ISSN 2278-3091
Volume 8, No.6, November – December 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse27862019.pdf
https://doi.org/10.30534/ijatcse/2019/27862019

Artificial Intelligence with the Internet of Things on Healthcare systems: A Survey

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ABSTRACT

The technologies of Artificial intelligence (AI) and the Internet of Things (IoT) perfectly complement each other for future enlargement. IoT connects all the things in the world over the internet. The number of connected devices contains a large number of data, which means IoT devices have endless information in chips and sensors for empowering people in various aspects of their lives. Even human and computer software can't handle and processes the considerable number of data which are generated by IoT devices. So, Artificial intelligence and machine learning algorithms help to control them. AI provides the functional solution to managing the various connected IoT elements. The critical issue is learning abilities and unlimited data processing that is generated by IoT devices. To rectify this issue, the companies are using the powerful subset of AI, called machine learning (ML). For applying ML to IoT data, the smart systems provide an accurate prediction. AI applications for IoT, enables the organizations to avoid unplanned downtime, spawn new services or products, increase operating efficiency, and enhance risk management. This combination is mainly used in the applications of healthcare, smart homes, autonomous vehicles, agriculture, and marketing. In these various applications, this survey paper describes healthcare applications based on Artificial intelligence (AI) and IoT. It also introduces the survey of different AI-based IoT techniques to predict the diseases earlier in the medical filed.

Key words : Internet of things, Artificial intelligence, Healthcare applications, Machine learning, Deep learning, and Sensor networks

1. INTRODUCTION

IoT is the enlargement of current internet services. It defines the network of physical things or physical objects which exist in today's world. IoT uses the API, sensors, mobile phones, and actuators to connect or exchange the data through the internet. It accommodates to connect all the devices into other connected devices to the internet. It is anticipated that things are identified automatically and can communicate with each other by themselves (Tiwary, Mahato, et al. 2018). Indeed, the IoT strength provides strong influences on various aspects of everyday life and behavioral of potential users. It mainly used in updated technologies such as pervasive computing, ubiquitous computing, communication technologies, embedded devices, sensor networks, and internet protocols. The survey report states, the global market of IoT is projected to more than 1$ billion from 2017 onwards. It indicates the rapid growth in large data volume and variety of data. Therefore, IoT based systems generate a large amount of data, usually called big data. Traditional techniques and data processing algorithms can not process this data.

Nowadays, Artificial Intelligence (AI) acts as the most crucial factor to imitate human tasks such as healthcare applications, business monitoring, research and development, product development, business process, share market prediction, social network analysis, environmental control and industrial applications (Lloret, Tomas, et al. 2016). It performs the tasks that were earlier limited to human intelligence. AI contains the characteristics of Context-aware, Embedded, Personalized, and Anticipatory.

IoT and AI will play an essential role in several ways in the future (Zhou, Wang, et al. 2019). It mainly requires industries, governments, scientists, engineers, and technologists to implement in various circumstances. Potential benefits and possibilities of both IoT and AI can be experts when both are combined in servers. For example, AI comprises with machine learning for data analyze and identify the future actions in advance named equipment failure in industry and order replacements in marketing. Furthermore, AI can use machine learning for smart home experience. Likely, AI methods with IoT can be used to identify human behavior through sensors, Bluetooth signals to make the corresponding changes in lighting and room temperatures. The main aim is to process and store the data which are gathered from IoT as depicted in the figure 1.

Figure 1: Representation of IoT applications (Al-Fuqaha, Guizani et al. 2015)

IoT is used to collect the massive amount of data, and it handles by Artificial Intelligence algorithms. So we require machine learning models to handle the enormous amount of quality data and relevant data. IoT devices generate the amount of data that can be used with AI. Fortunately, the IoT provides the interface to receive the data generated from various methods and utilize these IoT data into AI systems. There are multiple applications, and the healthcare industry contains a large amount of data. In this field, medical devices, fitness trackers, and healthcare apps are collecting and producing vast amounts of data. The AI and IoT method helps to predict the diseases and suggests preventive maintenance. When it comes to disease control and health protection, the patients and hospitals could appreciate the benefits of AI and IoT approaches. This paper presents various surveys of healthcare applications in AI and IoT. The main objective of this survey is summarized as follows:

1. To study the importance of IoT and AI in the healthcare and medical field.
2. To study the various surveys of AI-based IoT techniques in healthcare.
3. To analyze the various challenges of healthcare IoT in the existing literature.

