IOT Based Health Care Devices: A Review

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Abstract— The Internet of things (IOT) has shown potential application to technologies in connecting various medical devices, sensors, and health-care professionals to provide quality medical services in a remote location. To be more specific, the last decade has witnessed extensive research in the field of healthcare services and their technological up gradation. The Health care industry always expect reduction in healthcare cost; enhanced the accessibility of health-care services attached to the smart wheel-chair; ease of interpretation so that amplified the operational efficiency in the healthcare industry; improvement in patients safety; and recovery of patients personal satisfaction. IOT based techniques helps to reduce various hurdles or complications. This paper aims to provide a complete state-of-the-art summary of IOT based potential healthcare applications or technologies research trends. We anticipate that the information gathered in this will enhance awareness of its benefits; challenges; and applications.

Index Terms— smart wheel-chair; radio frequency; bluethooth; wi-fi; mobile; service; technology; wearable devices; .

1 Introduction

In recent year, IOT has not only enhanced the independence but also diversified the ability of the human to interact with the external environment. With help of futuristic protocol and algorithms, became a major contributor to global communication. The growing popularity of the IOT is due to its advantage of showing higher accuracy, lower cost, and its ability to predict future events in a better way. Further, increased knowledge of software and applications, with the up-gradation of mobile and computer technologies, easy availability of wireless technology, and the increased digital economy have added to the rapid IOT revolution [1].A few years ago, the diagnosis of diseases and abnormality in the human body was only being possible after having a physical analysis in the hospital. Most of the patients had to stay in the hospital throughout their treatment period. This resulted in an increased healthcare cost and also strained the healthcare facility at rural and remote locations. The technological advancement that has been achieved through these years has now allowed the diagnosis of various diseases and health monitoring using miniaturized devices like smart watches. Moreover, technology has transformed a hospital-centric healthcare system into a patient-centric system [2, 3].

IOT based smart wheel-chair have been developed using the various different technologies such as artificial intelligence technologies (AIT) help the users gain mobility and moving freely and safely without needing someone's help. However, they are too expensive, and their hardware is too heavy which makes the software system response too slow. The most of the people in this world wants to be wealthy, comfortable, successful and normal life. However, but every of us have to face some annoying factors such as long illness diseases; car accidents; impairment, weakness due to eldership. In such situation, the smart wheel-chair with IOT based technologies including artificial intelligence helps to survive independently and happily for long time. The healthcare application with the framework of IOT aids to integrate the advantages of IOT technology and cloud computing in the field of medicine. It also lays out the protocols for the transmission of the patient's data from numerous sensors and medical devices to a given healthcare network. The topology of a health based IOT is the arrangement of different components of an IOT healthcare system/network that are coherently connected in a health-care environment.

2 Literature Review

Wheel-chairs have evolved very little over the past 1000 years. Most of the design changes have occurred within recent decades as shown in the following outline of wheel-chair history. In 5th century BCE: The earliest record of a device resembling a wheelchair dates back to China. Early versions came from wheeled furniture designs. It's believed the Chinese used wheelbarrows to move disabled people around. In 6th Century A.D.: Earliest recording of a wheelchair; a Chinese engraving picturing a man in a chair with three wheels. 10th Century A.D., Wheel-chairs were well-developed in Europe and commonly found in drawings and literature [4].

In 12th century: It's believed the concept of the wheelbarrow and crude versions of the wheelchair began to be used around this time in Europe. In 1655, the first self-propelled wheelchair is developed and was invented in Germany by disabled watchmaker Stephan Farfler. His design included three wheels and he could move it with the use of a rotary handle on the front wheel. Around the same time frame, German inventor and mechanic, Johann Hautsch, developed a series of rolling chairs. In 1760, the bath chair was created by English inventor James Heath. It became a popular way to transport people with illnesses and disabilities, even though it was initially designed

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for women. The design is similar to a rickshaw. It had a three- and four-wheel design, and it could be pushed or pulled. Other designs were developed so people could be pulled by horse.

In 18th century: Wheelchairs began to become a normal fixture in medical catalogues. They were advertised as transportation devices for patients. They resembled armchairs with two larger wheels at the front and a smaller wheel at the back. In 1901: The basic chair was invented. It closely resembles the modern design of wheelchairs used today. It had a seat, footrests and four wheels – two smaller wheels at the front and two larger at the back. In 1903 - An electrically-driven wheelchair operating on a 12-volt battery and a 3/8 horsepower motor was used to give people rides. At the time it was not used for handicapped mobility but it did pave the way for future developments.

