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Towards intelligent healthcare: Investigating IoT, Big Data, and AI Collaboration

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Abstract The rising prevalence of chronic disorders such as COVID-19 has reopened the worldwide demand for urgent healthcare services. The current pandemic highlights weaknesses in the established healthcare system, demonstrating that hospitals and clinics cannot handle this situation by themselves. One important aspect of technology supporting modern healthcare solutions is intelligent networked wearables. The Internet of Things (IoT) has advanced to the point that these wearables can collect data on an unparalleled scale. Wearable technology is used to collect context-specific data about our behavioral, psychological, and physical well-being. Managing the large amounts of data produced by wearables and other IoT healthcare devices can be difficult and have a detrimental impact on the decision centers ability to make informed decisions. Using big data (BD) analytics to mine and extract information and make predictions and deductions using knowledge has generated a lot of interest. Research in machine learning (ML) has been effective in addressing a range of networking issues, including resource allocation, routing, traffic engineering, and security. The use of ML-based approaches to enhance different IoT applications has increased. Even though ML and BD analytics have been deeply investigated, most of it talks concerning the way ML-based BD analysis approach is developing in the context of IoT healthcare. In this study, the Analysis of BD using ML techniques in the healthcare industry has been extensively discussed. The advantages and disadvantages of current methods are also discussed, along with a number of research challenges. Our research will help government organizations and healthcare professionals stay up to date on the most recent developments in ML-based data analysis for intelligent healthcare.

Keywords: chronic conditions, medical system, Iot, BD analysis

1. Introduction

The present period is characterized by the widespread adoption and integration of information technology. The integration of technology and scientific theory has led to the digitization and informatization of traditional medicine, with biotechnology serving as its central component. The integration of advanced information technologies has given rise to a new era of intelligent healthcare (Tian et al 2019). BD, Blockchain, IoT, AI, and health technologies are merging to change the healthcare industry. This integration makes use of BD to make well-informed decisions, IoT to monitor patients remotely, Blockchain to provide secure data management, and AI to provide tailored therapy (Rabah 2018). Over the past ten years, the extraordinary growth in global data traffic has led to a rise in curiosity about BD by 2024, the huge data sector will be valuable as 229.4 billion dollars, reducing expenditure in a number of different sectors, including healthcare, sales, production, media, entertainment, logistics, and transportation (Deepa et al 2022). AI techniques are predominantly employed in the field of biomedical data analysis to facilitate the early detection of chronic diseases. These methods handle vast quantities of healthcare data, hence enhancing the delivery of medical services (Nguyen et al 2022).

Today's devices are smarter and grow in supporting humans with a wide range of modified and specialized tasks. The concept that technology can make decisions that are better than humans caused an enormous rise in the use of intelligent technology in numerous sectors as a result of AI (Sreedevi et al 2022). AI has a huge opportunity to improve medical care by aiding with diagnosis, surgery, treatment, and prevention (Ghazal et al 2021). A growing number of chronic patients and the aging population have made preventing illness an important healthcare need. An increasing amount of chronic issues and a lack of available therapies will need to be addressed by the healthcare sector to meet patient demand (Alshehri and Muhammad 2020). The field of healthcare AI applications has noticed a significant increase in interest and progress in recent years. This can be attributed to the notable improvements in the computing capacity of modern technology, as well as the large amount of digital data that can be collected and utilized (Secinaro et al 2021). Intelligent healthcare systems facilitate the utilization of modern diagnostic techniques, continuous monitoring of vital signs in real-time, and empower patients to take appropriate actions in crucial situations (Ahad et al 2020). The medical industry has witnessed the gradual integration of BD analysis due to the rapid advancement of Internet technology. This integration has been facilitated by the digitization of medical information, resulting in the emergence of a substantial volume of data such as electronic health records, hospital information systems, and medical imaging (Lv and Qiao 2020). Our study will keep government organizations and medical experts updated on the latest advancements in ML-oriented Analysis of data for intelligent medical care.

