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Review in IoT for Healthcare in Our Life

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Abstract
Over the previous decade, significant research has been conducted in the field of healthcare services and their technological advancement. To be more precise, the Internet of Things (IoT) has demonstrated potential for connecting numerous medical devices, sensors, and healthcare professionals in order to deliver high-quality medical services in remote locations. This has resulted in an increase in patient safety, a decrease in healthcare expenses, an increase in the healthcare services' accessibility, and an increase in the industry's healthcare operational efficiency. This paper provides an overview of the possible healthcare uses of Internet of Things (IoT)-based technologies. The evolution of the HIoT application has been discussed in this article in terms of enabling technology, services of healthcare, and applications for resolving different healthcare challenges. Additionally, effort difficulties and drawbacks with the HIoT system are explored. In summary, this study provides a complete source of information on the many applications of HIoT together the purpose is to help future academics who are interested in working in the field and making advances gain knowledge into the issue.

KEYWORDS: Internet of things, Healthcare, Body Sensor Networks, Smart Emergency System.

I. INTRODUCTION

Remote monitoring, smart sensors, and medical device integration are all used in IoT applications in the healthcare industry in addition to activity trackers, wearable biometric sensors, blood sugar and blood pressure monitors, drug dispensers, and smart beds [1]. If the Internet of Things is developed and invested in, the future of healthcare will be bright, as this technology will improve a component of healthcare while also changing how it is managed. Because health-care necessitates the Internet of Things, a number of responses provide a realistic and practical great picture of the IoT's role in the sector and convert data to measurements. Because it can be improved more efficiently, measurable health, also known as health statistics, may be the future of health care treatment. Because it is commonly understood that data has an impact on performance, it is prudent to take use of quantitative health technology. One of the reasons for the IoT's importance is the ability to assess persons and follow their health in order to provide better results [2]. Improving the health of patients, notably through the use of patient-specific wearable gadgets. It alerts patients when their heart rate fluctuates or if they are falling behind in self-care, and it shares this information with by updating the personal health data of tech-savvy individuals on other devices [3]. The cloud does away with the requirement to store data locally manually enter data convert into records pertaining to an emergency since the Internet of Things ensures the all relevant data is considered while making patient-friendly decisions [4].

Additionally, it can be used at home to keep track of medicine compliance and patient health [5]. As healthcare expenses continue to climb, prevention has become a significant focus area, and universal access to achieve high-resolution real-time data on everyone's healthy will go to healthy care confirm by supporting people in overcoming sickness. Improving patient participation and satisfaction, such the IoT has been shown to improve patient satisfaction by expediting surgical progress [6]. By allowing patients to spend more time communicating with their doctors, reporting a patient's exit from the operation room to his family can improve patient participation. It also minimizes the need for communicating directly between the doctor and the patient, as internet-connected devices provide essential data [7].

The objective is to contribute to preventive medicine, as wearable gadgets that monitor sleep, perspiration, temperature, and exercise allow show concern teams to accumulate millions of data points and connect them with individual fitness levels. As a result, the data acquired by sensors can be used to provide patients real-time notifications. Event-triggering messages, such as alerts or triggers, can really cause people's heart rates to rise. This will not only speed up the process, but it will also ensure that the

patient's therapy is administered at home. The IoT allows providers to integrate devices to monitor the expansion of wearable devices since the data collected by the device will be supplemented by data discarded in electronic data recording, allowing care teams to build vision-driven priorities and exploit the IoT. This is another way caregiver can indicate their presence in patients' daily lives by monitoring who is at home for chronic conditions [8]. Not only has the Internet of Things increased human independence, but it has also expanded human ability to engage with the external environment. The Internet of Things has become a big contributor to global communication thanks to futuristic protocols and algorithms. It links a wide range of many devices, including wireless for sensors, all home appliances, and electrical equipment, to the Internet [4].

The “Internet of Things” is being used in agriculture [9], autos [10], the household, and healthcare. The IoT's increasing popularity is due to its features of improved precision, decrease cost, and the mount of capacity to forecast future occurrences more accurately. Furthermore, the quick rise of the IoT revolution has been facilitated by better understanding of software and apps, as well as advancements in mobile and computer technologies, widespread availability of wireless technology, and the expansion of the digital economy. Sensors, actuators, and other Internet of Things (IoT) devices have been collected together physically devices for monitoring and share data employ a number of protocols of communication, including as “Bluetooth, Zigbee, IEEE 802.11 (Wi-Fi)”, and others. Sensors embedded in or worn on the body of human are used in healthcare to collect physiological data from patients, such as degree of heat, blood-pressure, electrocardiogram (ECG), and electroencephalogram (EEG) [11].

Furthermore, environmental data such as many factors first, temperature effecting, humidity rate, date factor, finally, time can be stored. These data enable the generation of meaningful and precise inferences about the patients' health problems. Because a large volume of data is collected/recorded from a variety of sources, data storage and accessibility are also key components of the IoT system (sensor devices, mobile phones techniques, e-mail, package of software, and applications). +e Physicians, caregivers, and other authorized individuals have access to the data collected by the aforementioned sensing devices. The ability to quickly diagnose patients and, if necessary, take medical action is enabled by exchanging this information with health-care suppliers via cloud-server. For effective and secure transmission, collaboration between users themselves, all patients, and the module of communication is managed to maintain. The majority of IoT project systems employ a user interfacing that serves as a dash-board for medicine providers, executing user controlling, data visualization form, and functions of apprehension. There is a lot of research in the literature that shows how the IoT system has advanced in terms of healthcare monitoring, control, security, and privacy [12]. These achievements demonstrate the usefulness of IoT in the healthcare sector and its bright future. However, the primary worry when developing all IoT devices are ensuring the matrices of service quality, which contain data privacy policy, security level, amount of cost, dependability, and accessibility. In order to boost the use of IoT in healthcare systems, a number of countries which have established update technologies and new policies. The shifted the focus of this healthcare research to a more advantageous area to investigate. The purpose of this study is outlining the progress of conclude research in IoT depend on healthcare applied systems and to conduct a comprehensive review of the technology, services that introduced, and all applications that enable them.

II. HIoT Development

Healthcare is a critical component of society. Electronic health (e-health), remote monitoring systems, and home and community care are all examples of electronic health (e-health) are examples of specialized e-health services with enormous growth potential in the healthcare and communication technology industries, to name a few. The Internet of Things presents various prospects for enhancing healthcare services and operations. The Internet of Things encourages a more comprehensive healthcare approach by titling the health requirements of a population as a entire rather than just individuals, with by encouraging actions that mitigate the consequences of diseases, disabilities, and unintentional injuries Integrating healthcare apps with other aspects of the Internet of Things also helps to ensure the long-term viability of healthcare [13]. The healthcare world has determined that disease prevention is just as critical as medical therapy as a result, the IoT enables the maintenance of sustainable settings conducive to a healthier lifestyle. Additionally, the IoT contributes to mitigating the effects of climate change on the population's health and well-being. Providers and services must include sustainability concepts into their operations, including as energy and water efficiency, as well as environmental compliance, to ensure the future sustainability of healthcare. Additionally, it's critical to create environments that safeguard and promote community health. As a result, the Internet of Things makes a substantial contribution to the creation of a sustainable environment, resulting in a more effective healthcare strategy. Medication delivery and monitoring are only two of the many IoT applications in healthcare that are being considered. [14].