The survey initializes the importance of IoT in the healthcare sector. The remaining part of the review explains the AI-based IoT in healthcare and various techniques used in IoT. Then it describes the multiple challenges of IoT in healthcare. Finally, section 5 concludes this paper.

2. IMPROVING HEALTHCARE QUALITY THROUGH IOT

The Internet of Things creates economic value and enhances the patient's experiences in the healthcare industry (Mohapatra, Kumar, et al. 2018). With the use of this technology in healthcare, there are unmatched benefits that could enhance the quality and treatment efficiency and accordingly improves the patient's health. The benefits are defined as,

1. Simultaneous reporting and monitoring
2. End-to-End connectivity
3. Data analysis and data assortment
4. Tracking and alerts
5. Remote medical assistance

(Rodrigues, Segundo, et al. 2018) Explained the various technologies for IoT. This paper provides multiple IoT techniques for ambient assisted living and healthcare, and is also called the Internet of Health Things (IoHT). This work identified the technological advances and analyzed the challenges to overcome. It also reviewed the information source for medical care specialists, healthcare providers, and populations interested in IoT. This study doesn’t comprise any profound concept of fundamental topics, architectures, and IoT platforms.

(Ahad, Tahir, et al. 2019) Explicated the 5G based smart health care network. In the existing 4G network, healthcare widely used and contains various intelligent healthcare applications. It firstly introduced with architecture for 5G smart healthcare and multiple techniques such as small cells, D2D communication, SDN, and edge computing. Then they describe the taxonomy of 5G smart healthcare. It identified new requirements such as high bandwidth, ultra-low latency (ULL), and ultra-high reliability (UHR). Thirdly, it defines the network layer solutions, which include routing, congestion control, and scheduling for IoT based 5G smart healthcare.

(Alabdulatif, Khalil, et al. 2019) Explained the smart healthcare surveillance framework. In the existing system, the main challenge was to handle the billions of data generated from IoT. Edge computing provides the solution by processing the middle layer between cloud computing and IoT devices. This study presents with novel Edge of Things for secure services and smart healthcare monitoring services. It explained the fully homomorphic encryption to maintains data privacy within the IoT framework. The proposed framework analyzed the execution time, performances of encrypted data, and data privacy. The disadvantage is, it doesn’t explain the advanced data mining methods for homomorphic computation.

(Alansari, Soomro, et al. 2018) Described the IoT in big healthcare data. This research mainly prioritizes the usage of IoT in the medical sector. This work accumulated a descriptive analysis based on data collection. Based on the survey, the weight of environmental protection in the healthcare sector is 23.63% to develop the IoT. (Akrivopoulos, Chatzigiannakis, et al. 2017) It provides various applications through FOG computing infrastructure. FOG is the most enhanced cloud computing to handle the issues of IoT framework. The IoT facilitates new applications with healthcare monitoring platforms. This study presents the various forms with a working prototype that collects the ECG traces from patient’s smartphones. This prototype involves allowing the patients to share the information with their physicians for monitoring the health status.

3. ARTIFICIAL INTELLIGENCE-BASED INTERNET OF THINGS IN HEALTHCARE

IoT defines the connection of various devices, sensors, and other technologies; it doesn’t contain direct communication like phones or computers.

(Ullah, Shah, et al. 2016) provides various ways to use IoT in smart healthcare. It used to connect the devices for communication. But, in healthcare, m-health and e-health still missing to use smartphone sensors to transmit the related data to a patient's health. This paper provides two contributions. Firstly, it evaluates the existing literature with various factors to deploy IoT in the healthcare field. Secondly, they proposed the k-healthcare model for patients' e-health. The proposed method uses four layers, such as network layer, sensor layer, service layer, and internet layer. All these layers were efficiently co-operated to offers a new platform for accessing the patient’s health-related data by using mobile phones.

