect illness predictions. The rest of this paper is arranged as follows: section II presents the literature review. Section III outlines the functionality of the proposed system design. The suggested system is labeled in depth in section IV. Section V summarizes the conclusion along with limitations.

II. LITERATURE REVIEW

A network made up of individually recognizable consumer goods that include sensing systems is known as the IoT technology [18]. It makes it possible for sensors [18], actuators, and other things to be connected to the Internet, allowing global interaction and perception. Despite being three separate technologies that have separately developed over time, cloud computing, big data [19], and IoT are becoming more intertwined over time [20].

In the last several years, the healthcare industry has produced vast volumes of data. However, the tremendous rise in data creation has made it difficult to extract useful data from large healthcare databases that might aid in epidemic prediction and illness cure research. Healthcare professionals may use data analytics to examine a lot of patient data as well as discover a disease's past (in the case of family doctors). When deciding on policies, insurance firms also may employ data analytics. An early detection of dangerous diseases by medical professionals has the potential to save lives [21]. Compared to a general IoT design, cloud-driven IoT provides a number of benefits. This design enables real-time query processing with little connection overhead, which can also minimize processing costs. The following lists the additional benefits of cloud-driven IoT above conventional IoT. The data generated by IoT sensors [22] is stored on a cloud-based platform, which is also known as a big data warehouse, in a cloud-driven IoT background. Real-time event processing is offered in this environment, which is particularly vital in some serious situations. It is also highly scalable. The communication parties (in a cross-component process, a communication party, or party for short, stands in for a broader process. In business-to-business situations, typically address a firm using a communication party) in crucial IoT applications are given required access to real-time data [23]. However, the external parties (users) are authorized in advance to access real-time data directly from the IoT sensors installed in the network. Therefore a session key is established once the user and an accessible IoT sensor [24] have successfully authenticated one another. They are enabled to safely interact with one another with the aid of the established session key. Approved users may occasionally request for big data analytics [25] and big data processing [26] on the data that has been kept to get some conclusions or forecasts on the vast amount of data, like the likelihood of a fire in an manufacturing facility in the upcoming, also forth [27]. Especially in the well-being industry, the fusion of big data analytics [28] and IoT technologies [29] is crucial [30].

The medical IoT system captures patients' physiological information and forwards it to a healthcare data center for storage and diagnostic analysis. The health file is encrypted before transmission to uphold patients' privacy and stop third parties from listening to it in private communications. Only the users possessing the proper attribute secret keys such as a doctor, nurse, anesthetist, or a patient's family are allowed to decrypt the ciphertext. This encryption technique is known as Attribute-based encryption [31]. There are billions of gadgets connected to sophisticated medical systems that can create a lot of information and analyze it. Personal information about the user as well as environmental data (heart rate monitor, ECG, etc.) may be included in this data. To examine this data, clever algorithms as well as methods are wanted. For massive data analysis techniques, for example, the data produced by a locally linked device can be used successfully [32].

The IoT is a novel model that enables a ubiquitous and more individualized type of care, serving the adult populace enhance their excellence of life. The FD-system, IoT system for noticing tumbles in older people, was introduced. It is built on big data and applies machine learning (ML) processing methods based on decision trees. The model, which is run on a smart IoT [33] gateway with fog computing competences, was built and trained using historical data from an available dataset of falls as well as Axiata Digital Labs (ADLs). The FD-system uses a 3D-axis accelerometer sensor integrated into a 6LowPAN-based wearable device to capture movement data from the aged that is recorded as acceleration in the x, y, also z axes. This data is used to forecast falls. The old people had the gadget strapped around their waists, and it provides an appropriate interior option for usage by any senior person. When a fall event happens, the system remotely notifies caretakers, emergency services, hospitals, and the elderly person's relatives utilizing QoS methods. Additionally, by allowing communication stations between all of the system's mechanisms over the smart IoT gateway via protocol conversion features, it ensures smooth compatibility [34]. IoT, a sector that focuses on tying a lot of smart devices to the internet so they may regularly record and transmit the condition of their surroundings, is one of the main sources of big data. Medical-oriented big data has a significant influence on healthcare decision-making [35] [36]. The general characteristics of big data have been described in some innovative works in light of many factors including variety, volume and velocity. The "6V"s velocity, veracity, variety, value, variability, and volume which are described in are properties of big data that should not be generalized when describing IoT-based medical big data. Researchers in and have identified more qualities in addition to the ones already listed [37]. EHRs may be easily exchanged between different physicians and contain the whole patient's health history (current prescriptions, vaccinations, test results, current diagnosis, etc.). They have demonstrated a positive impact on patient-provider communication. Digital health care is

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the term used to describe the use of information communication technology (ICT) in the health industry [38]. Recent studies such as have focused on integrating artificial intelligence (AI) with IoT for early illness prediction. However, these approaches often lack scalability and are limited to specific diseases. In contrast, our proposed system combines big data analytics with IoT-based wearable sensors to create a generalized and adaptable model for health monitoring and prediction.