The usage of IoT intends to increase the efficiency of medicine in comparison to the past. Individuals can more efficiently receive and exchange information regarding ailments and treatments. The Internet of Things allows people to get real-time medical or treatment information, which can help in illness detection and prevention. As a result, it enables people to either prevent developing a disease into best or to cure it as soon as feasible. The IoT health app(s)' backend system will be able to maintain track of crucial patient health information. This information is referred to as Electronic Health Records in the field of e-health (EHR) [15].

As a result, combining IoT with EHR systems increases healthcare-related information access and retrieval, as well as the accessibility and interchange of electronic health records (EHRs) between healthcare facilities. In addition, the

Internet of Things is projected to improve remote health monitoring systems in healthcare. Patients can be monitored at home using remote health monitoring technologies. These introduced systems a goal to achieve higher level quality services treatment at a lower cost to individuals and roles of governments with not jeopardizing the level of quality indicates to the healthcare supplied. The usage of method remote monitoring device enables the measurement of a patient's biological signals throughout his or her daily activities. This kind of device allows for the gathering of medical information and distinct signals from patients' bodies themselves, such as heart concept rates, from a distance. Enhancing the quality of treatment and services also has a number of benefits, including greater reliability, accessibility, frequency, accuracy, and availability. A remote monitoring system driven by the Internet of Things may detect changes in a person's physical condition and track important medical signals.

Other systems and entities, such as healthcare professionals and medical facilities, will be able to access this data in real time, and the data obtained by this system will be available on the Internet, creates several choices. For example, depending on the analysis of EHRs obtained via remote monitoring systems, an alert system may be developed. The system can be set to alert healthcare experts and emergency personnel in the event of a medical emergency, family members, and other appropriate persons. Furthermore, the system can provide insight into a monitored person's health situation, allowing for the provision of necessary help as early as feasible, potentially saving patients' lives. In addition, Internet of Things (IoT) services may be of assistance with illness surveillance, discovery, prevention, and treatment at an early stage [16].

Diabetes, heart disease, cancer, convulsions, and lung difficulties are only a few examples. Such diseases typically demand ongoing monitoring of the body's actions, which means the patient must be constantly monitored. Historically, medical practitioners and healthcare workers have been tasked with the responsibility of constantly monitoring patients' cases. However, patient monitoring is considered costly and ineffective. For instance, the doctor is unable of maintaining full attention on a single patient at all times. The collection of Body Sensor Networks (BSN) with all other means of IoT health systems is one real example of possibility the IoT can improvement patient monitoring. For instance, a BSN system may monitor a patient's bodily activities via using a biodegradable processor or by the use of many wearable wirelesses of biosensor sensors. This chip or biosensor gadget will be able to monitor a patient's vital signs. They detecting any abnormalities in the patient's state functions and communicate them to the IoT system. After that, the IoT system can take appropriate event, such as informing a health-care expert. Additionally, it enables healthcare providers to achieve more accurate diagnoses and communicate together patients. The case of emergency, the health-care modified can seek assistance from an ambulance team, depending on how the system is configured. As a result, IoT health monitoring systems can be thought of as an ecosystem of ambient intelligence aimed at providing a platform for remote monitoring and assistance to patients and the elderly at home or on the move [17]. Patients' chances of survival can be increased by monitoring them throughout the early stages of their diseases. Additionally, it will assist healthcare providers in reacting quickly in the event of a catastrophic medical situation a heart attack or a diabetic situation, for example. Electronic-health-records (EHRs) are now digitally feasible via the Internet of Things, therefore remote monitoring systems may contribute in the decrease of medical errors (IoT). EHR retrieval and access are easier and more organized now that they are available digitally. Not only will this help to reduce medical errors, but it will also allow for speedier data access while maintaining access control credentials. Personal area networks (PANs) are also used in IoT applications in healthcare. Individuals can use wearable technology like a wearable technique smart sensor, a smart of wrist gadget, or a smart of watch to monitor their bodily functions in a PAN. Wearable modern technologies in health-care are rising in tandem with technology and the Internet of Things. As a result of this technological evolution, individuals will be able to monitor many elements of their health. These health factors include blood pressure factor, sugar indicators, and insulin degree, medicine intake, heart-beats, sleeping-patterns, calorie consumption, and exercise levels, to name a few.

The IoT's capabilities in these areas are immense. Remote access to this information will enable healthcare professionals to administer therapy if necessary. This facilitates information sharing and self-management of health conditions, as well as illness early detection. As a result, Internet of Things (IoT) healthcare applications incorporate a variety of sensors types and monitoring used devices. All devices are typically parallel and connected in order to facilitate information sharing [18,19]. Figure 1 illustrates an IoT-enabled healthcare system that offers a variety of healthcare services. It shows how to build an Internet of Things system that integrates the following healthcare subsystems:

• **The Personal Area Network (PAN) for Healthcare** is an application that allows you to connect with personal devices via a closed or local area network. Wearable devices, for example, can be used to track and manage an individual's case health.

• **Elderly Monitoring Concept:** The application uses a group of sensor employed devices to keep track of the health of an elderly individual. The device may also collect information about the elderly's physical activity, such as nutrition and sleep patterns. The method, in particular, enables healthcare experts and vocations to monitor the health of elderly persons in real time. It uses alerting and notification mechanisms in the event of an emergency, such as automatically contacting an ambulance.

• **Smart Medicine Mechanism:** is a drug administration application. It ensures that patients take the right prescription at the right time and dose as advised by their doctor.

In addition, if a patient fails to take his or her prescription as prescribed, the system can alert a physician.

• **Community-Based HER Category:** This category of community-based EHRs includes outpatient care and electronic medical consultation subsystems that automate health-care tasks. These subsystems collaborate to improve

health care services by minimizing medical errors, lowering costs, and enhancing efficiency.

• **Smart Emergency System:** Collaboration and information sharing among the different healthcare subsystems are at the heart of the smart emergency application. It's an important part of all of the previously described healthcare subsystems. Obviously, this is because medical emergencies necessitate the use of emergency various services, example is summoning ambulance. However, the method smart emergency application's functionality is not restricted to immediately summoning an ambulance. They also include advanced capabilities like automatically sending the patient's status, including any necessary treatment, to the hospital while in transit. This method improves emergency response.