(Vashistha, Dangi, et al. 2018) proposed the Futuristic biosensors for cardiac healthcare. In modern biomedical applications, biosensor based devices were used for cardiac healthcare. The artificial intelligence was utilized for cardiac monitoring under biosensors to POC (point of care) diagnostics. This paper proposed the machine learning method for futuristic bio-sensors based on IoT, computational techniques for real-time health surveillance. This study discussed cardiac biosensors with technical schemes along with their applications in healthcare. The pseudo-touch-based biosensor technique was used for disease diagnosis.

(Knickerbocker, Budd, et al. 2018) provides the various integration technology (HIT) for improving future healthcare, AI computing solutions, and IoT. This study describes the new technologies and tools of HIT and the process for diagnostic tools and sensors. The technologies were used to achieve the focused applications in sensor monitoring and healthcare diagnostics for minor product size and minimum cost. Some of the presented technologies were defines as precision micro-component, injection modeled soldier, micro-fluidic systems, and flexible multi-channel. It explains the advantages and key challenges of these technologies for various applications.

(Soumya and Kumar 2019) provides details about healthcare monitoring using IoT. In India, death caused by many diseases, and some diseases can be curable. When the problem is identified earlier, the chance of death can be reduced. For example, heart attack patients could not analyze their situation. To analyze that, this paper proposed a healthcare monitoring system, and it tracks the location of the patient and their health conditions. This healthcare monitoring system was the most important for identifies the patient's physiological parameters. In smart healthcare systems, the WSN, Ultra high frequency, Radio frequency identification, smart mobile, and GSM technologies were used for implementation. It collects real-time data for the monitoring system. They also estimate the parameters and patient’s psychological conditions with the assistance of ultra-low-power HSN, RFID, and UHF functionalities.

(Ukil, Bandyoapdhyay, et al. 2016) explained the importance of anomaly detection in IoT healthcare analytics. Healthcare data analyzing was the most important for monitoring patient health. This paper describes the proactive healthcare analytics for preventing cardiac disease. Also, anomaly detection is essential in healthcare analytics. The main goal of this research was to maximize early disease detection, minimize the diagnosis error, and better prognosis. It determines the cost-sensitive learning, multiclass logistic regression, and reinforcement learning.

(Gondalia, Dixit, et al. 2018)explained about war soldiers' healthcare monitoring system in IoT with the technique of machine learning. This research was developed to track or analyze the location and screen soldier’s health who had lost and got damaged in the real-time battlefield. The advantage was that it reduces time, detects and saves operation labors of an army control unit. It allowed the army control unit to track the soldiers' location and monitor soldier health by utilizing a GPS module and WSN area named temperature, heartbeat sensor, and so on. The sensor data and GPS receiver would be transferred by utilizing the ZigBee module between other soldiers wirelessly. The disadvantage was that the global system for mobile communication would not be helpful due to certain factors such as network connectivity at a greater elevation, weather, and environmental condition across the soldier unit integrated with extensive rangeability. At the time of war rescue operations, it could be utilized for military forces without providing any network limitation integrated with ZigBee and LoRaWAN system. A composed data would be charged on the cloud for data prediction analysis by utilizing a K-means clustering algorithm. Finally, the selection of a squadron leader could be utilized a suitable and effective cluster-head selection algorithm for further process.

(Sood and Mahajan 2018) explicated about IoT-fog based healthcare control hypertension attack framework. This study was developed to forecast continuous monitoring and statistics of blood pressure analysis for hypertensive users. Hypertension stages got detected using user-health parameters that were composed by utilizing IoT sensors at the Fog layer. The objective of this research was to produce emergency alerts of blood pressure fluctuation through smartphones using Fog. The advantage was that the user would be able to forecast and avoid hypertension risk at an early stage. The disadvantage was that if the blood pressure was high, then the specific symptoms such as severe headache, chest pain, disorientation, and irregular heartbeat could have occurred. Temporal information of the healthcare system could be produced from a fog layer to deliver precautionary suggestions for patients within a specified period. At last, the proposed research result achieves bandwidth efficacy, minimal delay, and high accuracy in response time than existing systems an also, the privacy data among several layers could be produced in the proposed system for further process.