Human body components are equipped with a variety of sensors, including coordinator sensors, medical sensors, and activity sensors. The heart, head/helmet, ankle, chest, wrist, besides other body parts are among the human body components. These sensors gather a variety of data, including information about diabetes, heart rate, and blood pressure. Additionally, a variety of activities are tracked, including sitting, walking, cycling, and other physical activities. The sensors heart rate, measure body temperature, perspiration production, blood pressure as well as blood glucose levels when engaging in these kinds of activities. We used a director, which functions as a sink node, to aggregate and collect data from multiple sensors as well as to decrease the energy ingesting of the system. On a relay node, a coordinator node gathers the data as well as sends it to the main medical device personalized medical device (PMD). The PMD might be a mobile app or a tiny wireless device or access point that is linked to the Internet. Through Zigbee [39] or Bluetooth technology, the coordinator and PMD may communicate with one another [40].

III. METHODOLOGY

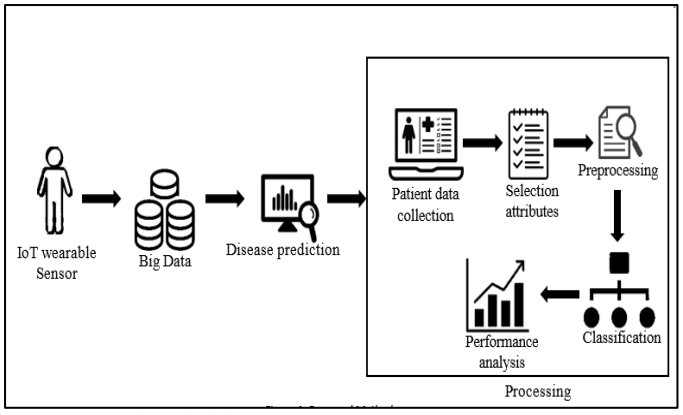

Fig. 1: Proposed Methodology

Fig. 1 shows the proposed model of the system. Important characteristics of the suggested system model comprise:

- Sensors are utilized to gather patient well-being information that is then processed and communicated.
- Medical IoT agent is used to analyze sensor-related data and stored for big data analysis.
- Using the map reduces method of big data to analyze data from medical records.
- Graphical user interfaces that are managed by health monitors.

A. IoT Wearable Sensor

Wearable sensors (e.g.: a heartbeat sensor and temperature sensor) can serve as data gathering devices by gathering the patient's physiological signals. The captured data are then sent to a local gateway server through a Wi-Fi network so that end-systems (like a doctor's laptop) may access the gateway server and get the collected data. In addition to being helpful to the patient, this data may be combined with research and forecast global healthcare trends.

B. Big data

The quantity of data that may be produced as a result of fusing IoT sensors with smart health devices is enormous. Big data is a common term for these types of data. Big data analysis using efficient technology can help doctors make timelier, educated judgments and take proactive steps for improved health management by giving them valuable information.

C. Disease Prediction

The fuzzy rule-based neural classification algorithm is used by the health prediction and diagnosis system is in charge of predicting the disease. The severity module, a part of this research, is in charge of analyzing the severity level utilizing clever fuzzy rules.

D. Processing and Analyzing

The data collection, selection of attributes in the sensor, processing, dividing the diseases such as high, moderate, low-level diseases and finally patients' performance analysis of a week or a month could include in the processing area. This analyzing area is read by physicians or healthcare advisors, and guidance is given to the care giver of the patient.

The proposed system was implemented using NodeMCU microcontroller, heartbeat sensor (MAX30100), and DHT11 temperature sensor. Data were transmitted through Wi-Fi to a local gateway, then stored on a Hadoop-based big data platform for analysis.