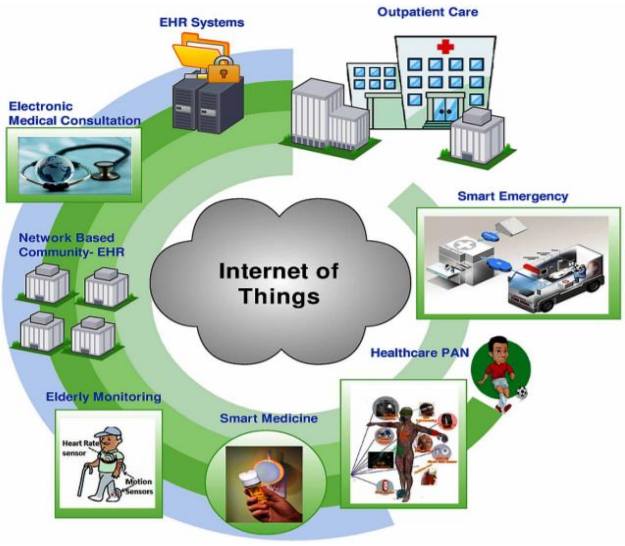

Fig. 1: The HIOT system

Additionally, hospitals. It enables more efficient patient allocation and distribution within hospitals within a specific geographical area. As a result, a spot for the transferred patient is guaranteed. Additionally, they help to improve the efficiency of medical resources and services including X-rays and CAT scans. As a result, healthcare providers now have access to a hitherto unknown category of data thanks to the capacity to acquire health information instantaneously and remotely over the Internet. This information may include any elements affecting the patient's health symptomizes, such as activities that represent daily regular. Acquiring some knowledge into a patient's life enables a more personalized therapy strategy. By and large, existing monitoring from a remote programs lack the interoperability that the Internet of Things enables. With the development of an Internet of Things-based system capable of communicating successfully with other Internet of Things devices such as sensors and actuators, Ambient Assisted Living (AAL) will become a reality. Individuals will be able to see how often they have taken their medications and when they will need to take them again, for example. Patients will be able to obtain pharmacological information on the medication they require quickly and in real time. This contains details on the correct dosage, allergy precautions, and any potential side effects.

III. HIoT Applications

In the field of medical device management. Its cutting-edge technology enables seamless communication between medical devices and caregivers, benefiting both patients and doctors and nurses. Because it facilitates the transfer of the patient's condition prior to his arrival, and because it enables the communication process with these devices a seamless and incredibly fast process of sending the patient's data in real time [14]. Instead of waiting for the afflicted case to arrive at the hospital and then identifying it, doctors can approve and transform the data that arrives through it into practical steps, perhaps saving the lives of many people [15]. Rather than waiting for the afflicted patient to arrive at the hospital and then identifying it, doctors can authorize and translate the data that enters through it into actionable steps, perhaps saving many lives [16].

The smart devices collect important data about the condition of the patient around the clock or during the day, then electronically distribute it to the doctor's computer, having allowed him or her to take appropriate action in the case, such as operating or not operating, writing a prescribed medication, and other indicators [17]. IoT technology assists health and medical organizations in lowering costs. It is automatically programmed and operated by decreasing the human aspect and artificial intelligence intervention in everything. Remote patient monitoring is one of the IoT applications in the different specific of medicine, and it involves the continuous and comprehensive monitoring of patients via sensor equipment and cameras tools which monitoring the patient's vital signs, blood type circulation, sanity measurement, amount of temperature, and other parameters. From these examples about the HIOT are:

A. The Elderly's Health and Development

More emphasis should be focused on community-based healthcare and development for the elderly in an aging society [20]. The use of welfare technologies on the elderly is increasing. The method by which product creation is aligned with the the requirements of human progress is critical [17]. Users and the old are significant supporters of technical product development, there is even a link between the advancement of technology for the elderly and its development. Information technology has been integrated into the long-term represent care systems of many countries. They intend to give medical and care services to the elderly in their homes while also lowering medical costs [18] through initiatives such as the medically home. Medically home collaborates with its clients' providers and also employs physicians and nurse practitioners who oversee patients' treatment from a central hub via remote monitoring, video, and other telehealth tools.

They consult with attending physicians at Tufts Medical Center to ensure that patients are appropriate candidates for the program. Advanced practice clinicians, paramedics, nurses, phlebotomists, technologists, and therapists, among others, visit acutely ill patients in their homes to provide

infusion, laboratory testing, imaging, nutrition, and translation services. "All the services patients are accustomed to receiving in a hospital are delivered quickly – in less than an hour," says founder Raphael Rakowski, an engineer by background who views home acute care as a logistical challenge rather than a therapeutic one. Similarly, these long-term nursing concerns, as well as numerous aging-related illnesses, hypertension and cardiovascular disease, to name a few, should be well-planned. As a result, long-term care is becoming increasingly popular accounts for a sizable portion of our nursing care at home. It is critical to have an aging support system that is both healthy and secure. Technology, medical treatment, education, business models, and marketing development have all evolved in recent years to encourage a healthier and more active aging lifestyle. A healthy and aged system should have privacy and security, simplicity of use, and a more favorable legal and regulatory framework. Initiatives to improve health at home [19], which can be implemented with a typical Windows desktop PC, have emerged as commodity component trends. Forming an intelligent assisted management living system for the elderly might, among other things, change social networks to keep seniors engaged with family, friends, neighbors, and communities. Nowadays, many gadgets that are an electrical indication is in charge might be considered actuators, including televisions, air conditioners, and electric fans. A telecare system depend on lifestyle monitoring was developed with an emphasis on the elderly. Another system centered on the elderly utilized the techniques of connecting many individualized and environment monitoring gadgets to deliver medical aftercare at home. With the use of technological tools, seniors' lives could be made easier. As a result, the housing market has begun to provide smart homes, as well as functional and well-equipped residential facilities, particularly in terms of emergency protection. Wide service frameworks and emergency response capabilities are critical for users and caregivers. In order to build such a system, it is necessary to conduct research on both software and hardware solutions. We were fortunate in that we were able to develop an Internet of Things system that allows for physiological monitoring in real time while the elderly and those at high risk clean, they are not often accompanied by relatives or caregivers. Based on security and protection, it's expected that the number of elderly and high-risk disease users will decrease. As a result, they miss out on relaxation and become more sluggish. Numerous research papers in the topic of smart drugstore automation covers various strategies. This section discusses the prior work that was done to develop the smart pharmacy system. In 2010, A. J. Jara et al. [20] presented a method for investigating relevant problems in the drug store system through the use of IoT technologies and Web access via smart phones. The 6LoWPAN technology is utilized in this research to care for patients who require worldwide data collecting in hospitals. Utilizing this technology will reduce errors, improve service quality, and enable a plethora of applications in healthcare, but it will only support certain cases. D. H. Kuo et al. [21] proposed a smart drug under medical services in 2015 to keep pharmacists and family members informed about senior patients' suppository. They merged the APP and ICT to provide health education films as needed and to monitor patient information online via mobile Internet (3G / 4G), however the system operates at a slow speed and offers restricted services, and it is also quite small. In 2016, E. N. Mambou et al. [22] described a simple and reliable method for monitoring the refrigeration temperature and medication distribution in a pharmacy using a sensor connected to an Intel Galileo board. The sensor is used to control the refrigeration temperature and perform medication exploration within pharmacy tables. Although this approach provides an effective and straightforward method for monitoring medication in a pharmacy, the system suffers from a lack of control due to lax security measures, which results in a variety of network attacks. T. Edoh et al. [23] proposed a new smart pharmaceutical transportation system in 2017 that leveraged the Internet of Things and Machine-to-Machine (M2M) technologies.

