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TRANSFORMING HEALTHCARE DELIVERY VIA IOT-DRIVEN BIG DATA ANALYTICS IN A CLOUD-BASED PLATFORM

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ABSTRACT
An advanced healthcare network combines integrates the devices that are connected to the Internet of things through which sensing and big data analytics tracks everything that improves patient satisfaction, at affordable healthcare costs. The healthcare industry, as it currently stands, has several issues with regards to storing and processing the data captured for gaining key insights from it. With increasing amount of healthcare data being generated by IoT devices and e-health, m-health or telemedicine broadcasting novel techniques are needed for an efficient management. Data mining study in the healthcare sector distinguishes itself from other data studies due to the intricate nature of medical data, the requirement for specialized medical expertise, and the protection of personal medical information. This paper proposes a contemporary approach to address these challenges by advocating for the adoption of the Internet of Things (IoT) in healthcare to enhance big data analytics. A comprehensive cloud-based platform has been introduced for healthcare businesses. The platform is designed using data processing and IoT technologies to reduce the cost of medical records in order further increase safety. By leveraging remote monitoring, smart algorithms & tools; robust processes along with proximate real-time analysis and intervention by experts to deliver healthcare services not just those who are sick but even the healthy populace. Integration of technologies has brought a major revolution in delivering healthcare. Here, we propose a unique big-driven intelligent healthcare framework for the daily activity tracking (DAT) of healthy and unhealthy people.

Keywords: - Healthcare, Big Data, IoT, Cloud, Analytics, Artificial Intelligence

I. INTRODUCTION
The recent years witnessed the health care in processing territory of internet, cloud computing and Big Data Analytics. This change is fueled by the demand for flexible, massive-scale and customized care solutions to fulfill all this data related needs of IoT instruments. IoT-based healthcare models combine several smart devices and sensors to monitor the health of patients in real-time, which can be useful for remote care solutions medical monitoring system that allows determination when a patient is becoming unwell or falling ill.
This ecosystem for managing, processing and aggregating large scale health data requires scalable on-demand access to computing resources (and storage) solved by cloud computing. By using cloud infrastructure, IoT healthcare applications gain flexibility for agility and scalability as well to lowers operational costs in addition with integrations of advanced analytics and machine learning models.

By combining these solutions, healthcare providers can extract value out of patient data to gain insight on how patients are being treated and cared for in the hospital, make information -based adjustments about treatment plans that provider better outcome with a more efficient operation at its core.

The internet emerged from the establishment of computer networking. Subsequently, the World Wide Web was formed by connecting multiple computers together. The advancement of mobile-internet technologies is contingent upon the availability of internet connectivity on mobile devices. Individuals starting utilizing the internet via social networks. Subsequently, the notion of connecting ordinary objects to the internet was introduced, resulting in the advancement of Internet of Things technology [1].

The International Telecommunication Union officially acknowledged this. The abbreviation "ITU" stands for the International Telecommunication Union. The Internet of Things (IoT) envisions a future when all devices in our surroundings, known as "smart objects," are interconnected over the Internet and can communicate with each other with minimal human intervention [2]. The ultimate objective is to establish a highly sophisticated society in which objects can autonomously and efficiently react without explicit instructions, as they possess a comprehensive understanding of human preferences, objectives, and requirements [3]. The Internet of Things (IoT) enables the continuous connection of individuals and objects, regardless of location, using any network and service, to any entity or device. The Internet of Things (IoT) has the capability to function autonomously, without requiring human intervention [4]. Early IoT applications have been developed in the healthcare, transportation, and automotive sectors. IoT devices can be used to monitor a patient's current medications and evaluate the potential risks of new prescriptions in terms of allergic responses and negative interactions. Figure 1 illustrates the diverse applications of the Internet of Things (IoT).

Figure.1 Smart Applications for Internet of Things (IoT)

II. LITERATURE REVIEW

The advent of Cloud-based Smart IoT Healthcare Networks along with Big Data Analytics has brought about a paradigm shift in the healthcare sector by improving patient care quality, cutting costs and better data handling capabilities. This has been possible through the transformation driven by; The Internet of Things (IoT), Custom Cloud computing; which allows to process vast healthcare data and store them too wherever required. These devices (e. g., sensors, wearable technology) constantly capture sensory data from patients and streaming it to the cloud for processing and storage [5] [6]. This issues gave rise to the new concept of fog computing; over time, cloud has been a relevant infrastructure for managing large amount of biomedical data due its processing, networking and storage capabilities [7], but is not designed optimizing user-oriented real-time applications due latency. Edge and fog computing have been proposed as opportunities to reduce latency, enhance the reliability of healthcare data management [7]. Big data analytics used in these cloud-based systems helps extract meaningful information from the huge datasets produced by IoT devices. The use of AI enabled algorithms for diagnosing, classifying or even predicting diseases which not only improve patient health outcomes but also apply precision and personalized medicine