2. Classification of articles

We have looked at a well-known research publishers and databases in this work, including Google Scholar. Including journal articles and conference papers, we aim to provide the recent literature. Many keywords have been used to explore the primary concerns and challenges associated with the implementation of ML in analytics of BD in relation to IoT smart health, such as IoT health, Electronic IoT medical services, ML, and BD analysis in IoT healthcare. Each publication underwent a thorough evaluation to pinpoint any gaps in the literature, establish our research objectives, and provide context for the investigation.

3. Concept of IoT

IoT refers to a network of intelligent, self-organizing things capable of communicating with one another via a worldwide network of links. The idea might be characterized as a connected system of networks or as cyber-physical systems.

The Internet, wireless networks, and Micro-Electro-Mechanical Systems (MEMS) are crucial for IoT development. IoT is expected to grow with analysts predicting by 2020, there will be over 25 billion devices with sensors (Shirvanimoghaddam et al (2017)). Furthermore, by 2025, it is anticipated that the total market size for these devices will be close to 2.1 trillion (Agiwal et al 2019). Smart cities, energy conservation, the agriculture sector, defense, monitoring the environment, and healthcare are few of the industries that have seen a sharp rise in IoT applications in recent years (Ansari et al (2020)). By 2026, the combined value of IoT in software and hardware will reach more than USD 177.73 billion (Shah and Ververi 2018). Almost 42% of the IoT market is expected to originate from the healthcare sector alone. Energy comes in second at 8% and industrial automation at 34% (Enginkaya and Akgül 2018).

4. IoT in medical fields

Wireless body Sensor Networks (WBSN) are widely utilized in the field of healthcare IoT, specifically in eHealth and mHealth, as a well-known health surveillance technology. A network of sensors that are carefully placed close to the human body makes up WBSN (Alkhayyat et al 2019). Sensor, connection, compute, store, and mining layers are among the layers that make up the architecture of WBSN (Nguyen et al 2017). Figure 1 illustrates the layered architecture of WBSN.

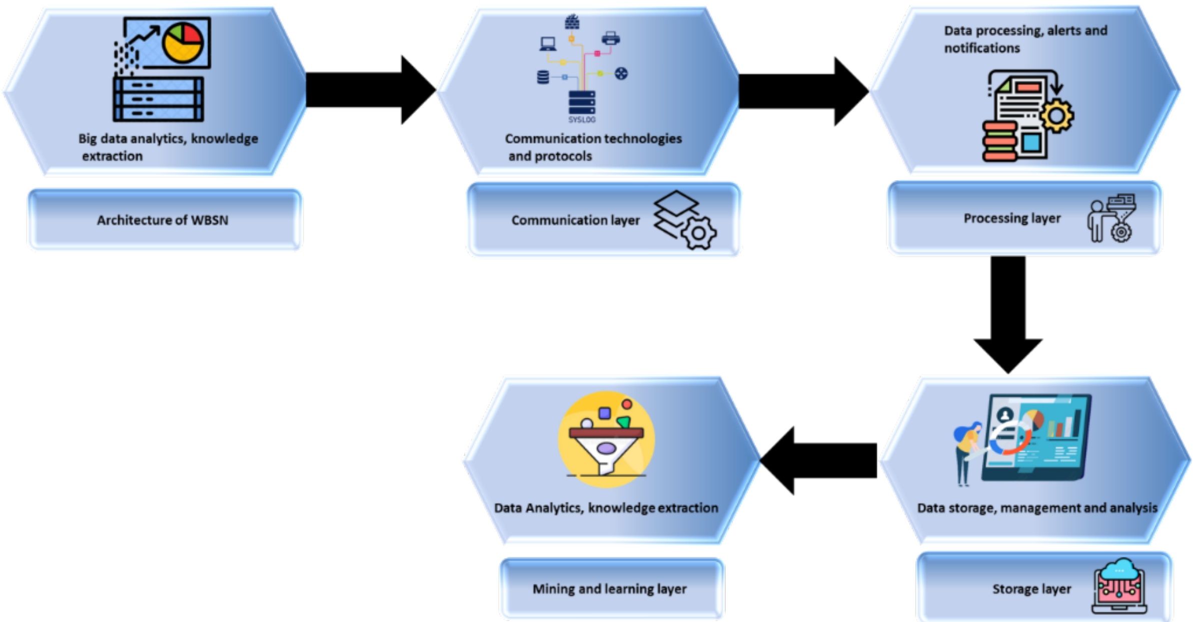

Figure 1 WBSN layered architecture.