They utilized intelligent transportation and context-aware tour optimization for the carried medical products, thereby protecting the patient from any health complications caused by improperly dispersed and/or falsely exchanged products. It is the only Internet of Things (IoT)-based solution designed for secure transportation and medication monitoring in order to improve treatment adherence in the case of chronic health conditions. In 2019, S. S. Arumugam et al. [24] developed an automated medication dispenser that is capable of being employed successfully in pharmacy by utilizing (GSM) technology. The experiment's objective is to provide the medication to the consumer in the shortest amount of time possible (an automatic medicine dispenser machine is developed which helps in identifying the exact medicine rack and pharmacist can dispatch the medicine more quickly). In 2020, R. E. Riantini et al. [24] proposed a new marketing technology via a mobile application utilizing digital pharmacy application approaches, although it is merely a digital pharmacy application if the speed of finding the exact drug rack is not considered.

B. Baby Incubator

The study's aim is to help create a new project that will be cheaper, while also providing better usability. This chapter introduces the key ideas and projects that preceded this one.

In the [26] Complaints from physicians and child nurses may be common when the incubator is used to care for infants. The customer is displeased with the goods found in incubators at hospitals. Broadly speaking, baby incubators are rejected because of improper designs. To cope with these concerns, the researchers use the Quality Function Deployment (QFD) approach to help decide which product features are of high importance. As the beginning point for the QFD process, consumers' requirements and wants guide the QFD work. Because of this, QFD is known as the voice of the consumer. While consumers aren't always pleased with a product even if the thing has been properly made, the fundamental idea is that customers are never happy. During the course of constructing Team of newborn incubator, a low-cost neonatal incubator for poor countries hospitals, baby formed the [27] Team Incubator.

A major cause of newborn mortality throughout the globe is hypothermia. While incubators that are presently accessible are too expensive, dangerous, or ineffectual for this disease to be treated in the poor world, there are other methods that may be used to do so. We came up with an incubator to fulfill the following specifications: Under $250 USD, adjustable temperature (gets temperatures between 27 to 37 degrees Celsius), accurate (has less than 2.5 percent error), and insulated (falls only 2 degrees Celsius over 45 minutes in the event of a power outage). Simple to use, easy to repair, and very clean and simple to use. Safe, can comply with IEC standards for alarms, and easily shipped or fabricated in country. In order to fulfill these requirements, we constructed a wooden two-walled incubator, with one acrylic window for convenience and an acrylic lid for accessibility. The heating components are two commercial low-power heating pads, which are changed in the event that they become damaged. The heating pads are located in the rear wall and floor, where they are used to both diffuse and transmit heat. It needs 90 watts of electricity to power the incubator. Temperature data from the baby is captured by a thermistor and is sent to a microprocessor, which then controls the heating components.

The heating capability of the incubator has been extensively tested: a heated IV bag is filled with water and inserted into the incubator, simulating a baby's body heat. To demonstrate that the present incubator design can successfully elevate a hypothermic Simi Baby (34°C) to a temperature no lower than 37°C, we put the microcontroller feedback system to work, adjusting the temperature within 1°C of the programmed setting. To ensure the final design was very effective, we added an alarm system. Rice 360°: The Institute for Global Health Technologies' incubator will be sent to Malawi this summer to collect information from health care providers. Clinical studies and testing will be conducted in Malawian district hospitals.

Air temperature measurements in baby incubators, which were conducted in [25-28] four incubators with proportional heating control were used in addition to six incubators with on/off heating cycles, in order to collect daily air temperatures. There was no temperature differential between the roof and mattress temperatures, and the air temperatures remained consistent throughout. As compared to earlier models, the records of later models revealed a cyclical pattern with a range of cycle lengths, ranging from 14 to 44 minutes. Individual incubators had unique profiles. Depending on the cycle, the temperature in the roof may fluctuate between 7 1°C and 7 3°C while the temperature in the mattress could range between 2 60C and 2 67C. In open-ended hemispherical hemi-cylindrical heat shields, the oscillation in air temperatures remained even though it was much decreased in closed-ended hemispherical heat shields. The concentration of carbon dioxide within the latter did not rise substantially.

Because of chronic and hereditary illnesses, including heart disease and diabetes, there was a rise in growth in [29] owing to an underweight birth rate. Allowing the egg to enter the incubator for a certain amount of time without incubators due to the high cost of pricing, many children die. And who knows, maybe the death of infants because of a lack of sufficient temperature regulation might be another possible cause. The gathering of enough data has been obtained to help address this issue and construct an incubator for children to continue their growing at a cheap cost and with a high degree of precision, which results in the preservation of children's lives. An inexpensive microcontroller was utilized to run the incubator's temperature and humidity management. It sends signals to many other devices, which helps raise and decrease the aforementioned variables. Premature infants are those born before to thirty-seven weeks of gestation. Prematurity is a serious issue in underdeveloped nations, where 25% of all newborns are preterm. While the World Health Organization (WHO) and Engineering World Health (EWH) recognize the need for a portable baby incubation unit that can be used just during transit, they argue for a less expensive design that accomplishes the same goal. An existing design with numerous modifications was suggested for an incubation unit. The HVAC system will incorporate the heating and humidity systems. An improved humidity monitoring system has been installed along with a control mechanism. This novel heating element uses coils present in products including toasters, toaster ovens, and refrigerators. The design's safety and effectiveness were assessed using data on the size and thermal parameters of a preterm infant. Simulink modeling of the incubator and a model of a baby will be used to better understand the thermodynamics of the system.

Within [30] preterm or low-birth-weight neonate within an incubator has an impact on the environment because of the effects of thermo-neutrality. Shivering, hypothermia, and apnea are caused by infant hypothermia and air flow and air velocity within an incubator, respectively. The research simulated newborn incubator airflow using hot-wire velocity measurements, flow visualizations, and computational fluid dynamics. The 3D laser scanning technology and fast prototyping machine help designers build anatomically accurate models of neonates. Flow visualizations show that a significant number of tiny moving eddies are created in the chamber as a result of rotating airflow, while at the same time, the air intake exhibits a high number of stationary eddies. During hot-wire inspections, it was discovered that the air velocity across the lengthy inlets was not even. According to computational fluid dynamics, the neonate's anterior region stays fairly consistent at a temperature of approximately 34°C, with the maximum temperature measured near the right armpit and the crotch being 36.1 °C. Both qualitatively and statistically, flow fields computed from flow visualizations, hot-wire observations, and computational fluid dynamics are very comparable. Convective and evaporative heat fluxes from the neonate may be impaired by the tiny eddies generated between the newborn and the bedding. Eddies should thus be eliminated in newborn incubators in the future.

Between [31] Premature birth complications are the most significant causes of mortality in children who are five years old or younger. So, it is important to take great care of these infants during the initial weeks or months after they are born. Because the cost of incubators in Peru is prohibitive for most families, this project focuses on developing a low-cost home incubator with telemetry. Temperature and humidity

within the incubator are the two critical factors to monitor. An Arduino Uno was used to build a piece of software that maintains the temperature and humidity at set medical standards. In order to get more accurate monitoring of the aforementioned metrics, a Bluetooth module with the Arduino Uno was utilized with the mobile phone app. The humidity and temperature levels inside the incubator have been shown to be consistent with the required range, as well as the cardiac pulse is as anticipated. The next phase of the research will include limiting the top limits of the humidity and temperature levels. It is anticipated that this incubator would help Peruvian families who cannot afford costly equipment, and particularly those who live at the margins of poverty. Home-based incubator or spending money on these services for preterm infants. In this part, the introduction of a new recycled incubator method in Nigeria has potentially enhanced the neonatal delivery system (RIT). The use of RIT in 15 Nigerian neonatal facilities was investigated to evaluate how the application of RIT affected clinical, technical, and human aspects. Before and after the RIT-financed Neonatal Intensive Care Unit (NICU) was opened, case studies contrasted the pre-RIT and post-RIT mortality rates.

