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Research paper

Biomedical engineering and its aspects through IOT

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Extended Abstract

The use of innovations to interact with the world has had a profound impact. In biomedical systems such as healthcare, diagnosis, prevention, therapy, and monitoring, IoT-based biomedical applications are employed. Regulatory, moral, and technological barriers related to biomedical technology are preventing the development of the medical IoT. Medical IoT is developing in terms of biological hardware and tracking data including physiological metrics, electrical impulses, and cancer signs. It is anticipated that in the next years, medical IoT will replace antiquated healthcare systems. Biomedical engineers can use IoT technology, but more study is needed before these technologies become ubiquitous for physicians and healthcare practitioners. This paper's findings are intended to better prepare biomedical engineers to lead and supervise multidisciplinary research endeavors.

Introduction

Given its capacity to connect the Internet with virtually any type or number of sensors and devices, the Internet of Things (IoT) is a hot issue in communications technology today and is changing how we live and work [1]. Integrating other applications with the IoT is a topic of extensive research in this area [2]. Smart sensors, medical devices, and remote sensing are just a few of the medical uses for the IoT. While safeguarding and observing patients, it can improve the level of care. Over the next 10 years, it is predicted that the IoT will have a significant economic impact, with the public sector expected to create $4.6 trillion and the private sector roughly $14.4 trillion [3]. Today, there is minimal widespread use of robotics in healthcare and most of what is found in literature. [4,5,6]. Solutions based on IoT and robots may be used to aid the elderly, the disabled, and others who have mobility problems [7, 8]. In addition to addressing the overlap between IoT and robotics, this article highlights IoT technologies that are applicable to robotics. Digitization, which has permeated many areas of medical technology, has also made it easier to monitor and manage medical equipment. The use of IoT in medical imaging will reduce waiting times and patient and physician angst. IoT in medical imaging enables the identification of issues and the prompt implementation of corrective action by automatically evaluating the imaging device features. one of the other goals in This the essay aims is to make a scientific contribution to the topic of IoT applications in healthcare by illustrating their link to bioinformatics, providing a brief bibliographic background, and summarizing the potential of technologies. Therefore, in this review article, we focused on IoT-based medical technologies for healthcare applications.

Doi:

The Impact of Robotics, Artificial Intelligence, and the Internet of Things on Healthcare and Medicine

In the last two decades, robotics has been one of the new and challenging fields for scientists who have continuously tried to improve it. Robots are machines that have the power to act but are more independent from humans than other machines [9]. Recently, the role of robotics in the field of medicine has greatly increased for humanity and it contributes significantly to medicine. Robotics in the field of health care has various applications and challenges [10]. Today, these services and health care have become very widespread and inclusive; For example, there are advanced technologies in the field of health care that doctors and even the patient himself can monitor the health of the patient. Or even computer-assisted surgery helps the surgeon to perform surgery remotely and more accurately [9,10]. Systems based on robotics and artificial intelligence have made complex issues and problems in the field of complex treatment easy, for example, spine and joint surgery and its replacement. The advancement of artificial intelligence technology has improved and increased the speed of diagnosis and treatment [9,10]. Internet of Things devices that are used instead of providing human services in the hospital create a sudden speed in the environment. Internet of Things devices have great uses in medicine; from various wearable devices to care devices and remote monitoring. The main advantage and application of IoT and artificial intelligence and robotics in healthcare and medicine for patients is saving time and quick access to vital information, especially in emergencies or when the doctor needs to control the patient remotely. [11]. There is also the application of Internet of Things and robotics in fields such as rehabilitation, care for the elderly, care and assistance for patients with disabilities, remote surgery and prosthetics, etc. It is expected that in the future, the role of the doctor in treatment and care will decrease and this system will lead to significant progress and improvement of health care services [12]. Health care programs using robotics and the Internet of Things will achieve the health of patients with a high percentage [13]. Finally, it should be mentioned that the science of artificial intelligence, robots and the Internet of Things is progressing rapidly, and the help of this system to the medical community will cure diseases that humans have not been able to cure so far, but there are challenges in the way of scientists. It includes the cost-effectiveness and availability of robots and gadgets for the general use of people and the use of doctors in more deprived areas [13].