Increased diagnostic capabilities, better medical care and remote patient monitoring are made possible by this technology (Ramathulasiand RajasekharaBabu 2020). IoT devices can send useful data to medical practitioners, enabling more effective and individualized healthcare solutions that will improve patient outcomes. Examples of these devices include portable health-tracking devices, intelligent implants for medicine, and hospital equipment (Al-Garadi et al 2020). Each of these regulations possesses advantages and disadvantages and is employed to the specific requirements of the application (Shah and Bhat 2020). Network management, quality of service (QoS), safety, and privacy difficulties at this tier (Aman and Khan 2019). BD analytics and data aggregates are also necessary for research. In order to conserve energy, these techniques lessen network data transfer (Jayaraman et al 2017). Using the operating system, hardware, and processors, the computational layer manages making decisions, alarms, and data analysis (Khan et al 2019). Cloud-based solutions like ThingWorx, OpenIoT, and Google Cloud overcome the memory limitations of IoT systems (Bowya and Karthikeyan 2020). The analysis and learning layer assumes the responsibility of conducting substantial data analytics and extracting knowledge (Qian et al 2020). The primary constituents of this layer encompass classification, clustering, Analysis of associations, longitudinal evaluation, and outlier analysis. In the future, it is anticipated that input will originate from this layer.

5. BD problems in the framework of smart healthcare facilitated by the IoT

BD management and usage are difficult and complex tasks. The patients' bodies are fitted with sensors and numerous medical gadgets that produce substantial quantities of varied data, also known as BD (Jagadeeswari et al 2018). Large datasets with redundant and linked data patterns present transmission issues for networks. This puts stress on networks with limited resources by consuming more energy and bandwidth, which shortens the lifespan of the network and causes congestion (Elhayatmy et al 2018). It becomes very important for everyone involved to handle the data in the system in a smart and effective way. The primary goal of BD analytics is to eliminate irrelevant and inaccurate information while identifying and obtaining fresh insights and knowledge from the enormous amount of unprocessed information that is collected (Wang et al 2018). These techniques improve performance and save energy by using creative energy management measures, while enabling the continued operation of these systems.

6. AI and BD analysis for IoT

ML's application for large information analysis, a discipline derived from the theories of computation learning and pattern recognition, is examined in this section (Huang et al 2018). AI includes ML, which gives machines the ability to learn on their own and make complicated decisions (Khattak et al (2018)). Many domains, including natural language processing, computer vision, recognition of speech, and intelligent control, have shown promise for ML (Kremer et al 2017). Because managing data on these platforms is difficult, new techniques for data analysis are required. The efficient processing of data from many sources requires the use of novel analysis methods. The research makes evident that ML techniques have been shown to manage massive datasets in numerous IoT applications, such as intelligent traffic (Malakis et al 2020). Future difficulties, as well as strengths and shortcomings, are mentioned. The readers are given a fresh viewpoint by this, which will enable them in future readings.

7. Incorporating ML and BD analysis techniques for IoT in adaptive healthcare systems

BD analysis and ML techniques for IoT smart medical systems are categorized in part by organizing tactics for gaining valuable insights from vast amounts of healthcare data. These methods help with disease detection, health trend prediction, and better patient care, which support the establishment of IoT-driven healthcare systems (Mehta et al 2020). In addition, the patient's current medications are tracked, and the potential for an allergic reaction to a new drug is assessed. As a result, money value is retained in addition to time saved. We simply go over a few of the ML methods used in IoT eHealth big information analytics in this part. Additionally, the main ideas are presented along with their advantages and disadvantages, strengths and weaknesses. Table 1 displays ML-based forecasting methods for smart medical care.

Table 1 ML-based prediction methods.