The effect on neonatal nursing was examined by administering questionnaires to 79 nurses from 9 different institutions who had direct responsibility for caring for premature and newborn infants. It was based on 10 indices for physicians and nurses to evaluate technical performance. Neonatal survival, practice confidence, and passion for nursing were all higher as a consequence of the findings. In the context of neonatal practice in low-income nations, appropriately recycled incubators may be used to supplement the price of contemporary incubators, raising neonatal practice result. In [32], several diabetic newborns suffered respiratory failure immediately after delivery until 1938, for reasons that were unknown at the time but now believed to be linked to a disordered endocrine system. One of us (P. W.) had hypothesized that helium supplemental oxygen could aid such newborns before all this discovery. The incubator described here was built for this purpose. The intention of this incubation is to keep the newborn at the right temperature in an oxygen and helium-only environment. A mixture of 20% oxygen and 80% helium has a lower density than room air, according to Alvan L. Barach, to whom we are grateful for his helpful comments and suggestions, requiring the child to exert less effort in breathing. As a result, the breathing aid is mechanical. When breathing is humiliated, other researchers2 have reported that breathing helium-oxygen mixes has good consequences. Since the use of this chamber began, prenatal hormone therapy has successfully prevented respiratory failure in diabetes neonates. Several infants have benefited from being placed in the incubator throughout the three years that it has been in operation, and the use of the apparatus with gaseous mixes other than the one originally envisaged has performed beneficial for certain situations. In addition to its unique feature of being able to determine and maintain the composition of the gaseous mixture in the chamber, this apparatus incorporates the four basic requirements of an incubator, namely, maintaining proper temperature, proper ventilation or oxygenation, adequate humidity, and easy access to the infant without harmful exposure. Kangaroo Method Management is a novel invention in the management of preterm infants who bring their babies and moms closer (PMK). The kangaroo technique is used to develop emotional connection between the mother and her infant, making the mother more secure while taking care of the child. The research and manufacturing of this module utilizes a technique of treating baby incubator with a room temperature reading that is applied when the kangaroo mode is used. During usage, the reading of the room temperature is applied, and then the results are measured after about two minutes. LM35 sensors are often used to measure temperature, while DHT22 humidity sensors are used to detect humidity. As a consequence of the measurement data acquired, uncertainty values on humidity 2.1, as well as on temperature stability, can be shown on the graph. This research has shown the creation of baby incubators, which may assist preterm infants' moms in establishing a strong connection, to be an effective treatment for premature babies' mothers. This research has shown that the precision of our methods is suitable for helping to treat preterm infants and preventing prematurity-related PMK in certain hospitals.

According to recent statistics, India is the second most populous nation in the world, with an extremely high birth rate. The findings of a market research study indicate that each year in India, there are about 26 million babies born. Out of the approximately 26 million babies born each year, about 2.6 million are born preterm and weighing less than 5.5 pounds at birth (lbw). Most LBW babies are maintained in incubators, called "incubators," which include temperature and humidity control. There has been a notable increase in the survival rate of preterm infants since incubators were widely used in hospitals. Hospitals' Intensive Care Units benefit greatly from incubators, which are very essential in-room devices. The goal of this research is to create an Infant incubator with enhanced usability in order to serve the needs of low-budget hospitals. Data is gathered, referenced to, and recorded from different resources to find solutions to the issue. We carried out a study of the product at a nearby hospital. A market research is conducted to find out what kinds of models are accessible. As a benchmark, the top-of-the-line model on the market is chosen. Based on the results of a literature research, an in-depth analysis of the product, and a thorough market survey, a Product Design Specification (PDS) is developed. The ideas that stem from the PDS are comprised of five components. Caring for the freshly born infant has gained more and more attention because of society's growth and contemporary technologies.

These freshly born infants' safety is dependent on the conventional baby incubator. Most parents nowadays have very demanding jobs, which causes them to have insufficient time to provide adequate care for their kids. Due to the circumstance, the conventional baby incubator may not be able to offer infants with a better standard of care. By doing an intensive study, it is possible to develop a new type of incubator that can self-adaptively alter the environment based on a set of sensors and continuously monitor the baby's vital signs. More and more academics study the advances in Internet and network technologies, and the Internet of Things is thus being created. The Internet of Things (IoT) links the

real and virtual world via the use of sophisticated communication and data collection technologies. The existence of this cause results in IoT being a critical area of study in the twenty-first century. Other IP-based wireless technologies such as Wi-Fi have enabled the development of a broad range of WSN applications including environmental monitoring, forest fire warning, and home automation. This study was done to see whether a remote-control incubator could be created to monitor the temperature and oxygen levels of premature infants.

IV. IOT against COVID-19

The Internet of Things (IoT) was a very well network of integrated pervasive computing, digital, and mechanical equipment that can transmit data at any level without requiring human intervention. A unique identification number or code is assigned to each of the devices listed above. IoT is a well- constructed and proven technology which that acts as a central center for a variety of techniques, real-time analytics, machine learning concepts, and sensory products, among other things. In addition, the Internet of Things is recognized in everyday life and also the usefulness of products or apparatus that meet persons' real-life requirements in a range of methods, for example, home protection equipment, intelligent illumination arrangements, and many others that are easily controlled via smart speakers, smartphones, and other devices [33].

During the the prevailing pandemic crisis, COVID-19 is being fought by all regions, especially India, and a realistic and cost-effective solution to the difficulties is still being sought that have emerged due to a range of factors. Engineers and scientists working in the physical sciences are working to meet these issues by developing new theories, describing novel research problems, developing user-centered explanations, and educating both themselves and the general public. This brief description was created to raise awareness about this groundbreaking technology method and its possible petition in the COVID-19 epidemic. The Internet of Things (IoT) is a platform of networked devices and processes that are equipped with the necessary network elements such as hardware, software, network connectivity, and any other electronic/computer methods to assist in data manipulation and collecting. If we expand on IoT a little further, it’s a concept that underpins the complete architectural framework that, in the end, allows for the seamless integration and data exchange here between patient who wishes help and the wireless carriers. The bulk of problems currently come as a result of ineffective patient reachability, which is the second most important issue after vaccine development [34]. The implementation of the IoT idea improves patients' reachability, which ultimately aids in providing them with important care to assist them recover from this sickness. Globally. Every day, the number of affected patients grows, creating an urgent want to exploit the right-equipped and infrastructures that are well-organized made possible by the Internet of methodology of things. Additionally, IoT has previously been used to accomplish the requested goals in a variety of fields where the Internet of Healthcare Things (IOHT) and the Internet of Medical Things (IOMT) are both important to today's challenges. The number of resolved cases can be enhanced and improved by following to the criteria and utilizing the IOHT/IOMT services.