Fig. 1: The relationship between robotics , IoT and healthcare

Advancement of telecommunication technologies and effects on early warning systems

IoT has a significant impact on the enhancement of service quality and reduction in the expenses of medical imaging [14]. Nowadays, the number of patients has faced notable growth. Therefore, the reports are on the increase, which may result in losing track of records, confusion and incorrect treatments [14]. Medical imaging equipment should be able to transfer the medical data and diagnosis reports to the related doctor and patients immediately so there will be a remarkable reduction in records misplacements, patient waiting time and irritation, and mistreatments [14]. The IoT enabled in medical imaging systems affects diagnostic approaches. Physicians can now track their patients' health conditions and prescribe the desired treatment in real-time [14]. These records are stored in the hospital's cloud server, where security is a critical issue [15]. A complex system of encryption and decryption in the network is required for secure transmission and storage of the records [15]. Medical images given by IoT are mostly grayscale and well-versed doctors can locate the injury or wound quickly by using them [16]. However, the interpretation of grayscale medical images might be difficult for patients and residents, which can be resolved by adding image coloring technology to them [16].

The Role of IoT and Artificial Intelligence in Advancing Healthcare through Biomedical Engineering

Medical engineering is the science of applying an understanding of engineering theories and medical science analysis to improve healthcare [17,18]. With the expansion and advancements of medical science, society's need for health care and biomedical equipment and methods increased; With the help of IoT and artificial

intelligence technologies, medical engineers can provide better conditions and a higher level of health care for the patient [17,19,20]. The IoT has already formed many new technologies and devices in the life of Rome, and health processes are moving towards the use of the IoT in the field of medical engineering and health care [21]. Healthcare based on the Internet of Things and artificial intelligence is an interconnected network of automated and human-independent communication that predicts medical equipment and personnel. Health care based on IoT and artificial intelligence has the possibility of exchanging health care data, accessing and collecting information, and making correct decisions related to the spontaneous process of the patient, remote monitoring, and control of the patient so that high-quality health services can be provided. Focused on fast and safe preventive care, lower overall cost, and increased sustainability [20,21,22].

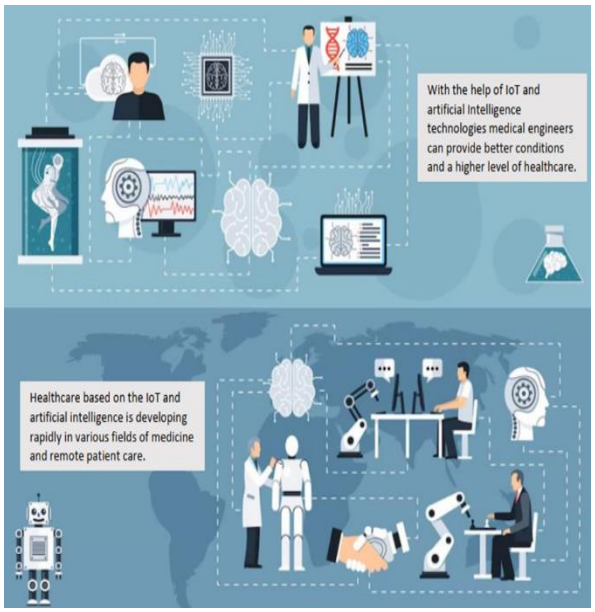

Fig. 2: IoT and artificial intelligence in interaction with health care and remote control of patients improve the quality of health services