In 1909 - Compact wheelchairs were developed using metal tubing instead of the traditional bulky wood components. In World War I - The first electric wheelchairs were used for the handicapped. A battery and motor were applied to existing wheelchairs with a simple one-speed on/off switch [5]. In 1932: The folding wheelchair was introduced. It's one of the biggest design breakthroughs in the device's history. It was invented by Harry Jennings for his friend. The folding design and tubular steel chair with a cross frame became the standard design. This model allowed people to use the wheelchair outside of the home, hospitals and care facilities. Later designs built on Jennings concepts and were focused on decreasing weight of the chair and improving its overall performance. In 1937 - The patent for a wheelchair with a folding X-brace frame was issued to two engineers named Everest and Jennings. Though previous chairs had been foldable top-to-bottom, the side-to-side folding position of the cross frame allowed the drive wheels to remain in place. In 1940 - The first patent was issued for an electric wheelchair.

In 1950 - Sam Duke received a patent for a releasable add-on power drive applied to a manual wheelchair (the unit was actually permanently fitted to the chair with U-bolts). In 1960's - Folding wheelchairs were commonly fitted with electric drives. The drive units were still very heavy and quite difficult to put on and take off. At that point both joystick and steering column mechanisms were available. After World War II, demand for wheelchairs spiked. There were thousands of wounded veterans who needed mobility assistance. A Canadian, George Klein, saw the need and invented the electric wheelchair for veterans. The original design was a standard wheelchair with a motor added. Later designs had the motor and battery built into the chair under the seat. Additional developments in ergonomics, controls, comfort, and performance were created as new technologies were developed. In 1970's - Wheelchair frames made of aircraft quality aluminum were introduced to the market and started a revolution of ultra-light wheelchairs. The technology has aided in the reduction of the overall weight of many types of wheelchairs In 1980: Niche wheelchair designs began to come to market. During this time, the rigid wheelchair was created. It was intended for athletes. They are self-propelling and some can reach speeds of up to 30 km/hr. Most electric wheelchairs on the market were still bulky, heavy, and required a special vehicle for transportation. The power components of the chair were integrated into the frame which has been strengthened to support them [6].

In 1990's - The popular electric wheelchairs on the market are foldable though they require removal of at least the leg rests and batteries. The Americans with Disabilities Act (ADA) and a growing awareness for the rights of the disabled have greatly improved research and design efforts in the assistive technology industry. Interest has also increased in this area due to the current trend toward the "graying of America" as the average age of Americans increases [7]. Ergonomics addresses the problems of human comfort, activity and health in environments. Selection of the proper seat width is important to comfort and stability. A seat too narrow is not only uncomfortable, but access to the chair is made difficult. In addition, a seat wider than is necessary makes propulsion more difficult [8]. A seat that is too deep or longer than it should be, can restrict circulation in the 2 legs, and causes the patient either to sit with his legs extended or to slide forward in the chair. The backrest of the basic chair is made of a flexible material stretched between the two side frames which are fixed with respect to the seat. The backrest should be high enough to provide support without inhibiting motion and avoid discomfort. Armrest is providing support for the patient's arms in a resting attitude, and also provides lateral support. The function of the footrests is to keep the feet off the floor. In the light of the current biomechanical and physiological knowledge of manual wheelchair propulsion there seems to be a need for the stimulation of other than hand rim propelled manual wheelchairs [9, 10].

3 Final Stage Health Based IoT Framework And Technologies

A basic Health-based IOT system contains mainly three components (Fig. 1) such as publisher, broker, and subscriber [11]. The publisher represents a network of connected sensors and other medical devices that may work individually or simultaneously to record the patient's vital information. This information may include blood pressure, heart rate, temperature, oxygen saturation, ECG, EEG, EMG, and so on [12]. The publisher can send this infor-mation continuously through a network to a broker.