The Internet of Things (IoT) is a cutting-edge technology that ensures that everyone affected with this virus is confined. Having a proper monitoring system in place during quarantine is beneficial. All high-risk patients can be easily tracked thanks to the internet-based network system. This technique is employed to obtain bio-metric data such as blood level pressure, heart rate, and blood glucose range. We should anticipate to see an increase in medical staff efficiency while also lowering their workload if this technology is used correctly. In the event of a COVID-19 pandemic, the same may be done with less expenses and errors. The Internet of Things is a cutting-edge technical framework for combatting the COVID-19 epidemic that may be overcome important obstacles during a lockdown. This method is helpful since it permits real-time statistics and other essential information about an afflicted people to be recorded [35]. The primary procedures taken by IoT to produce COVID-19 are depicted in Fig. 2. IoT is used in the initial stage to collect health data from the afflicted patient's many locations and manage it all through a virtual management system [36]. This technology supports in data control and subsequent follow-up on the received report. The internet of things concept relies on a network of connected devices to ease data flow and exchange. Additionally, It allows social workers, patients, and civilians to communicate with one another service benefactors for the purpose of talking and cooperating on any issue. Thus, by implementing the introduced IoT approach in the COVID-19 epidemic, medication identification that performs and suspicious cases may be ensured. The majority of them, civilians, are now aware of the coronavirus's symptoms. The cluster can be discovered much more readily by developing an informed group within a connected network. Additionally, a specific smartphone application can be designed to aid the less fortunate [37].

The controller, i.e. doctors, physicians, caregivers, etc., must receive accurate reporting of symptoms and recovery in order to opt out of the impressive move and optimize the entire quarantine period. Thus, in order to combat and educate civilians in regard to COVID-19 epidemic, the Indian the federal government possesses established a smart mobile application targeted at establishing a connection between critical health-care services with Indian people. Similarly, China has launched e Close Contact (English translation) as a smartphone application for its residents. This type of application notifies the user of their proximity to a corona positive test. So that exceed caution can be exercised before going to step up. At the end of April 2020, U. S. government will make a comparable smartphone app available to its citizens. Following China region, Taiwan is perhaps the most predictable of the group country in terms of COVID-19 cases. In order to protect the community's health, Taiwan quickly militarized and adopted specific tactics for coronavirus case identification, suppression, and resource distribution. The catalog was utilized to kick-start the construction of big data for analytics, since it generated real-

time warnings during clinical visits based on travel background and clinical indications, supporting in case classification. They've also used this cutting-edge technique to detect infected persons, which includes QR code scanning and related reporting of transportation history [38].

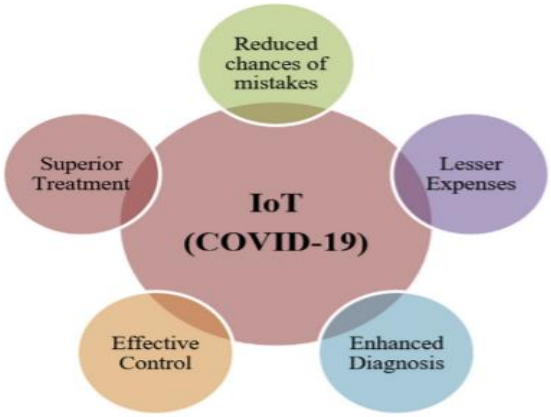

Fig. 1: The key metric used of IOT for fighting COVID-19

The Internet of Things (IoT) makes use of a huge number of networked equipment to establish an intelligent network for efficient supervision of health. It detects and tracks any form of disease to ensure the patient's security. It digitally captures the patient's data and all the information without the need for human engagement. This information is also useful in achieving informed decisions [39]. IoT is being used for a variety of purposes in order to meet the critical need of reducing the effects of the COVID-19 pandemic. With the help of suitably gathered data, it has the potential to forecast the upcoming circumstance. Its applications are used to handle the epidemic effectively. For tailored attention, the patient can use IoT services to monitor their heart indicator, pressure of blood, gluco-meter, with rest activities. It aids in the monitoring of elderly people's health. The most important performing of this technique in health-care are tracking the fact-time position of medical tools and instruments to ensure a smooth and timely treatment process. This technology can be used by healthcare insurance companies to identify deception claims and promote opacity across the whole system. This improves the patient's treatment workflow by allowing for more efficient performance, as well as assisting in the decision-making process in complex circumstances. In the current pandemic situation, COVID-19 is concerned with the security and privacy of the data received, which is unique and critical in terms of patient health, and is a major source of worry when using the Internet of Things. The second factor to consider is the caution that must be exercised when integrating the data network among the various devices and protocols.

IV. EEG-Based Transceiver Design

Rapid advanced data amounts, late cloud storage, approaching edge computing, and omnipresent networking capabilities have made it possible to acquire, store, and analyze huge volumes of operational data that were previously unattainable in the IOMT and Industry 4.0 eras. Data processing is a critical component of achieving Industry 4.0's predicted goals. Without effective information processing and management, providing valuable services will be difficult given the predicted volumes of received data. The G06F19/00 category (i.e., digital computing or data processing equipment or methods, specially adapted for specific applications) is ranked fifth among the top 20 technical IPC categories, according to the leading International Patent Classification (IPC) analysis, with 130 patents filed between January 2006 and December 2015 [40]. Moreover, for battery-operated IOMT devices, minimizing the amount of communicated data is critical in order to minimize transmitting power consumption in this case, several promising approaches are:

- processing and compressing acquired data locally in the network prior to propagation, with hardware implementation included (CS).
- Deep learning is being used as a powerful machine learning and health informatics technique to generate the best high-level features and semantic interpretation from data [41]. The original signal is multiplied with a linear form of reinforcement in CS to achieve sampling, resulting in a low-dimensional subspace projection of the high-dimensional data vector. Although CS has showed significant promise in terms of high compression ratios, building CS-based technology is difficult [42]. Signal reconstruction, in particular, has a significant CS has a high computational cost, which limits its utility in scenarios that must be completed in real time [43]. The Correlation - based feature Chasing (OMP) signal reconstruction approach, for example, necessitates a lot of matrix processing. Furthermore, there is a tradeoff between the energy economy of the hardware and the precision of signal recovery. If a data-driven optimization strategy is employed to improve signal recovery precision, for example, additional computing capacity will be consumed. On the other hand, excellent recovery accuracy cannot be assured if non-data-driven random Boolean embedding is used to improve energy efficiency of hardware [44]. Compression algorithms designed exclusively for e-health depended in applications that have been proposed in the literature The computational complexity, loss and lossless properties, and waveform transformations performed in these techniques are all different (Fourier or wavelet transforms, vector quantization, or the discrete cosine transform are only a few examples). In summary, most present compression research focuses on upper layers, while lower layer factors (such as wireless channel characteristics, Bit/symbol error rate (BSER) and signal-to-interference-plus-noise ratio (SINR) are ignored. Furthermore, the increased processing complexity may make implementing such systems on battery-powered devices prohibitively expensive. Designing application-specific transceivers, on the other hand, has recently become popular. Long-range IoT connectivity and multi-standard RF transceivers are being addressed in future transceiver architecture, while preserving a high level of adaptability, versatility, and renewability [45]. SRT Marine Systems, for example, was granted US patent 9473197 and European patent EP2951930 for their reversible time domain duplex (RTDD) transceiver technology. This method allows a single

RF architecture to be utilized for both receiving and sending by electrically reversing the RF chain between receive and transmit. This would be possible because to a complicated combination of clever intermediate frequency selection and ultra-fast switching. In addition, Bristol-based SRT Marine Technology Ltd has received a patent for a radio transceiver that allows numerous transceivers to share a single antenna, lowering installation costs and time (GB patent no. 2460012).