[5]. Furthermore, integration of smart healthcare networks with big data analytics enables remote monitoring and real-time health status updates which plays an important role in both chronic diseases management and elderly care [6]. A plethora of cloud based solutions are available at Amazon and IBM for consumer as well big data storage with more complex computing solution in health care [5]. Besides, SDNs secure and protect sensitive medical data - which is one of the major concern in IoT based healthcare systems [8]. Existing research also emphasizes the importance of creating new methods, techniques and algorithms to analyze continuously increasing volumes of healthcare data - highlighting need for effective management and security measures [7]. In addition, the implementation of IoT enabled smart healthcare systems in rural and sub-urban areas organizes an aptitude which delivers preventive medical care for who do not have reasonable amount medial infrastructure to access health facilities, hence it helps to bridge gap between more urbanized parts of world and less modern [10]. This allows to not only improve the efficiency of medical treatment but also helps in developing preventive care and healthcare plan from real time and historic data analysis [6] The literature, overall, highlights the prospective of big data analytics and use cases with respect to cloud-based smart IoT healthcare networks; however cautions challenges in dealing them - some avenues for potential research areas/discredited facts needs fleshing-out regarding making these infrastructures efficient philosophically as well as practically towards contributing general populace good-healthcare at large.

The integration of cloud computing, Internet of Things (IoT), big data analytics is interestingly transforming the healthcare industry by providing efficient, cost-effective and personalized healthcare services. In this respect, some studies summarize technical details and improvements of sensor systems used to develop BCI [8-10], whereas others review recorded advances in their applications or signal processing issues encountered during the development of different types of microcontroller-based brainwave control interaction software covering proposed solutions over them.

Mobile cloud computing is an architectural framework where both mobile devices and clouds work together to perform computationally extensive processing tasks which then provides end users seamless access on their ubiquitous hand-held (personal) mobile devices over the network. Big data analytics, which core characteristics includes volume, variety and velocity play a crucial part in drawing insight to healthcare related dataset due its veracity. This could effectively provide a better service in addressing the healthcare big data applications through networked healthcare systems. To this end, an infrastructure of cloudlet-based mobile cloud computing for handling health restoration has been proposed [11]. This section presents hybrid model with combination of IoT technology and cloud computing for the big data management in health services applications. This model determines when to select its VMs in order to efficiently process the large data content that can make these so difficult, especially considering the high number of sensors and thus very diverse sources. While the newly designed system eliminates healthcare performance and reduces execution time, there is one way to increase real-time data retrieval through improved storage solutions [12]. Supporting the healthcare industry, UbeHealth framework is based on edge computing and deep learning in order to empower IoT big data analytics for HPC-the generative adversarial network (GAN). The framework seeks to improve network quality of service and data rates as well enhance caching and routing decisions. It also processes treatment of recognizing disruptive movement and international data moving, the upgrading in transportation healthcare service on brilliant city [13].

New age solution for consuming IoT-based big data in healthcare. In light of the existing issues regarding storage and processing of large quantities Big Data associated with Healthcare, considering today's technology era we came across a novel approach towards its practical execution as Proposed by experts [8]. This method requires a cloud-based platform in order to reduce costs of medical data management as well as increasing security. This system enables remote monitoring, faster analysis and expert engagement which lead to better treatment recommendations thus changing the way healthcare services are delivered drastically. Health-CPS (Cloud-based Patient health monitoring System) is a cloud and big data analytics based patient-centric healthcare application. It is broken down into 3 layers; a common standard for data collection layer, the distributed storage and parallel computing of Data management layer selected out on from our text mentioned respectively above as pivot sentences allows to meet various needs when using big-data frameworks with different Data-oriented service groups. This system improves the performance of healthcare by offering multiple smart healthcare apps and services [14]. Privacy preserving e-health system comprised of IoT, big data and cloud storage for patient physiological data monitoring and electronic health record (EHR) management. The system provides encryption and fine-grained access control to the data so that security or privacy is guaranteed. Related work also includes a keyword match-based policy update mechanism that enables flexible access policy updates without privacy leakage [15].