Transforming Healthcare: The Impact of IoT on Patient Care and Treatment

The Internet of Things is widely used in various fields, for example, from smart homes to smart cities. In the field of health care, the Internet of Things is a new emerging technology and a new trend. It also speeds up the smallest thing, such as noting the patient's information and accessing it. Therefore, the improvement and quality of the desired treatment increases. One of the other reasons for the superiority of the Internet of Things over more traditional treatments in the field of health care is the precision in measuring and recording the patient's vital parameters [23,24]. Technology in this field is progressing significantly, as we will see a new generation of services. For example, when samples of a disease and its treatment are recorded so that it is accessible to everyone, it speeds up the treatment and health care process; Digitization of medical records will help similar patients in addition to helping the patient himself [25]. Scientists are trying to save energy by using the Internet of Things; For example, an emergency patient under care is constantly checked with wireless devices and remote control, which saves time and travel [24,25]. Among other applications of the Internet of Things in health care, we can mention the patient's independent life; If the patient can monitor his vital signs and control his condition, and can communicate with health care professionals, life will be easier for him and his health will be more guaranteed [26]. It is worth mentioning that there are challenges in using the Internet of Things, both in the field of medicine and in all other fields; For example, medical data or information provided to a doctor or patient must be verified, so healthcare organizations must monitor the information. Or even the information recorded from the patient may violate the privacy of the patient, so security must be established and this system must be monitored [25,26,27]. Finally, the Internet of Things improves the patient's life as well as the diagnosis and the speed of the doctor's and the treatment department, because the communication between the doctor and the patient becomes easier and the doctor monitors the patient remotely. For example, wearable gadgets or sensors placed on the patient's body help [27].

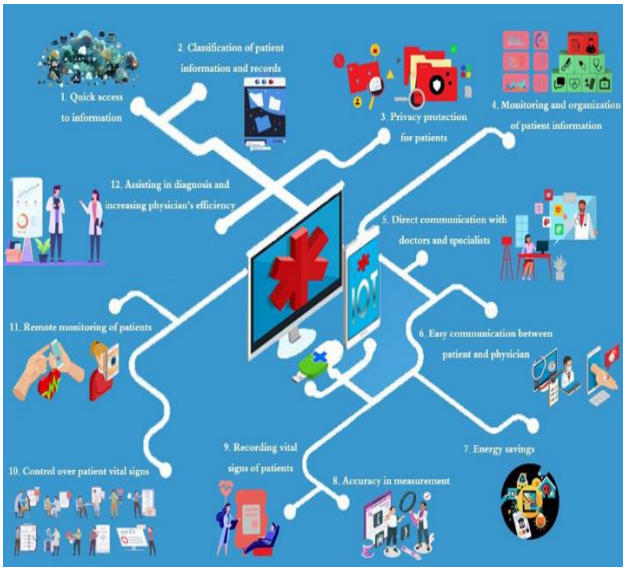

Fig. 3: Achievements and developments of the IoT in health care

IoT in Medical Engineering: Advancements, Applications, and Benefits for Patient Care

The emergence of IoT is widely used in various fields such as medicine, smart cities, emergency services, medical engineering, applications and management, smart homes, and patient health care. IoT has already introduced new technologies and devices in the field of health care in medical engineering. IoT in medical engineering has caused human-computer interaction and