(Putta, Abuhussein, et al.)elucidated about security benchmarks for wearable medical things using stakeholders centric method. This research was analyzed to enhance security for the internet of medical things wearables. The main objective was to reassure the recovered rivalry between manufacturers of the internet of medical things wearables. The advantage was that security and privacy devices could be enumerated more easily. The disadvantage was that users required to select an appropriate internet of medical things wearable devices within the stipulated amount of time. Internet of medical things (IomT) wearable was internet-connected electronic devices, and it could be worn onto the body to enhances the medical treatment quality for different patients. Finally, the proposed process would be utilized to guide users regarding conflict of interest systematically in decision making.

(Albahri, Albahri, et al. 2019) explained about a fault-tolerant m-health framework in IoT based wearable health data sensors. This research was developed to solve different healthcare problems regarding frequent failures that happened in telemedicine architecture over IoT solutions, specifically at wearable body sensors. The advantage was that a three-level triage method was utilized to detect compatible healthcare service packages for chronic heart disease patients effectively. The disadvantage was that users needed to classify available healthcare services for designated packages within a specific period under deliberation time of arrival patient at the hospital to reach a final decision using medical center failure. From this study, a medical dataset had been collected from 572 patients with chronic heart disease were compatible packages could be estimated by utilizing the three-level localization triage algorithm. Depend on crossover among healthcare service package, the hospital was prioritized by utilizing multi-criteria decision making to evaluate less power consumption in the analytic hierarchy process. Both mean and the standard deviation was performed to check similar authentication in systematic ranking outcomes. Finally, an analytic hierarchy process renowned among users to resolve hospital selection problems within m-health.

(Al-Makhadmeh and Tolba 2019) explicated about a classification approach utilizing IoT based wearable medical device for early diagnosis using the technique of higher-order Boltzmann model. This research was developed to transfer information about a patient within the health care center. The main objective was to improve the heart disease recognition rate by utilizing huge data in IoT wearable devices. The advantage was that the time complexity got reduced while the diagnosis of heart disease for different patients was analyzed. The disadvantage was that both higher-order Boltzmann DNN and IoT based analysis required to reduce the complexity of diagnosing heart disease within a particular time. Finally, an improved IoT-based medical disease diagnostic method could be analyzed by utilizing optimized and efficient feature selection procedures to cope database and explain the progression stage of heart disease in the future.

(Parthasarathy and Vivekanandan 2018) explicated about a typical IoT based architecture in arthritis disease monitoring by using the time wrapping algorithm. This research was analyzed to identify the beginning time of joint pain illness. The advantage was that the recommended IoT-based method could be interrelated with original distributed computing in very effectively and its develop adaptability and accessibility in IoT medical care system to monitor regular arthritis disease. The disadvantage was that the human movement acknowledgment was required to differentiate arthritis infection within a specific amount of time. Finally, the practical importance of hub choice calculation could be separated to choose the better portable emergency vehicle for further process.

(Catherwood, Steele, et al. 2018) explained about a community-based IoT with a wireless healthcare solution trail. This research was developed to transfer and diagnose healthcare to secure cloud servers in remote areas for each case. The advantage was that the automated analysis of strips provides a proper orientation based on lighting conditions within the users. A LoRa method enabled data to be received under power stages as signals in the background noise got lost in the IoT network. The main objective was to represent an advanced IoT-POC bio-fluid analyzer in the IoT field. Finally, an IomT network could be recognized deployment of identical IoT for further process.

(Sood and Mahajan 2017) elucidated about wearable IoT sensor-based healthcare system for detecting and controlling the chikungunya virus. This research was developed to detect and manage an eruption of the chikungunya virus. The advantage was that minimum latency, less response time, higher mobility, improved service quality, and location awareness at network end. The disadvantage was that the user required to prevent the chikungunya virus within a particular period. The main aim of the fuzzy c-means method was to diagnose probably infected users and produce emergency alerts directly from fog computing. Finally, a real-time generation was computed to attain a high service quality process in the future.

(Thibaud, Chi, et al. 2018) explicated a comprehensive review of IoT for health and safety in a high-risk environment. This research was developed to deliver a better solution because the user could perform fine granular levels and also deliver rich level data. The advantage was that the IoT user provides an ability to gather information from the environment through sensors. The disadvantage was that the user required to communicate internet standards within a specified time as the working environment of health safety was highly dynamic concerning the process, labor, and equipment management. The main objective was to represent characteristics of IoT based applications through high-risk environment health safety industries. Lastly, research challenges and likely trends for IoT industries could be represented for future processes.