This paper has proposed a novel cloud and IoT-based mHealth mobile application framework for lifestyle and serious disease diagnosis in real time. This happens using a Fuzzy Rule based Neural Classifier, which is responsible for predicting and diagnosing diseases such as diabetes. We validate that our method is more accurate compared to previous systems for disease prediction [16]. They have proposed the architecture of an IoT-enabled smart healthcare system with wireless sensor networks and radio-frequency identification. Through the use of high-performance data analytics tools, such as Rapid Response for Healthcare solution to process health records with real-time and precision. It can be a venue for lab-testing IoT-based systems and is applicable to vast amounts of data this certain kind of architecture manages [17]. They have suggested a framework for monitoring health using wearable sensors and social networking data streams. To analyze healthcare data and predict drug side effects and abnormal conditions, the system uses an innovation called big-data analytics engine by mining patient records using bidirectional long short-term memory (Bi-LSTM) based on ontologies. This leads to more accurate health condition classification and drug side effect predictions [18]. This paper has proposed a framework which can facilitate, and organize the processing happened at both edge side as well in cloud leading towards achieving live data analytics on wireless IoT networks. In contrast to the above cases, this one uses a combination of cloud and edge computing so as both technologies can be used together for better performance in IoT networks. The framework addresses major concerns related to data and analytics for research [19].

Cloud computing + IoT and big data analytics are changing the face of healthcare, offering better ways to manage data, monitor in real-time or personalize treatment. Highlights various frameworks and models that provide a way to overcome the challenges in healthcare delivery are discussed through reviewed studies, which propose unique solutions towards health care service improvement.

III. MATERIALS AND METHODS

Given the potential applications to IoT and Big Data, specialist intervention is needed - for rapid diagnosis of disease as well as therapy recommendations. Our objective is to focus more on the entire E-health components research trends with respect in using IoT and applying big data analytics mechanisms for this very particular sector over various advanced fields. Presented here in detail is a choice selection of recent and best articles with the ultimate aim to highlight the full breadth, open-access nature as well uniqueness of research currently under way.

E-Health is the utilization of electronic technology and communication systems for the purpose of providing healthcare services and information. The improved machine communications of the Internet of Things (IoT) model have enabled the possibility of telemonitoring in e-health [20]. The utilization of big data in the field of e-health has a significant impact as it transitions research from being hypothesis-based to being driven by data, by effectively analyzing substantial quantities of medical data. This allows for the integration of many sensing devices in both straightforward and intricate manners. Suciu et al. examined secure techniques for handling substantial volumes of data using cloud connections. The suggestion entailed the establishment of an e-health framework utilizing the EXALEAD CloudView search engine [21].

M-Health refers to the application of mobile technologies, such as smartphones and tablets, for the purpose of achieving healthcare goals.In the era of data production, gadgets and software can be utilised to analyse data and generate a self-assessment of one's health [22]. Various hardware and mobile applications have been developed to improve the healthcare sector. Moreover, it allows healthcare professionals to evaluate a patient's performance by measuring the level of mobility. In addition, Milstein revealed that their current investments mostly centre around bioelectrical and electroceutical therapies, including those that entail the stimulation of nerves at a microscopic level [23]. In addition, J&J partnered with Google, Philips, and J&J itself to develop blood pressure monitors and other wearable devices, respectively. In addition, these companies focus the development of sensing technology, such as wearable plasma glucose metres and smart lenses. HeartCare+ is a mobile application that assesses the likelihood of coronary heart disease in individuals residing in rural regions and facilitates remote connection with specialists in urban areas.

Table.1 Latest research content on internet systems built on cloud technology

Publication	***Research content***
Ohud et al. [27]	The research paper proposes a patient-centric healthcare system utilizing blockchain technology to store personal health records (PHRs).
Defaf et al. [28]	The paper discusses utilizing DNA sequences for information hiding, focusing on steganography and cryptography.
Irada, et al. [29]	Created a smart home environment based on the cloud for analysis of human behaviors
Ruina et al. [30]	In the cloud data lakehouse-based AI diagnostic solution proposed for small and medium-sized health facilities, patient data collected from real-world scenarios is utilized to enhance diagnostic capabilities.
Mukund et al. [31]	Discusses the development of an IoT-based health monitoring system that utilizes various sensors to track body temperature, oxygen levels, humidity, air quality, and surrounding temperature
Nourchene et al. [32]	Developed a technological solution that offers WBAN consumers services based on the amount of sensory data and the type of application.