healthcare [21]. IoT provides information to medical engineers to inform them of the limitations and possibilities of work in the field of health care, and to provide this information to doctors and specialists to facilitate and improve services and development. Patients should try to recover [17,28]. Biosensors are an example of IoT technology that can pursue many goals for medical engineers, from measuring people and places to measuring systems and parameters. Creates [28]. Biosensors have three components: detection tools, transducers, and signal processing systems. The most important application of biosensors is in medical diagnostics and laboratory sciences. Biosensors have other applications such as controlling and monitoring the treatment of diseases and health care and the condition and health of the body [19]. RFID is a fast and automatic recognition system with radio waves that has various applications in health care due to the presence of unsupervised environments [19,28]. Medical personnel can use RFID to spend less time acquiring medical devices and supplies. RFID can help to obtain and categorize medical information quickly and immediately when necessary. Most of the applications of RFID are in patient care and improving the quality of life and medical analysis; It is also expected to be used for remote patient monitoring [19]. IoT with a lot of information about the patient's pathology causes complete control and monitoring of the patient [28]. Some of the IoT-enabled sensors can detect medical symptoms of underlying diseases such as Parkinson's disease. At the core of these IoT technology breakthroughs are advances in microelectromechanical systems (MEMS). MEMS are systems of micro-engineering that are the result of the integration of actuators and circuits and microscopic mechanical components and sensors used in silicon microchips [28,29]. With MEMS sensors, it is possible to create monitoring systems that are capable of remote measurements, such as a different approach from a sensor that combines three sensors for electrocardiogram (ECG), photoplethysmograph (PPG), and electrocardiogram (SCG). has been This sensor is used to measure heart rate simultaneously from 12 sensor nodes (each node contains 3 sensors), which were able to perform 36 unique and individual high-frequency heart rate measurements. A very important advantage of IoT technology is its low cost because a comprehensive sensor and control system can be created to monitor patients and reduce related costs [28].

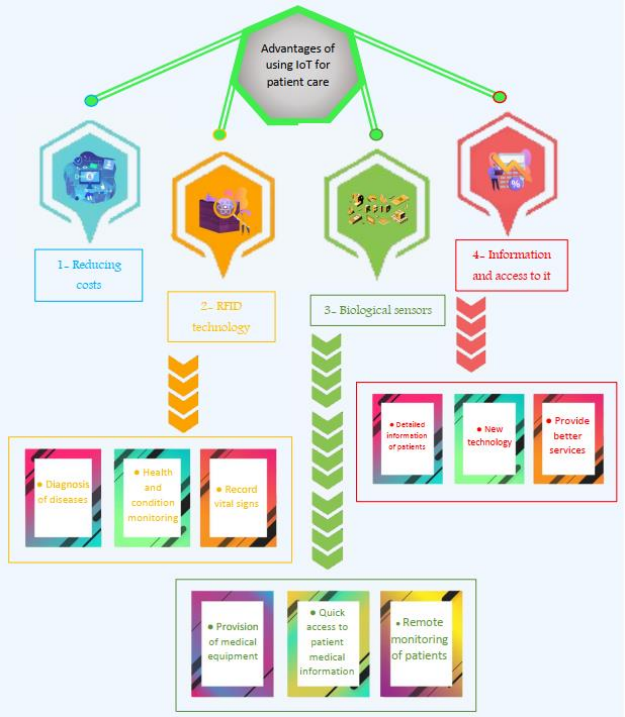

Fig. 4: Benefits of the relationship between the IoT and healthcare

IoT, AI, and Machine Learning in Bioinformatics: Revolutionizing Healthcare through Data Analytics

The remarkable development in IoT, artificial engineering and machine learning has transformed the aspects of bioinformatics and biomedical engineering [30]. Bioinformatics helps to discover unseen perceptions of diseases and find novel treatments for them [31]. This multidisciplinary field, which uses basic principles of computer science, statistics, mathematics and biology, can examine medical data with its algorithms and methods to find a cure customized for each patient [31]. This data can be collected with a well-combined IoT system in real-time [31]. Due to the infinite amount of medical data available, it can be categorized as “Big Data” [32]. The term of Big Data is used when the volume, velocity and variety of data become so immeasurable that regular data processing algorithms and methods cannot be applied [32]. Utilizing IoT-enabled computational intelligence (CI) techniques in bioinformatics helps to track the effects of different drug doses and other interferences and have a better understanding of illnesses and their treatments [31]. A variety of devices, computing patterns and computer algorithms will have an essential role in discovering future treatment guidelines for healthcare system [31]. There are significant limitations of IoT in the framework of bioinformatics. Having a substantial storage and memory for keeping medical data is a must, IoT devices need patch updates of software regularly, and standardized protocols in the application layer and network interfaces are required for IoT-enabled tools so they can understand each other’s demands [31].