Description	Strengths	Features	Weaknesses
Diagnosis of heart disease using machine learning (Ahsan and Siddique 2022).	Superior accuracy	Finding deadly illnesses	Poor sensitivity and high false alarms
Technique for forecasting acute renal damage (Song et al 2021).	greater accuracy in forecasting	forecasting unexpected damage to the kidneys	Effectiveness, scalability
An inexpensive heart monitoring system (Khan et al 2019).	Frequency and Accuracy	Predicting cardiovascular stress using SVM	Effectiveness, Privacy
Smart speech-recognition telemedicine system (Borthakur et al2017).	Compact and energy-efficient	Parkinson's illness	Safety and Efficiency
Three-tiered ROC-based prediction model for cardiac conditions (Kumar and Gandhi 2018).	Reliable, scalable, and high throughput	Cardiology forecast	Efficiency in energy and accuracy

MAPE-K for disease detection based on IBM (Azimi et al 2017).	Response time, bandwidth, and memory use	Heart arrhythmia	Precision
A system for remotely monitoring cardiovascular activity (Kirtana and Lokeswari 2017).	inexpensive, safe, and simple to use	Identity of lethal illnesses	Web compatibility and minimal memory

7.1. ML-based recommendation framework

A system that uses sophisticated algorithms and data Analysis to offer users individualized ideas and guidance is known as an ML-driven recommendation framework. These suggestions can be made in a variety of fields, such as e-commerce product recommendations or streaming service content suggestions. Model-driven recommendation frameworks (ML-driven) improve customer service, engagement, and decision-making by learning from and adapting to user interactions and data (Yao et al 2019). This study suggests a five-tiered IoT framework. Similar to the physical as well as sending layers of OSI, it controls data transfer mechanisms. Communication methods, such as Bluetooth, WiFi, and LTE, are utilized for transmitting data to the cloud. While the fourth tier manages data storage on servers or in the cloud, the third layer generates alerts using gadgets like microcontrollers and cell phones. Analysis of data and ML are used by the final layer, information mining, to extract insights.

7.2. ML-based forecasting framework

An ML-driven prediction framework improves planning and making decisions in a variety of fields, including banking and climate prediction, by applying AI techniques to generate precise forecasts based on data (Khan et al 2019). Using sensor data, a cloud-based IoT platform applies techniques from computational science to forecast the severity of student diseases. It presents a new machine-learning model and a number of classification techniques for identifying illnesses in healthcare monitoring systems. Simulations show increased precision. Using Heart Rate Variability (HRV) data from Zigbee pulse sensors, the method provides affordable remote surveillance for diseases including hypertension, diabetes, and cardiovascular disorders. HRV measurements are evaluated on an application server using fuzzy rules for efficient illness prediction and classification.

7.3. ML-based collection of information

The utilization of ML algorithms facilitates the automation of data collection, organization, and extraction of insights across several areas. The Adaptive Learner Vector Quantization (ALVQ) algorithm is known for its ability to do real-time data compression, particularly noteworthy for its topology-agnostic operation (Khan et al 2019). The IoT relies on the medical informatics processing pipeline because it makes BD analytics possible. It employs a range of approaches to extract significant patterns and encompasses essential activities such as data gathering, archiving, processing, and searching.

7.4. ML-based assistance for living

The utilization of AI applications in daily encompasses the implementation of ML-driven living aids. Intelligent technology, such as cloud-connected wristbands, is employed to monitor and preserve essential patient data. During emergency situations, alarms are utilized to alert medical personnel. One of the primary characteristics of this system is the utilization of medication monitoring, which is tailored to the patient's medical background. This functionality serves to provide notifications in cases of missed or excessive dosages, assisting both patients and healthcare providers.

7.5. ML-based security analytics

Threat detection and response in cybersecurity are improved by ML-based security analytics, which employs AI to identify security threats. This method reduces mortality risks thorough assessment and assures data security in the healthcare industry while collecting and analyzing patient health data utilizing medical devices and sensors (Khan et al 2020). They combined a number of methods, including signal improvements and watermarking, to increase security and performance while taking clinical errors into consideration in the suggested plan.

8. Challenges and issues in research

In this part, we want to offer a comprehensive understanding of the diverse obstacles associated with ML methods for the purpose of Analysis of data in the medical field within IoT. This information is visually represented in Figure 2.