Telemedicine, enabled by the Internet of Things (IoT) and other multimedia technologies, has achieved significant advancements in healthcare by providing remote medical services and promoting communal living. Telemedicine refers to the timely provision of electronic medical consultation and specialised care services through telecommunications technologies such as telephone, facsimile, and distance learning. Various federal agencies are now employing telemedicine technologies. Nevertheless, the utilisation of IoT devices gives rise to concerns regarding interoperability, service level, security, and the necessity for prompt installation and enhanced storage capacity [24, 25]. Additional technologies have the potential to enhance this process, and telemedicine has the capacity to greatly progress the current comprehension of healthcare [26]. An example of this can be observed in the advancements achieved in micro engineered machine systems (MEMS), which are categorised within the realm of nanotechnology. This advancement has generated new opportunities in the field of telemedicine. These can manifest in several forms. Table 1 displays a compilation of research papers centred on Health Systems that have been generated via cloud-based internet technologies.
Wireless wearable sensors equipped with the capability to monitor physiological activity, a miniature photographic camera that can be swallowed to visually illustrate the process of digestion, and arthroscopic surgical robots.

3.1 Cloud-based platform for healthcare in the Internet of Things (IoT)

The healthcare industry utilises a distinctive wireless body area network (WBAN) technology, which offers a wide array of services as a versatile platform. It utilises sensors and other medical devices to observe both internal and external biological signals in the human body. Moreover, these signals can be used to optimise the efficient distribution of patient information throughout many medical networks. The execution of this stage led to a substantial enhancement in the velocity and capability of gathering complete health information. The majority of the data in the domain of big data is classified as confidential, and healthcare big data utilises many methods to ensure the security and integrity of data during storage and transfer protocols.

Consequently, health systems are required to uphold stringent levels of information confidentiality and safety while effectively handling substantial volumes of data. Big data in healthcare entails the gathering and examination of vast amounts of data pertaining to different facets of an individual's life. The cornerstone of healthcare is the collection and analysis of observational data pertaining to an individual's environment, dietary patterns, and physiological functions, commencing from birth. Moreover, the crucial information encompassed in health big data primarily consists of medical data that is generated by medical organizations.

Medical data encompasses various types of information, such as health records, computed tomography and magnetic resonance imaging (MRI) scans, ultrasound reports, and endoscopic images. Health statistics encompass information regarding both physical activity and the surrounding environment. The current model of medical services seeks to revolutionize the healthcare industry through the utilization of advanced technologies such as cloud computing, Internet of Things (IoT), big data, and artificial intelligence (AI). Table 1 provides a concise overview of the literature review conducted on healthcare systems that employ cloud and internet technologies.

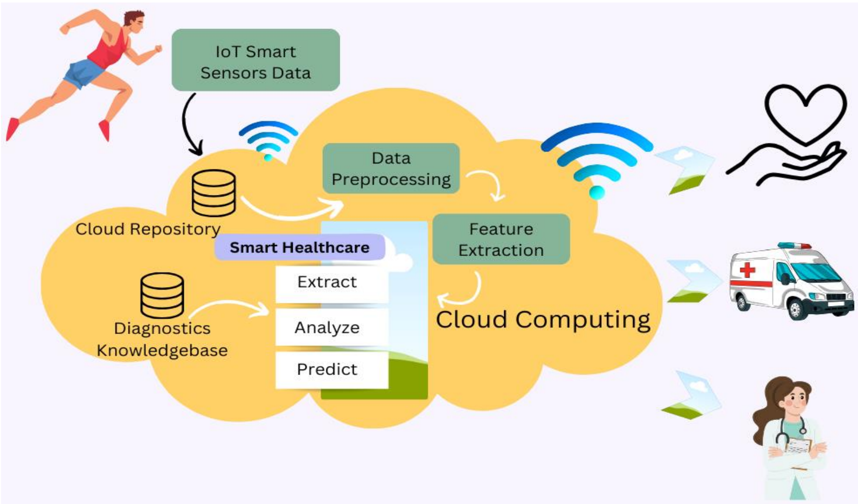

Figure 2. Healthcare network utilizing Internet of Things (IoT) technology

Figure 2 illustrates a healthcare network that has been built utilizing Internet of Things (IoT) technology. This network consists of a distinct topology and an architectural framework. The network interface circumstances in the healthcare sector exhibit variability as a result of the users' movement. When evaluating a healthcare environment that operates without interruption, several factors are considered about the portability of the devices, the management of connections, and the transmission of data among WBAN devices. The elements consist of the condition of the communication channel, the status of communication, the type of data being transmitted, and the amount of data being communicated.