(Xu and Pombo 2019)explained about the prediction of human behavior through non-invasive and privacy-preserving IoT assisted monitoring. This research was implemented to safeguard privacy between users in the IoT network. The advantage was that complex security protocols could be employed to protect better security for corresponding parameters such as sensing, storage, and data transmission. The disadvantage was that the user found it difficult to protect high-security data within a particular period. One of the most effective methods in the IoT domain was ambient assistant living. The main objective was to enhance users' observed privacy and prevent data exposure issues. Finally, data could be gathered and transferred into the IoT network for further process to sense data with less productivity.

(Yasin, Tekeste, et al. 2017)explained about ultra-low power secure IoT platform for predicting cardiovascular diseases. This research was developed to deliver less power consumption through electrocardiogram processor signals. The advantage was that a less-powered wireless transceiver could be encompassed to transfer biomedical signals in the IoT network effectively. The disadvantage was that the user required to study a complete solution to offer a secured energy-efficient product in the IoT network. The main aim was to extract the electrocardiogram processor chips to permit protection communication channels between users in wearable systems. Finally, a multi-layered electrocardiogram processor could be implemented from an alternative resource in the biomedical system for further process.

4. CHALLENGES OF IOT IN HEALTHCARE

The healthcare IoT contains various applications, and it allows us to determine the deep connections (Patrono, Atzori, et al. 2019). However, we face some critical issues such as,

- Data security and privacy
- Data overload and accuracy
- Product cost
- Sensor design and signal conditioning

Security and privacy are essential issues of healthcare IoT. Cybercriminals can access the patient's data to create fake IDs to buy medical equipment and drugs. (Sharma, Garg, et al. 2019) Explained the smart e-health with IoT trends, challenges, and solutions. It defines the organization of issues due to IoT problems.

(Farahani, Firouzi, et al. 2018) Explained about challenges and promises of IoT in medicine and healthcare towards fog-driven IoT eHealth. This research was developed to represent the general architecture of the IoT health ecosystem. The advantage was that the IoT eHealth user could be realized easily to deliver better performance over smartphone applications. The challenges were that the patient-centric IoT eHealth Ecosystem required to provide a multi-layer architecture such as fog computing devices and cloud to authorize handling complex data using variety, latency, and speed. Healthcare became very difficult to cope with IoT because of insufficient and less efficient healthcare services to meet enhancing aging population demands along with chronic diseases. To overcome challenges, a clinic to patient-centric transition treatment could be implemented for each agent such that patients could be integrated with a hospital. The main aim was to produce a better service layer in the IoT field. Finally, the challenges of health could be employed to provide data management, scalability, and security process in the future.

(Hassan, Hu et al. 2018)This study proposed the challenges and the way for a kinetic-powered wearable to promote the use of KEH technology in human activities. This study has added advantages to other kinetic energy harvesting solutions, which was successfully implemented in IOTs. It generates a little amount of energy for useful wearables. Although that is existing is inferior for classifying human activity. It proved to be an accurate sensing device. Finally, summarizing table 1 indicating exciting existing literatures are given below.