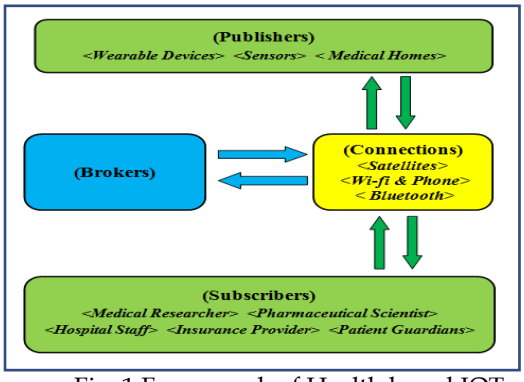


Fig. 1 Framework of Health based IOT

The technologies that are used to develop an HIOT system are crucial. This is because the use of specific technology can enhance the ability of an IOT system [13]. Hence, to integrate different healthcare applications with an IOT system, various state-of-the-art technologies have been adopted. These technologies can broadly be categorized into three groups, namely, identification technology, communication technology, and location technology (Fig. 2). In case of identification technology, a practical consideration in designing an HIOT system is the accessibility of the patient's data from the authorized node (sensor), which may be present at remote locations. This can be carried out with effective identification of the nodes and

sensors that are present in the healthcare network. Identification follows the process of assigning a unique identifier (UID) to each authorized entity so that it can be easily identified and unambiguous data exchange can be achieved. In general, every resource associated with the healthcare system (hospital, doctor, nurses, caregivers, medical de-vices, and so on) is accompanied by a digital UID [14]. This ensures the identification of the resources as well as the connection among the resources in a digital domain.

Whereas, communication technologies ensure the connection among different entities in an halth based IOT network. These technologies can be broadly divided into short-range and medium-range communication technology. The short-range communication technologies are the protocols that are used to establish a connection among the objects within a limited range or a body area network (BAN), whereas the medium-range communication technologies usually support communication for a large distance, e.g., communication between a base station and the central node of a BAN. The distance of communication may vary from a few centimeters to several meters in the case of short-range communication.

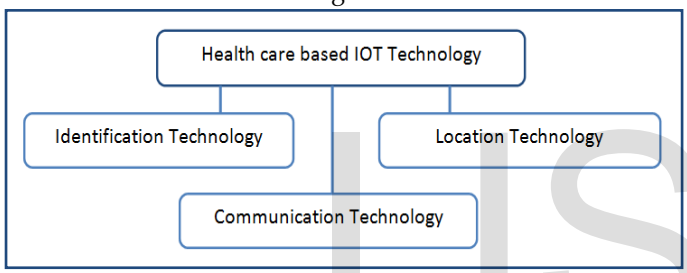


Fig. (2) Classification of Health based IOT

In most of the HIOT applications, short-range communication technology is preferred. Some of the most widely used communication techniques include RFID, Wi-Fi, Zigbee, Bluetooth, Satellite, NFC, etc. In location technology, the real-time location system (RTLS) or location technologies are used to identify and track the position of an object within the healthcare network. It also tracks the treatment process based on the distribution of available resources. One of the most widely used technologies is the Global Positioning System, which is commonly known as GPS. It makes use of satellites for tracking purposes.

An object can be detected through GPS as long as there exist a clear line of sight between the object and four different satellites. In HIOT, it can be employed to detect the position of the ambulance, healthcare provider, caregivers, patients, etc. However, the application of GPS is only limited to outdoor applications as the surrounding infrastructures can act as an obstruction to the communication between the object and the satellite. In such cases, a local positioning (LPS) network can be effectively used. LPS can track an object by sensing the radio signal that is emitted from the traveling object to an array of pre-deployed receivers [15].

4 Role Of Services And Applications In Health Based IOT

The considerable impact of IOT, which has been witnessed in recent years, is contributing to the evolution of HIOT applications that includes disease diagnosis, personal care for pediatric and elderly patients, health and fitness management, and supervision of chronic diseases. For a better grasp of these applications, it has been divided into two basic categories, namely, various services and their applications to be used (Fig. 3). Services: The recent advancement in the IOT technology supported the healthcare centers to reach more people at a time and deliver excellent healthcare service at a minimal cost. The application of big data and cloud computing has also made communication between the patient and doctors more reliable and easier. This resulted in an enhanced patient's engagement in the treatment process with a reduced financial burden on the patient.