The data layer consists of equipment used for storing and processing data obtained through Wireless Body Area Networks. Furthermore, it includes the capacity to instantly filter data, hence enhancing the reliability and consistency of data analysis. The knowledge layer analyzes users' health data and generates and categorizes knowledge depending on their specific situations, using specialist medical statistics for healthcare services. The service layer offers tailored services by converting gained knowledge and information into the consumer health system.

Multiple recent studies have analysed the advantages of utilising cloud technology for healthcare applications. The following layer, known as software as a service (SaaS), delivers medical information to users through virtual software services, such as web applications. I conducted a research project on health prediction technology and healthcare big-data methodologies to anticipate future health problems. Figure 3 depicts a health-analysis platform that leverages the advantages of scalable cloud technologies. The study described in article [33] investigated the utilisation of big data in the healthcare sector and the creation of health prediction systems to anticipate future health problems.

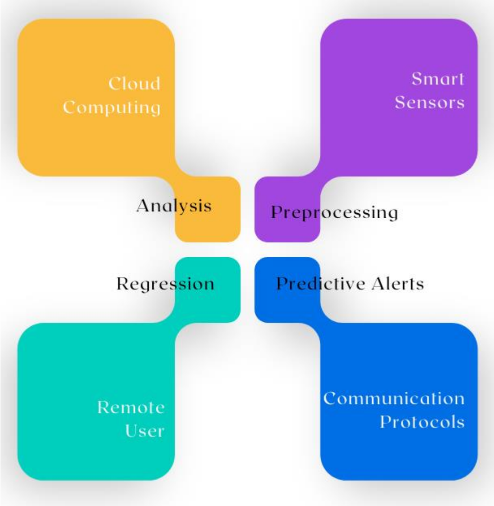

Figure.3 Health prediction system leveraging scalable cloud infrastructure and big data analytics

Wireless Body Area Networks are employed for the purpose of monitoring patients' health, and the gathered data is stored in a scalable cloud. A signature-based access control system efficiently prevents unauthorised users from accessing data. The individual is accountable for generating user accounts, deciding data access credentials, and selecting from a range of options for ongoing, real-time, or planned surveillance.

3.2 Big Data Framework in Smart Healthcare

Collecting data for healthcare applications that utilise biomedical sensors presents a notable difficulty because of the placement of sensors throughout the body. Due to the current situation, there is a notable increase in the adoption of diverse cutting-edge technologies and approaches, such as the integration of Machine Learning in education and the utilisation of live-streamed health-related contributions. An intricate healthcare infrastructure can be developed to address the aforementioned challenges. Remote monitoring has the ability to forecast chronic illnesses, especially those that pose a significant risk to one's life. The Smart Healthcare Framework consists of the components illustrated in Figure 4 and Figure 5.