Table 1: Study on different existing approaches

S.No	Author / Journal	Technique	Description	Advantages / Disadvantages
1.	(Ullah, Shah, et al. 2016)	k-healthcare with four layers	The proposed model uses four segments, such as the network layer, sensor layer, service layer, and internet layer. All these layers were efficiently co-operated to provide a new platform to access the patient's health-related data by using mobile phones.	* The proposed method allows us to access the relevant data directly from sensors and automatically process these data. * It doesn't comprise any privacy and security issues of proposed k-healthcare.
2.	(Vashistha, Dangi, et al. 2018) (Springer)	Futuristic biosensors for cardiac healthcare	The proposed machine learning method for futuristic bio-sensors based on IoT, computational techniques for real-time health monitoring. This study discussed cardiac biosensors with technical strategies, along with their applications in healthcare. The pseudo-touch-based biosensor was used for disease diagnostics.	* AI with biosensors used to prevent medical malpractice upon exceeding its proof limitations and shorting high efficiency.
3.	(Knickerbocker, Budd, et al. 2018)	Heterogeneous Integration Technology (HIT)	It described the various technologies, such as precision micro-component, injection modeled soldier, micro-fluidic systems, and flexible multi-channel. These technologies were used to achieve the targeted applications in sensor monitoring and healthcare diagnostics for smaller product size and minimum cost.	* HIT was used to create high-performance micro-systems for future healthcare solutions. * The disadvantage of this study is, it doesn't expand with intellectual property technology platforms
4.	(Soumya and Kumar 2019)	Ultra-high frequency, Radio frequency identification, smart mobile, and GSM	The healthcare monitoring system was the most important for identifies the patient's physiological parameters. They also estimate the environmental parameters and patients' psychological conditions with the assistance of ultra-low-power HSN, RFID, and UHF functionalities.	* Healthcare monitoring system monitors the patient's health at all times and in emergency conditions.
5.	(Ukil, Bandyoapdhyay, et al. 2016)	Proactive healthcare analytics	It contains the importance of anomaly detection in IoT healthcare analytics. It determines the cost-sensitive learning, multiclass logistic regression, and reinforcement learning.	* Advantage is to maximize the early disease detection, minimize the diagnosis error, and better prognosis.
6.	(Albahri, Albahri, et al. 2019)	Fault-tolerant m-health framework	It was developed to solve different healthcare problems regarding frequent failures happened in telemedicine architecture over IoT solutions specifically at wearable body sensors and medical center server. The medical dataset had been collected from 572 patients with chronic heart disease were compatible	* The advantage was that a three-level triage method was used to detect compatible healthcare service packages for chronic heart disease patients effectively.

			packages could be estimated by utilizing three-level localization triage algorithm	
7.	(Al-Makhadmeh and Tolba 2019)	Classification approach	It defines the classification approach for heart disease prediction using a higher-order Boltzmann model. The main objective was to improve the heart disease recognition rate by utilizing massive data in IoT wearable devices.	* Minimum time complexity while the diagnosis of heart disease for different patients was analyzed. * The disadvantage was that both higher-order Boltzmann deep belief neural network and IoT based analysis required to reduce the complexity of diagnosing heart disease within a particular time.
8.	(Catherwood, Steele, et al. 2018)	Community-based IoT	It explains a community-based IoT in personalized wireless healthcare solution trail. The main objective was to represent an advanced internet of things point of care bio-fluid analyzer in the IoT field.	* The advantage was that automated analysis of strips provides an accurate orientation under defined lighting conditions within the users.
9.	(Ahad, Tahir, et al. 2019)	5G based smart health care network	It presents with architecture for 5G smart healthcare and various techniques such as small cells, D2D communication, SDN, and edge computing. Then they describe the taxonomy of 5G smart healthcare.	* Proposed network layer solutions include routing, scheduling, and congestion control for IoT based 5G smart healthcare.
10	(Parthasarathy and Vivekanandan 2018)	Time wrapping algorithm	It explains IoT architecture for arthritis disease monitoring with using of a time wrapping algorithm. This research was analyzed to identify the beginning time of joint pain illness.	* The recommended IoT-based method could be interrelated with original distributed computing to achieve the high efficiency. * The disadvantage was that the human movement acknowledgment was required to differentiate arthritis infection within a specific amount of time

5. CONCLUSION

This paper surveys various aspects of IoT-based healthcare technologies and defines diverse healthcare network architectures. Different machine learning methods were used to handle the IoT data in the healthcare field. It provides detailed research activities concerning how the IoT can address healthcare monitoring, early diagnosis, and data analysis. For better understanding, the paper considers IoT healthcare security, various challenges, and issues. The results of this survey are expected to be most useful for researchers, health professionals, and engineers, working in the area of the IoT and healthcare technologies.