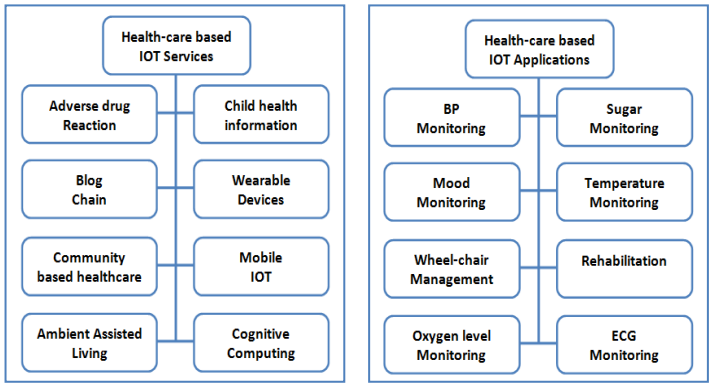
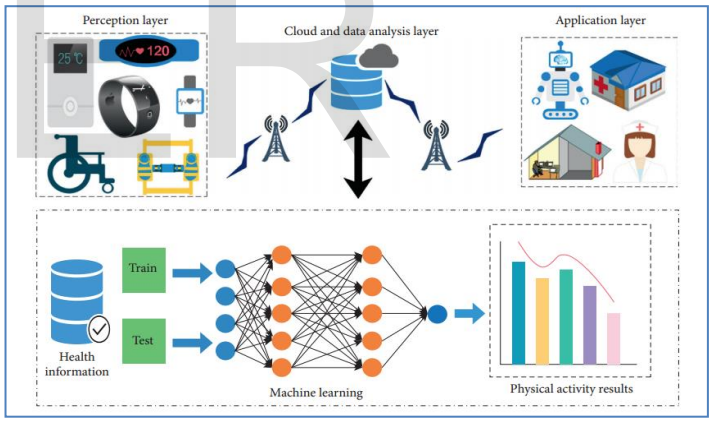


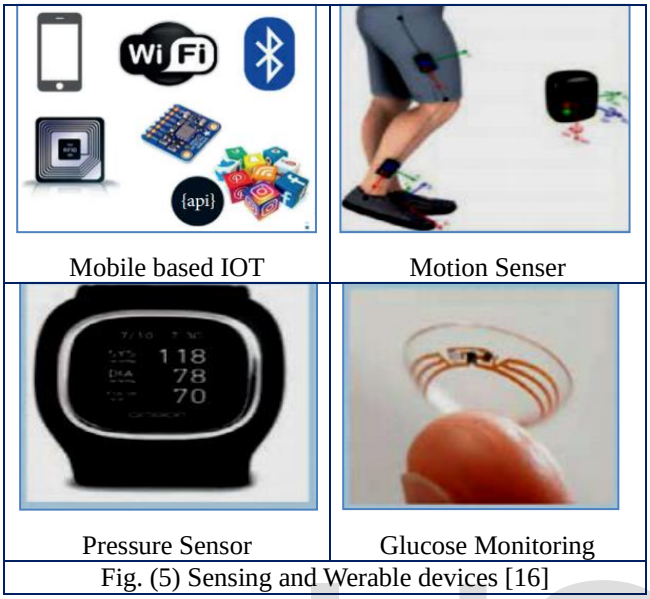
Fig. (3) Health based IOT Services and Applications

Fig. (4) Services Framework [16]



AAL is a specialized branch of artificial intelligence that integrates with IOT and is used for assisting aging people. The main purpose of AAL is to help elderly people to live in-dependently at home with convenience and safety. AAL provides a technique for real-time monitoring of these patients and making sure that they will receive human service-like assistance in case of a medical emergency [16]. The basic framework for AAL is shown in Fig. 4. IOT-based healthcare systems are now able to track indoor air quality with help of assistive robots. These systems check the quality of air in the environment where the patient resides [17] and trigger alerts to the caregivers when there is a reduction in the air quality below a standard value. Mobile IOT depicts the association of mobile computing, sensors, communication technologies, and cloud computing to track patient's health information and other physiological conditions (Fig. 5). In other words, it provides a communication interface between the personal area networks and mobile networks (such as 4G and 5G) to

provide an efficient Internet-based healthcare service [18]. Wearable devices (Fig. 5) help healthcare professionals and patients to deal with various health issues at a reduced cost. These devices are noninvasive and can be developed by integrating various sensors with wearable accessories used by humans such as watch, wristband, necklace, shirt, shoes, handbag, caps, and so on [19].