In the field of fiber-optic communications, [46] supplies a transponder for transmitting collected information and time code information through a fiber-optic connection means and obtaining data collected and rotary encoder information from the fiber-optic communication means. The creators demonstrate a transmitter [47] that can accept multitrack recording and product input from a range of sources and display a variety of technological audio and program information signals over a restricted amount at the same time, allowing a user to experience digital audio while also allowing for portable reception of the service in a restricted area. Another sort of transceiver design is one that reduces without adding additional hardware while transmitting large amounts of data still allowing the original data to be reconstructed from the received sequence.

Most present and future transceivers architecture [48] outfitted with accelerated Discrete Fourier Transform (FFT) buildings can leverage such a notion at the physical layer, saving energy and operational overhead expenses. Our findings can be extended to have a significant practical impact in many big data domains because most video, audio, and medical images are compressible or sparse in nature and can benefit from such compression schemes by leveraging the acquired data characteristics in the physical layer of the wireless transceiver.

However, in order to achieve such adaptive compression, new difficulties such as the influence of the physical layer, normalization and modification must be addressed [49].

V. Conclusion

This research looked into several facets of the HIoT system. The architecture of a HIoT system, its components, and the communication between these components have all been thoroughly discussed in this article. This research also contains information about existing healthcare services that have looked into IoT-based solutions. By integrating these concepts, IoT technology has helped healthcare practitioners monitor and diagnose a variety of health conditions, measure a number of health parameters, and provide diagnostic services at remote locations. The healthcare business has shifted from a A shift from a hospital-centric to a patient-centric model is beginning as a result of this. We've also talked about different HIoT applications and their present trendy. The obstacles and issues surrounding the HIoT system's design, production, and use have also been highlighted. These issues will serve as a foundation for future growth and research focus in the coming years. Furthermore, readers who are interested in not only beginning their research but also improving their understanding of HIoT equipment will receive a comprehensive overview of the devices.

Conflict of Interest

The authors have no conflict of relevant interest to this article.

References

[1] Z. Ali, M. S. Hossain, G. Muhammad, and A. K. Sangaiah, “An intelligent healthcare system for detection and classification to discriminate vocal fold disorders,” Future Generation Computer Systems, vol. 85, pp. 19-28, 2018.

[2] G. Yang, L. Xie, M. Mantysalo et al., “A health-IoT platform based on the integration of intelligent packaging, unobtrusive bio-sensor, and intelligent medicine box,” IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2180–2191, 2014.

[3] Y. Yan, “A home-based health information acquisition system,” Health Information Science and Systems, vol. 1, p. 12, 2013.

[4] M. Khan, K. Han, and S. Karthik, “Designing smart control systems based on internet of things and big data analytics,” Wireless Personal Communications, vol. 99, no. 4, pp. 1683–1697, 2018.

[5] P. J. Nachankar, “IOT in agriculture,” Decision Making,
vol. 1, no. 3, 2018.

[6] V. G. Menon, “An IoT-enabled intelligent automobile system for smart cities,” Internet of @ings, p. 100213, 2020.

[7] E. Qin, “Cloud computing and the internet of things: technology innovation in automobile service,” in Proceedings of the International Conference on Human Interface and the Management of Information, pp. 173–180, Las Vegas, NV, USA, July 2013.

[8] B. Alhasnawi, B. Jasim, B. Issa “Internet of Things (IoT) for Smart Precision Agriculture” Iraqi Journal for Electrical and Electronic Engineering, vol. 18, no. 8, p. 1-11, 2020.

[9] P. S. Mathew, “Applications of IoT in healthcare,” in Cognitive Computing for Big Data Systems over IoT, pp. 263–288, Springer, Berlin, Germany, 2018.

[10] V. Jagadeeswari, “A study on medical Internet of things and Big Data in personalized healthcare system,” Health Information Science and Systems, vol. 6, p. 14, 2018.

[11] H. Peng, Y. Tian, J. Kurths, L. Li, Y. Yang, and D. Wang, “Secure and energy-efficient data transmission system based on chaotic compressive sensing in body-to-body networks,” IEEE Transactions on Biomedical Circuits and Systems, vol. 11, no. 3, pp. 558–573, 2017.

[12] A. Gatouillat, Y. Badr, B. Massot, and E. Sejdic, “Internet of medical things: a review of recent contributions dealing with cyber-physical systems in medicine,” IEEE Internet of @ings Journal, vol. 5, no. 5, pp. 3810–3822, 2018.