Algorithm 1: Fuzzy Neural Classification for Disease Prediction

1. Input patient physiological parameters (HR, temperature, BP)
2. Apply fuzzification rules for each parameter
3. Combine rules to infer disease risk category
4. Output predicted illness and severity score

System Workflow

1. Data Collection
2. Data Preprocessing
3. Fuzzy Rule Classification
4. Prediction & Visualization.

IV. RESULTS AND DISCUSSION

Patients are always the owners of the data under the medical IoT system's watchful eye. To establish a health IoT network, numerous small wireless sensors are either attached to the patient's skin or implanted within the body. These sensors constantly

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monitor the essential physiological parameters as well as transmit them to an aggregate node. A patient's electronic medical file will thereafter contain their medical data. The medicinal file is encrypted to create a ciphertext to ensure patient privacy, also an access policy is set up for the ciphertext to exercise access control so that only authorized individuals may retrieve the secured medicinal data, which are then subcontracted to the public cloud. A patient presets a password, a break-glass key, and then a list of emergency contacts to lessen the likelihood of an emergency situation (such as family or friends, his physician-in-charge). Any encrypted medical records of the selected patient can be decrypted using the break-glass key. In the event of an emergency, the patient can provide the emergency contact person (ECP) with his password so that the ECP can obtain the break-glass key as well as retrieve the patient's medical records. The medical institute's private cloud is responsible for managing the ECP list. By capturing the patient's physiological signals, wearable sensors (such a heartbeat sensor and a temperature sensor) can act as data gathering equipment. So that end-systems (like a doctor's laptop) may reach the local gateway server and obtain the gathered data, the recorded data are then transferred to the gateway server using a Wi-Fi network. Since servers are regularly upgraded, doctors have entered real-time patient data. These resources work together to provide a thorough medicinal report that clinicians can access. This information may be utilized to foresee and study global healthcare trends in addition to being beneficial to the patient.

Big data analysis may assist the doctors in making quicker, more informed decisions and in taking proactive measures for better health management. The health prediction and diagnostic system's fuzzy rule-based neural classification algorithm is in charge of identifying the ailment. This module's severity module is in charge of using smart fuzzy rules to analyze the severity level of diseases. Additionally, the processing section might comprise data collecting, attribute selection for the sensor, processing, classifying the illnesses the severity, and ultimately patient performance analysis for the last week or month. This analysis section is read by a doctor or healthcare adviser, who then provides advice to the patient's caregiver.

V. CONCLUSION

Technological innovation has always shaped the evolution of healthcare. In recent times, this connection has undergone a substantial transformation due to extensive use of IoT devices and wearable gadgets. This results in personalized healthcare, increasing access to treatment as well as enabling unprecedented levels of personalization.

This article suggested a system which is used to identify disease prediction using IoT wearable sensors and big data. By capturing the patient's physiological signals, wearable sensors (such a heartbeat sensor and temperature sensor) can act as data gathering equipment. The end-systems (like a doctor's laptop) may reach the local gateway server and obtain the gathered data, which is transferred to the gateway server using a Wi-Fi network. Because servers are regularly upgraded, doctors have access to real-time patient data. The components work together to provide a thorough medicinal report that other clinicians may access. This information may be utilized to foresee and study global healthcare trends in addition to being beneficial to the patient. A huge quantity of data may be produced when IoT sensors and smart health devices are coupled. Analysis of this big data using effective technology may help doctors make quicker, more informed judgments and take proactive actions for improved health management by giving them important information. The diagnosis is carried out using the fuzzy rule-based neural classification algorithm. The severity categorization of this module is in charge of analyzing the severity level utilizing intelligent fuzzy rules. Data gathering, attribute selection for the sensor, processing, categorizing the severity of diseases, and finally patient performance analysis for the previous week or month might also be included in the processing part. A physician or other healthcare professional reads this analysis section and then advises the patient's caregiver.

Most crucially, new IoT as well as their function in the healthcare industry require hardware and software to be designed to cooperate. In order to offer eHealth services to people for better lives, this particular problem covered all significant facets of IoT eHealth technology, including smart body area sensors, healthcare wearable sensors, cutting-edge ubiquitous healthcare systems, and big data analytics as well.

Limitations

The privacy and security of users may be threatened by IoT devices. Patient privacy and their health might be seriously jeopardized by unauthorized access to IoT systems. Mobile as well as medical devices that are linked, gather, compile, process and send medical data to the cloud. This device layer is vulnerable to cloud polling, RF jamming, spoofing and tag cloning. During a man-in-the-middle attack, traffic can be rerouted in cloud polling to enable command injections into a device. A direct connection attack can be done by locating the IoT devices via a service discovery protocol, like universal play then plug or Bluetooth Low Energy (BLE).

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