Mobile based IOT | Motion Senser

Pressure Sensor | Glucose Monitoring

Fig. (5) Sensing and Werable devices [16]

Community-based healthcare monitoring is a concept of creating a healthcare network that covers a local community such as a private clinic, a small residential area, a hotel, and so on to monitor the health conditions of the people residing in that area. In a community based network, various networks are concatenated and can work cooperatively to give a collaborative service. An IOT based cooperative medical network was set up to provide healthcare monitoring in remote areas. To establish a secure connection between the networks, different authentication and authorization mechanisms were employed. In another study, a community medical network was proposed that was considered as a "virtual hospital." this helped to provide medical facilities to the needy from a remote location. In a four-layer structural framework was designed for sharing health information that includes medical records of the patients. This information can be accessed by the health centers to provide proper medical advice to the patients who are residing in the locality [20].

Applications: Electrocardiogram (ECG) represents the electrical activity of the heart due to the depolarization and re-polarization of atria and ventricles. An ECG provides information about the basic rhythms of the heart muscles and acts as an indicator for various cardiac abnormalities. These abnormalities include arrhythmia, prolonged QT interval, myocardial ischemia, etc. [21,22]. Diabetes is the condition in which the blood glucose level in the body remains high for a prolonged period. It is one of the most common diseases in humans. Three major types of diabetes are generally found, namely, type-I diabetes, type-2 diabetes, and gestational diabetes. The disease and its types can be identified following three tests, namely, random plasma glucose test, fasting plasma glucose test, and oral glucose tolerance test. Human body temperature is an indicator of the maintenance of homeostasis and is an important part of many diagnostic processes. Additionally, a change in body temperature can be a warning sign in some illnesses such as trauma, sepsis, and so on. Keeping track of the change in temperature over time helps the doctors to make inferences about the patient's health condition in many diseases [23]. One of the compulsory procedures in any diagnostic process is the measurement of blood pressure (BP). The most accustomed method of measurement of blood pressure requires at least one person to do the recording. However, the integration of IOT and other sensing technology has transformed the way BP was previously monitored. [24]. Pulse oximetry is the noninvasive measurement of oxygen saturation and can be used as a vital parameter in healthcare analysis. The non-invasive method eliminates the issues related to the conventional approach and provides real-time monitoring. The advancement in the pulse oximeter that comes from the integration of IOT-based technology has shown potential application in the healthcare industry. A non-invasive tissue oximeter was proposed that could measure the blood oxygen saturation level, along with heart rate, and pulse parameters [25]. Mood tracking provides vital in-formation regarding a person's emotional state and is used to maintain a healthy mental state. It also assists healthcare professionals while dealing with various mental diseases such as depression, stress, bipolar disorder, and so on. Medication adherence is a common issue in the healthcare industry. Non-adherence to the medication schedule may increase the adverse health complications in patients. Medication non-adherence is mostly found in elderly people as they develop clinical conditions like cognitive decline, dementia, and so on as the age progresses. Hence, it is difficult for them to strictly follow the prescriptions of doctors.

5 Challenges And Limitations

In the last few years, the healthcare industry has witnessed remarkable technological development and its application in solving healthcare-related issues. This has significantly improved the healthcare services, which have now been brought at the fingertip. With the application of smart sensors, cloud computing, and communication technologies, IOT has successfully revolutionized the healthcare industry. Like other technologies, IOT also has certain challenges and issues that provide potential scope for future research, such as servicing and maintenance cost in which the continuous up-gradation required, where high maintenance involved; others factors are of power consumption, where high-power battery is required; validation and standardization of electronic medical records (EMRs) must be maintained, which is considerably extensive; maintaining of data privacy and security are very much important health-care based IOT system as malicious attack may occurred; similarly, scalability, self configuration, continuous monitoring, exploration of new diseases, environmental impact, etc are such continuous precautionary and important required factors, which challenges the entire process of health-care based IOT system.

6 Conclusions

The different aspects of the health-care based IOT system have been investigated using the various current review. The comprehensive knowledge about the architecture of an HIOT system, their component, and the communication among these components has been discussed herein. Additionally, this research

provides information about the current healthcare services where the IOT-based technologies have been explored. This review reflects the robotic action using Artificial Intelligent (AI) concept helps to monitor and diagnose several health issues, and transformed the healthcare industry from a hospital-centric to a more patient-centric system.