[13] L. M. Dang, M. J. Piran, D. Han, K. Min, and H. Moon, "A survey on internet of things and cloud computing for healthcare," Electronics, vol. 8, no. 7, p. 768, 2019.
[14] B. Oryema, "Design and implementation of an interoperable messaging system for IoT healthcare services," in Proceedings of the 2017 14th IEEE Annual Consumer Communications & Networking Conference (CCNC), pp. 45–52, Las Vegas, NV, USA, January 2017.
[15] A. Ahad, M. Tahir, and K.-L. A. Yau, "5G-based smart healthcare network: architecture, taxonomy, challenges and future research directions," IEEE Access, vol. 7, pp. 100747–100762, 2019.
[16] M. N. Birje and S. S. Hanji, "Internet of things based distributed healthcare systems: a review," Journal of Data, Information and Management, vol. 2, 2020.
[17] K. T. Kadhim, "An overview of patient's health status monitoring system based on internet of things (IoT)," Wireless Personal Communications, vol. 114, pp. 1–28, 2020.
[18] Y. Yuehong, "The internet of things in healthcare: an overview," Journal of Industrial Information Integration, vol. 1, pp. 3–13, 2016.
[19] G. Shanmugasundaram and G. Sankarikaarguzhali, "An investigation on IoT healthcare analytics," International Journal of Information Engineering and Electronic Business, vol. 9, no. 2, p. 11, 2017.
[20] J.-Y. Lee and R. A. Scholtz, "Ranging in a dense multipath environment using an UWB radio link," IEEE Journal on Selected Areas in Communications, vol. 20, pp. 1677–1683, 2002.
[21] H. Aftab, K. Gilani, J. Lee, L. Nkenyereye, S. Jeong, and J. Song, "Analysis of identifiers in IoT platforms," Digital Communications and Networks, vol. 6, no. 3, pp. 333-340, 2020.
[22] G. Cerruela Garc´ıa, I. Luque Ruiz, and M. G´omez-Nieto, "State of the art, trends and future of Bluetooth low energy, A. D. Dwivedi, L. Malina, P. Dzurenda, and G. Srivastava, "Optimized blockchain model for internet of things-based healthcare applications," 2019 42nd Int. Conf. Telecommun. Signal Process. TSP 2019, pp. 135–139, 2019, doi: 10.1109/TSP.2019.8769060.
[23] M. S. Hossain and G. Muhammad, "Cloud-assisted Industrial Internet of Things (IIOT) -Enabled framework for health monitoring," Comput. Networks, vol. 101, pp. 192–202, 2016, doi: 10.1016/j.comnet.2016.01.009.
[24] A. Darwish, A. E. Hassanien, M. Elhoseny, A. K. Sangaiah, and K. Muhammad, "The impact of the hybrid platform of internet of things and cloud computing on healthcare systems: opportunities, challenges, and open problems," J. Ambient Intell. Humaniz. Comput., vol. 10, no. 10, pp. 4151–4166, 2019, doi: 10.1007/s12652-017-0659-1.
[25] H. Ahmadi, G. Arji, L. Shahmoradi, R. Safdari, M. Nilashi, and M. Alizadeh, The application of internet of things in healthcare: a systematic literature review and classification, vol. 18, no. 4. Springer Berlin Heidelberg, 2019.
[26] D. Pal, S. Funilkul, N. Charoenkitkarn, and P. Kanthamanon, "Internet-of-Things and Smart Homes for Elderly Healthcare: An End User Perspective," IEEE Access, vol. 6, pp. 10483–10496, 2018, doi: 10.1109/ACCESS.2018.2808472.
[27] S. B. Baker, W. Xiang, and I. Atkinson, "Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities," IEEE Access, vol. 5, pp. 26521–26544, 2017, doi: 10.1109/ACCESS.2017.2775180.
[28] G. Manogaran, R. Varatharajan, D. Lopez, P. M. Kumar, R. Sundarasekar, and C. Thota, "A new architecture of Internet of Things and big data ecosystem for secured smart healthcare monitoring and alerting system," Future. Genre. computer. Syst., vol. 82, pp. 375–387, 2018, doi: 10.1016/j.future.2017.10.045.
[29] R. M. Stuppia L., Ferone E., Manzoli L., Pitasi A, "Innovative Healthcare Systems for the 21st Century," Innov. Healthc. Syst. 21st Century, pp. 15–70, 2017, doi: 10.1007/978-3- 319-55774-8.
[30] L. Minh Dang, M. J. Piran, D. Han, K. Min, and H. Moon, "A survey on internet of things and cloud computing for healthcare," Electron., vol. 8, no. 7, pp. 1–49, 2019, doi: 10.3390/electronics8070768.
[31] P. Sundaravadivel, E. Kougianos, S. P. Mohanty, and M. K. Ganapathiraju, "Everything You Wanted to Know about Smart Health Care: Evaluating the Different Technologies and Components of the Internet of Things for Better Health," IEEE Consume. Electron. Mag., vol. 7, no. 1, pp. 18–28, 2018, doi: 10.1109/MCE.2017.2755378.
[32] F. Firouzi et al., "Internet-of-Things and big data for smarter healthcare: From device to architecture, applications and analytics," Future. Genre. Comput. Syst., vol. 78, pp. 583–586, 2018, doi: 10.1016/j.future.2017.09.016.
[33] Y. E. Gelogo and H. K. Kim, "Integration of wearable monitoring device and android smartphone apps for u-healthcare monitoring system," International Journal of Software Engineering and Its Applications, vol. 9, no. 4, pp. 195–202, 2015.
[34] O. Banos, C. Villalonga, M. Damas, P. Gloesekoetter, H. Pomares, and I. Rojas, "Physio droid: Combining wearable health sensors and mobile devices for a ubiquitous, continuous, and personal monitoring," The Scientific World Journal, 2014.
[35] C. Thuemmler and C. Bai, "Health 4.0: application of industry 4.0 design principles in future Asthma management," Springer International Publishing, pp. 23–37, 2017.
[36] H. Adeli, S. Ghosh-Dastidar, and N. Dadmehr, "A wavelet-chaos methodology for analysis of EEGs and EEG subbands to detect seizure and epilepsy," IEEE Transactions on Biomedical Engineering, vol. 54, NO. 2, Feb. 2007.
[37] Y. Chae, J. Jeong, and S. Jo, "Toward brain-actuated humanoid robots: Asynchronous direct control using an eeg-based bci," IEEE Transactions on Robotics, vol. 28, no. 5, pp. 1131–1144, Oct 2012.
[38] F. Duan, D. Lin, W. Li, and Z. Zhang, "Design of a multimodal egg-based hybrid bci system with visual servo module," IEEE Transactions on Autonomous Mental Development, vol. 7, no. 4, pp. 332–341, Dec 2015.
[39] A. J. C. Trappey, C. V. Trappey, U. H. Govindarajan, J. J. Sun, and A. C. Chuang, "A review of technology

standards and patent portfolios for enabling cyber-physical systems in advanced manufacturing," IEEE Access, vol. 4, pp. 7356–7382, 2016.

[40] T. Moy, L. Huang, W. Rieutort-Louis, C. Wu, P. Cuff, S. Wagner, J. C. Sturm, and N. Verma, "An egg acquisition and biomarker extraction system using low-noise-amplifier and compressive sensing circuits based on flexible, thin-film electronics," IEEE Journal of Solid-State Circuits, vol. 52, no. 1, pp. 309–321, Jan 2017.

[41] D. Craven, B. McGinley, L. Kilmartin, M. Glavin, and E. Jones, "Compressed sensing for bioelectric signals: A review," IEEE Journal of Biomedical and Health Informatics, vol. 19, no. 2, pp. 529–540, March 2015.

[42] J. Chiang and R. K. Ward, "Energy-efficient data reduction techniques for wireless seizure detection systems," Sensors, 14(2), pp. 2036–2051, 2014.

[43] D. Rav, C. Wong, F. Deligianni, M. Berthelot, J. Andreu-Perez, B. Lo, and G. Z. Yang, "Deep learning for health informatics," IEEE Journal of Biomedical and Health Informatics, vol. 21, no. 1, pp. 4–21, Jan 2017.

[44] T. Strohmer, "Measure what should be measured: Progress and challenges in compressive sensing," IEEE Signal Processing Letters, vol. 19, no. 12, pp. 887–893, 2012.

[45] S. Acciarito, G. Cardarilli, L. D. Nunzio, R. Fazzolari, G. Khanal, and M. Re, "Compressive sensing reconstruction for complex system: A hardware/software approach," Applications in Electronics Pervading Industry, Environment and Society, Springer, Cham, vol. 429, pp. 192–200, 2016.

[46] B. L. Sturm and M. G. Christensen, "Comparison of orthogonal matching pursuit implementations," Proceedings of the 20th European Signal Processing Conference (EUSIPCO), pp. 220–224, Aug 2012.

[47] C. Hegde, A. C. Sankaranarayanan, W. Yin, and R. G. Baraniuk, "Numax: A convex approach for learning near-isometric linear embeddings," IEEE Transactions on Signal Processing, vol. 63, no. 22, pp. 6109–6121, Nov 2015.

[48] Y. Wang, X. Li, K. Xu, F. Ren, and H. Yu, "Data-driven sampling matrix boolean optimization for energy-efficient biomedical signal acquisition by compressive sensing," IEEE Transactions on Biomedical Circuits and Systems, vol. 11, no. 2, pp. 255–266, April 2017.

[49] M. Hooshmand, D. Zordan, D. D. Testa, E. Grisan, and M. Rossi, "Boosting the battery life of wearables for health monitoring through the compression of biosignals," IEEE Internet of Things Journal, vol. 4, no. 5, pp. 1647–1662, Oct 2017.