8.1. Lack of resources

The difficulties in controlling finite resources, including energy, bandwidth, and memory, among IoT gadgets and networks, which affect their functioning and efficiency, are referred as a lack of resources in IoT. The majority of IoT devices, including RFIDs, microchips, sensors and actuators, telephones, and gateways, have modest computational, processing, and energy resources (Hussain et al 2020). The issue related to resource limitation is resolved when the cloud-based computing paradigm is combined with the IoT. But it also adds to the cost and complexity of things.

8.2. Privacy and Security

It was unimaginable to have individualized facilities or rapid, customized access to healthcare, but the usage of IoT in the medical field is making this possible. These apps combine the powers of technology and healthcare devices to offer a range of services. Security and privacy challenges in the medical field using IoT are centered on safeguarding patient confidentiality and ensuring the secure operation of medical equipment that is connected to IoT to ensure data integrity and patient confidentiality.

8.3. Compatibility

There are significant interoperability issues with healthcare IoT devices. In order to support healthier lifestyles, the designer must prioritize interoperability across all facets of IoT eHealth, including body area sensors, smart wearables, and enhanced ubiquitous healthcare, in addition to development (Qadri et al 2020). Reduced maintenance costs, less unscheduled outages, and higher throughput are advantages of compatible devices.

8.4. Power management

Another difficult component of IoT applications for healthcare is power control. Wearable technology and sensors placed on human beings are typically limited by energy. They have constrained energy sources installed (Park et al 2020). Power-efficient sensors that provide constant amounts of power without requiring frequent battery replacements are essential for overcoming and improving energy saving.

8.5. Analysis of Massive Data

Another problem for IoT healthcare is managing massive volumes of unstructured data via massive data analytics. Lately, Notable progress has been made in the domains of gadgets, programs, and other inventive IoT implementations. It is crucial to develop advanced analysis methods and tools that execute, assess, and extract the necessary data from vast amounts of data. Innovative methods of noise reduction are required to enhance the quality of collected information, the information indication, and the overall energy usage of the network (Wan et al 2019).

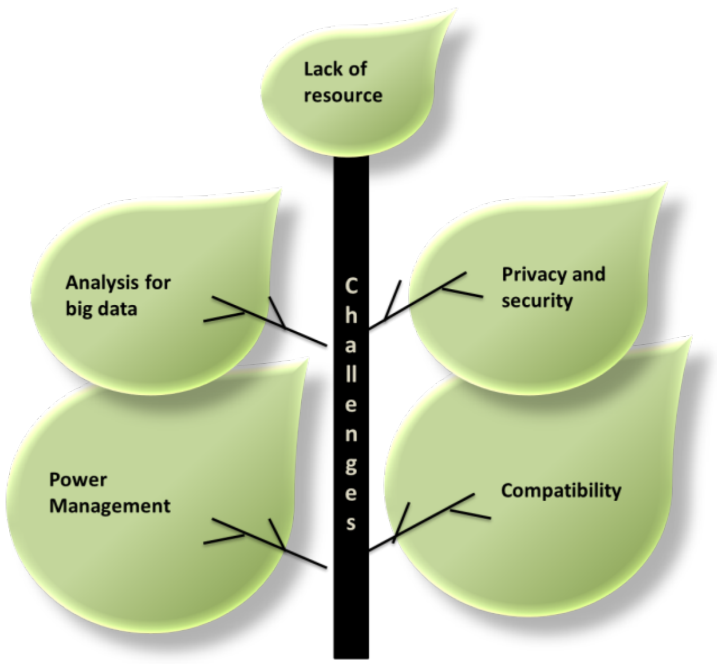

Figure 2 Challenges faced by ML methods.

9. Final considerations

Our paper offers an analysis of large-scale information analytics in the IoT healthcare sector. Selecting the most recent and pertinent surveys, we analyzed the literature to identify research gaps. Additionally, we have offered a thorough and up-to-date analysis of the research on ML-based massive data analytics approaches for IoT smart health. Their benefits and drawbacks were explained in great detail. This gave the readers insight into this area and allowed them to choose a topic from the variety of approaches available to begin their investigation. A number of research challenges and issues were mentioned, which encourages researchers to explore them further.

Ethical Considerations

Not Applicable.

Conflict of Interest

The authors declare no conflict of interest.

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