CONCLUSION

By developing equipment and building an intelligent environment to deliver healthcare solutions, the Internet of Things in the field of medicine will undoubtedly alter the medical industry. As we covered in the previous sections, IoT significantly improves the standard of care and cuts down on the amount of time patients must wait for imaging tests. This lessens patient anxiety and allows the radiologist or doctor to carefully evaluate the test findings. Additionally, it contributes significantly to improving the health state of patients by fusing IoT and bioinformatics. There are issues with using the internet of things in medicine. Devices connected to IoT collect enormous volumes of data, including information, and will cause data security issues. while IoT is still quite young, it is actively developing and daily news stories demonstrate how it might build a contemporary, intelligent living. As a result, although IoT has been discussed in scientific literature for a while, it may not be extensively deployed just now. But it is anticipated that we will clearly see the uses of IoT in the not too distant future, particularly in medical. Because there are innumerable advantages to integrating IoT in medical science, some of which include accelerating the healing process and making it simpler for the patient and the treatment team to communicate. IoT in medicine will redefine healthcare performance by ensuring complete care, improving treatment outcomes and reducing costs for costs, processes and doing better work.

References

[1] Jara, Antonio J., Miguel A. Zamora, and Antonio FG Skarmeta. "HWSN6: Hospital wireless sensor networks based on 6LoWPAN technology: Mobility and fault tolerance management." 2009 International conference on computational science and engineering. Vol. 2. IEEE, 2009.

[2] Venkatasubramanian, K. K., et al. "Interoperable medical devices." IEEE Pulse 1.2 (2010): 16-27.

[3] Roy Chowdhury, Ankur. "IoT and Robotics: a synergy." PeerJ Preprints 5 (2017): e2760v1.

[4] Kudo, Michiharu. "Robot-assisted healthcare support for an aging society." 2012 Annual SRII Global Conference. IEEE, 2012.

[5] Datta, Chandan, et al. "A healthcare robot for monitoring adverse drug reactions in older people." 2012 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI). IEEE, 2012.

[6] Swangnetr, Manida, and David B. Kaber. "Emotional state classification in patient–robot interaction using wavelet analysis and statistics-based feature selection." IEEE Transactions on Human-Machine Systems 43.1 (2012): 63-75.

[7] Zollo, Loredana, Kazuyoshi Wada, and HF Machiel Van der Loos. "Special issue on assistive robotics [from the guest editors]." IEEE Robotics & Automation Magazine 20.1 (2013): 16-19.

[8] Tapus, Adriana, Maja J. Mataric, and Brian Scassellati. "Socially assistive robotics [grand challenges of robotics]." IEEE robotics & automation magazine 14.1 (2007): 35-42.

[9] Patel, Ankit R., et al, "Vitality of robotics in healthcare industry: an Internet of Things (LOT) perspective." Internet of things and big data technologies for next generation healthcare (2017): 91-109.

[10] Verma, Varnita, et al. "IoT and robotics in healthcare." Medical Big Data and. Internet of Medical Things. CRC Press, 2018. 245-269.

[11] Kavidha, V., N. Gayathri, and S. Rakesh Kumar. "AI, IoT and robotics in the medical and healthcare field." AI and IoT-Based Intelligent Automation in Robotics (2021): 165-187.

[12] Pradhan, Bikash, et al. "Internet of things and robotics in transforming current-day healthcare services." Journal of healthcare engineering 2021 (2021): 1-15.

[13] Dixit, Pooja, et al. "Robotics, AI and IoT in medical and healthcare applications." AI and IoT-Based Intelligent Automation in Robotics (2021): 53-73.

[14] Chandy, Abraham. "A review on IoT based medical imaging technology for healthcare applications." Journal of Innovative Image processing (JIIP) 1.01 (2019): 51-60.