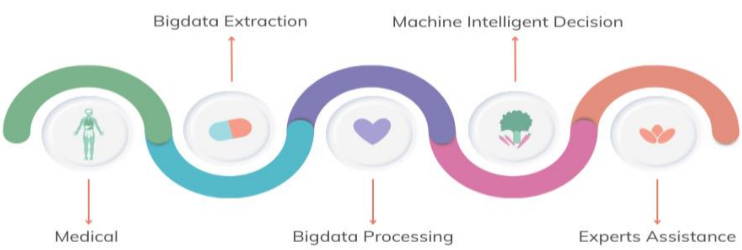

Figure.4 Sequence for an Intelligent Healthcare Network

Figure.5 Elements of an Intelligent Healthcare Network

Data collection: Data will be gathered from a range of biomedical sensors, including those affixed to the chest, hand, and ankle of persons, as well as Glucometer, blood pressure, motion sensors, plethysmography, electroencephalograms, electromyograms, and electromyography. Diverse data kinds, including organised, semi-structured, and unstructured data, are stored in various formats. The DICOM standards have been utilised for the transmission of both medical and non-medical data. DICOM fully conforms to internationally acknowledged international standards [34].
The Internet of Things (IoT) and cloud storage enable the transfer of data from several sources, such as sensor variations, mobile devices, and IoT devices, to a data processor on a large scale. Afterwards, this data is subjected to further analysis using machine learning approaches [35]. The widespread dissemination of healthcare information and the examination of data collected by Internet of Things (IoT) devices can be inflexible and costly. Cloud storage is suitable for storing large quantities of patient data, resulting in cost savings for administrations.
Big Data Processing: Healthcare data is ideal for big data processing and analytics because to its substantial volume, wide variability, and high validity. A comprehensive platform will gather healthcare data acquired from various sensing devices for the purpose of conducting big data analysis. In order to manage this vast quantity of healthcare data, we employ the Apache Hadoop Distributed File System (HDFS) [36]. MapReduce is a computational framework used for processing data in the Hadoop architecture. It allows for the simultaneous processing of several datasets and is a crucial element of Hadoop HDFS. Specialised intervention: The study's findings are conveyed to medical professionals and healthcare assistants to propose future therapeutic interventions. Patients can receive wireless notification alerts.
The existing advanced infrastructure for big data in the healthcare sector will be modified to support a range of healthcare applications, including monitoring carers of elderly patients and remotely tracking the physical activity of athletes [37]. Furthermore, a wide range of essential medical, genetic, and physical data can be remotely monitored. The main objective of our proposed intelligent healthcare system is to deliver customised patient care by effectively processing and promptly communicating with experienced decision-makers [38].

3.3 Management of extensive health data using cloud-based technology

Cloud-based health big-data management necessitates extensive investigation into the acquisition of vast amounts of data to uncover significant connections between patients' illnesses and symptoms, with the objective of creating efficacious remedies for a range of ailments. In addition, a physician has the capability to provide patients with comments relating to remote medical care. The deployment of a cloud system's interruption process ensures the accurate processing of data by rectifying errors and mitigating losses caused by delays.
The development of a robust framework for chest X-ray (CXR) anomalous object detection and classification is pivotal in enhancing medical diagnosis accuracy and efficiency. Various studies have explored the integration of artificial intelligence (AI) and deep learning techniques to address this challenge. For instance, the use of deep machine learning approaches empowered with fuzzy logic has been proposed to process diagnostic data, segment images, and classify objects to determine malignancy in thoracic lung diseases [39]. The WBAN sensor is utilized to examine the correlations between physiological and psychological alterations. Cloud storage functions as a repository for health information, while also functioning as a repository of knowledge that enables the generation of new knowledge through deduction and the utilization of machine learning techniques and data mining. Table 2 illustrates the research conducted on the use of explainable artificial intelligence to a substantial amount of health data. Microsoft is presently engaged in the development of explainable artificial intelligence (AI) using Azure, a domain that is actively being investigated within the study of AI. DAPRA has categorized explainable AI into two components: a transparent model that reveals the fundamental mechanisms of the previously described opaque system, and a user-friendly interface for providing explanations.

Table.2 Evolution of Artificial Intelligence (AI) Generations

AI Generation	*Characteristics*	*Implementation Use Cases*
1st	Rule-based systems, limited to specific tasks	Expert systems, early natural language processing (NLP)
2nd	Machine learning, statistical methods	Spam filtering, recommendation systems, image classification
3rd	Deep learning, neural networks	Speech recognition, object detection, language translation
4th	Contextual adaptation, self-learning	Autonomous vehicles, personalized medicine, smart assistants
5th	Autonomous decision-making, human-like reasoning	Ethical AI, complex problem-solving, creative applications

Sensitivity analysis examines the influence of alterations in input data on the ultimate results. The final conclusion is evaluated by thoroughly studying and clarifying each individual item or component of information [40]. Layer-wise Relevance Propagation (LRP) is a method that uses the backpropagation algorithm during the training stage of neural networks to improve visualisation. The neural system utilises learned weights to efficiently propagate the influence to every node in the preceding layer.

IV. CONCLUSION

This paper provides a succinct overview of data science and cloud methodologies and algorithms that are crucial for efficiently managing vast quantities of data in the healthcare sector and addressing its difficulties. Intelligent healthcare applications often employ data science and machine learning techniques to tackle the challenges associated with remote patient monitoring. This study introduced a modern method for analysing large amounts of health data from the Internet of Things, with the goal of addressing the issues that were previously found. A comprehensive healthcare data processing system and an Internet of Things health platform have been deployed, leading to decreased costs in medical data management and improved safety protocols.

The incorporation of diverse data and the accuracy of data analytics are essential components in the examination of the health big-data framework. The progress in approaches for analysing big data has shown promise in terms of both accuracy and efficiency. These offer personalised healthcare services while decreasing medical costs and wait times. Furthermore, sophisticated and intricate big-data-processing technologies offer clients with explicit and comprehensible anticipated results. By implementing these strategies, the progress of AI systems in many domains such as law, finance, economics, and medical treatments can be expedited.

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