REFERENCES

[1] V. Jagadeeswari, "A study on medical Internet of things and Big Data in personalized healthcare system," Health Information Science And Systems, Vol. 6, pp. 14, 2018.
[2] Z. Ali, M. S. Hossain, G. Muhammad, and A. K. Sangaiah, "An intelligent healthcare system for detection and classi-fication to discriminate vocal fold disorders," Future Generation Computer Systems, Vol. 85, pp. 19–28, 2018.
[3] B. Pradhan , S. Bhattacharyya, and Kunal Pal, "IoT Based Applications in Healthcare Devices", Journal of Healthcare Engineering, 2021, Article ID 6632599, pp. 18 page, 2021.
[4] Herman l. Kamenetz, "A Brief History of the Wheelchair", Journal of the History of Medicine and Allied Sciences, Volume 24, Issue 2, pp. 205–210, April 1969.
[5] Medical Equipment Distribution, https://www.medplushealth.ca/blog/the-history-of-wheelchairs-and-their-development/ (access on dated 02 Jul 2022).
[6] D.A. Hobson, "Seating and Mobility for the Severly Disabled", In Rehabilitation Engineering, Boston, MA: CRC Press, 1990.
[7] COMSIS Corporation, "Product Safety and the Older Consumer", Washington D.C. U.S., Consumer Product Safety Commission, 1988.
[8] B.R. Kotajarvi, MS, PT; Michelle B. Sabick, PhD; Kai-Nan An, PhD; Kristin D. Zhao, MA; Kenton R. Kaufman, PhD; Jeffrey R. Basford, MD, PhD, "The effect of seat position on wheelchair propulsion biomechanics", Journal of Rehabilitation Research & Development, Vol. 41, No. 38, pp. 403–414, May/June 2004.
[9] Veeger, Woude & Lucas & Veeger, Dirkjan & Dallmeijer, AJ & Janssen, Thomas & Rozendaal, L.A., "Biomechanics and physiology in active manual wheelchair propulsion", Journal of Medical Engineering & Physics, Vol. 23, pp. 713-33, 2002.
[10] 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.
[11] 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.
[12] 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, pp. 768, 2019.
[13] Y. Yuehong, "The internet of things in healthcare: an overview," Journal of Industrial Information Integration, vol. 1, pp. 3–13, 2016.
[14] 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.
[15] R. Peng and M. L. Sichitiu, "Angle of arrival localization for wireless sensor networks," in Proceedings of the 2006 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, pp. 374–382, Reston, Virginia, September 2006.
[16] L. Syed, S. Jabeen, M. S., and A. Alsaeedi, "Smart healthcare framework for ambient assisted living using IoMT and big data analytics techniques," Future Generation Computer Systems, vol. 101, pp. 136–151, 2019.
[17] G. Marques, I. M. Pires, N. Miranda, and R. Pitarma, "Air quality monitoring using assistive robots for ambient assisted living and enhanced living environments through internet of things," Electronics, vol. 8, no. 12, p. 1375, 2019.
[18] H. Mora, D. Gil, R. M. Terol, J. Azor´ın, and J. Szymanski, "An IoT-based computational framework for healthcare monitoring in mobile environments," Sensors, vol. 17, no. 10, p. 2302, 2017.
[19] Y. Zhang, J. Cui, K. Ma, H. Chen, and J. Zhang, "A wristband device for detecting human pulse and motion based on the internet of things," Measurement, vol. 163, 2020.
[20] A. Kelati, "Biosignal monitoring platform using Wearable IoT," in Proceedings of the 22st Conference of Open Innovations Association FRUCT, pp. 9–13, Petrozavodsk, Russia, May 2018.
[21] T. Tekeste, "Ultra-low power QRS detection and ECG compression architecture for IoT healthcare devices," IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 66, pp. 669–679, 2018.
[22] J. B. Bathilde, "Continuous heart rate monitoring system as an IoT edge device," in Proceedings of 2018 IEEE Sensors Applications Symposium (SAS), pp. 1–6, Seoul, Korea, March 2018.
[23] F. Valenzuela, A. Garc´ıa, E. Ruiz, M. V´azquez, J. Cortez, and A. Espinoza, "An IoT-based glucose monitoring algorithm to prevent diabetes complications," Applied Sciences, vol. 10, no. 3, p. 921, 2020.
[24] Q. Xin and J. Wu, "A novel wearable device for continuous, non-invasion blood pressure measurement," Computational Biology and Chemistry, vol. 69, pp. 134–137, 2017.
[25] Y. Fu and J. Liu, "System design for wearable blood oxygen saturation and pulse measurement device," Procedia Manufacturing, vol. 3, pp. 1187–1194, 2015.