[15] Elhoseny, Mohamed, et al. "Hybrid optimization with cryptography encryption for medical image security in Internet of Things." Neural computing and applications 32 (2020): 10979-10993.

[16] Li, Hong-An, et al. "Medical image coloring based on gabor filtering for internet of medical things." IEEE Access 8 (2020): 104016-104025.

[17] Javaid, Mohd, et al. "Sustaining the healthcare systems through the conceptual of biomedical engineering: A study with recent and future potentials." Biomedical Technology 1 (2023): 39-47.

[18] Khan, Yaqub, Poonam Gupta, and Vikas Kumar Verma. "A review-biomedical engineering-present and future prospective." Asian Journal of Pharmaceutical Research 3.4 (2013): 202-206.

[19] Aledhari, Mohammed, et al. "Biomedical IoT: enabling technologies, architectural elements, challenges, and future directions." IEEE Access 10 (2022): 31306-31339.

[20] Fritzsche, Holger. "Innovation Methodology I3 EME: Awareness for Biomedical Engineers." Novel Innovation Design for the Future of Health: Entrepreneurial Concepts for Patient Empowerment and Health Democratization. Cham: Springer International Publishing, 2022. 243-249.

[21] Priyadarshini, S.B.B., Sharma, D.K., Sharma, R., & Cengiz, K. (Eds.). (2022). The Role of the Internet of Things (IoT) in Biomedical Engineering: Present Scenario and Challenges (1st ed.). Apple Academic Press.

[22] Fritzsche, Holger, et al. "A structured pathway toward disruption: a novel healthtec innovation design curriculum with entrepreneurship in mind." Frontiers in Public Health 9 (2021): 715768.

[23] Gandhi, Disha Amrutlal, and Munmun Ghosal. "Intelligent healthcare using IoT: a extensive survey." 2018 second international conference on inventive communication and computational technologies (ICICCT). IEEE, 2018.

[24] Anand, Sharath, and Sudhir K. Routray. "Issues and challenges in healthcare narrowband IoT." 2017 International Conference on Inventive Communication and Computational Technologies (ICICCT). IEEE, 2017.

[25] Bhatt, Chintan, Nilanjan Dey, and Amira S. Ashour, eds. "Internet of things and big data technologies for next generation healthcare." (2017): 978-3.

[26] Raghuvanshi, Abhishek, Umesh Kumar Singh, and Chirag Joshi. "A review of various security and privacy innovations for IoT applications in healthcare." Advanced Healthcare Systems: Empowering Physicians with IoT-Enabled Technologies (2022): 43-58.

[27] Ratta, Pranav, et al. "Application of blockchain and internet of things in healthcare and medical sector: applications, challenges, and future perspectives." Journal of Food Quality 2021 (2021): 1-20.

[28] Coulby, Graham, et al. "Towards remote healthcare monitoring using accessible IoT technology: state-of-the-art, insights and experimental design." BioMedical Engineering OnLine 19 (2020): 1-24.

[29] Mahmoudian, Nina, et al. "Dynamics of a micro electro mechanical system (MEMS)." 2004 International Conference on MEMS, NANO and Smart Systems (ICMENS'04). IEEE, 2004.

[30] Bhardwaj, Kartik Krishna, Siddhant Banyal, and Deepak Kumar Sharma, "Artificial intelligence based diagnostics, therapeutics and applications in biomedical engineering and bioinformatics." Internet of Tings in Biomedical Engineering. Academic Press (2019): 161-187.

[31] Barbhuiya, Rejaul Karim, and Naeem Ahmad. "IoT applications in translational bioinformatics." Translational Bioinformatics in Healthcare and Medicine. Academic Press (2021): 69-79.

[32] Bhatt, Chintan, Nilanjan Dey, and Amira S. Ashour, eds. "Internet of things and big data technologies for next generation healthcare." (2017): 978-3.