REFERENCES

1. Ahad, A. et al. (2019). "5G-Based Smart Healthcare Network: Architecture, Taxonomy, Challenges, and Future Research Directions." IEEE Access 7: 100747-100762. https://doi.org/10.1109/ACCESS.2019.2930628
2. Akrivopoulos, O., et al. (2017). On the deployment of healthcare applications over fog computing infrastructure. 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC), IEEE.
3. Al-Fuqaha, A. et al. (2015). "Internet of things: A survey on enabling technologies, protocols, and applications." IEEE communications surveys & tutorials 17(4): 2347-2376.
4. Al-Makhadmeh, Z. and A. Tolba (2019). "Utilizing IoT wearable medical device for heart disease prediction using higher order Boltzmann model: A classification approach." Measurement 147: 106815. https://doi.org/10.1016/j.measurement.2019.07.043

5. Alabdulatif, A., et al. (2019). "Secure Edge of Things for Smart Healthcare Surveillance Framework." IEEE Access 7: 31010-31021.
6. Alansari, Z., et al. (2018). The rise of Internet of Things (IoT) in big healthcare data: review and open research issues. Progress in Advanced Computing and Intelligent Engineering, Springer: 675-685.
7. Albahri, O., et al. (2019). "Fault-tolerant mHealth framework in the context of IoT-based real-time wearable health data sensors." IEEE access 7: 50052-50080.
8. Catherwood, P. A., et al. (2018). "A community-based IoT personalized wireless healthcare solution trial." IEEE journal of translational engineering in health and medicine 6: 1-13.
9. Farahani, B., et al. (2018). "Towards fog-driven IoT eHealth: Promises and challenges of IoT in medicine and healthcare." Future Generation Computer Systems 78: 659-676.
10. Gondalia, A., et al. (2018). "IoT-based Healthcare Monitoring System for War Soldiers using Machine Learning." Procedia Computer Science 133: 1005-1013.
11. Hassan, M., et al. (2018). "Kinetic-powered wearable iot for healthcare: Challenges and opportunities." IEEE Comput.
12. Knickerbocker, J., et al. (2018). Heterogeneous integration technology demonstrations for future healthcare, IoT, and AI computing solutions. 2018 IEEE 68th Electronic Components and Technology Conference (ECTC), IEEE.
13. Lloret, J., et al. (2016). "An integrated IoT architecture for smart metering." IEEE Communications Magazine 54(12): 50-57.
14. Mohapatra, S., et al. (2018). "From a literature review to a conceptual framework for affordable quality healthcare service using internet of things (IOT) network." International Journal of Enterprise Network Management 9(1): 11-21.
15. Parthasarathy, P. and S. Vivekanandan (2018). "A typical IoT architecture-based regular monitoring of arthritis disease using time wrapping algorithm." International Journal of Computers and Applications: 1-11.
16. Patrono, L., et al. (2019). Challenges to be addressed to realize Internet of Things solutions for smart environments, Elsevier.
17. Putta, S. R., et al. "Security Benchmarks for Wearable Medical Things: Stakeholders-Centric Approach."
18. Rodrigues, J. J., et al. (2018). "Enabling technologies for the internet of health things." IEEE Access 6: 13129-13141.
19. Sharma, L., et al. (2019). "Smart E-Healthcare with Internet of Things: Current Trends, Challenges, Solutions, and Technologies." From Visual Surveillance to Internet of Things: Technology and Applications: 215.
20. Sood, S. K. and I. Mahajan (2017). "Wearable IoT sensor based healthcare system for identifying and controlling chikungunya virus." Computers in Industry 91: 33-44.
21. Sood, S. K. and I. Mahajan (2018). "IoT-Fog-Based Healthcare Framework to Identify and Control Hypertension Attack." IEEE Internet of Things Journal 6(2): 1920-1927.
22. Soumya, S. and S. Kumar (2019). Healthcare Monitoring Using Internet of Things. First International Conference on Artificial Intelligence and Cognitive Computing, Springer.
23. Thibaud, M., et al. (2018). "Internet of Things (IoT) in high-risk Environment, Health and Safety (EHS) industries: A comprehensive review." Decision Support Systems 108: 79-95.
24. Tiwary, A., et al. (2018). "Internet of Things (IoT): Research, architectures and applications." International Journal on Future Revolution in Computer Science & Communication Engineering 4(3): 23-27.
25. Ukil, A., et al. (2016). IoT healthcare analytics: The importance of anomaly detection. 2016 IEEE 30th International Conference on Advanced Information Networking and Applications (AINA), IEEE.
26. Ullah, K., et al. (2016). Effective ways to use Internet of Things in the field of medical and smart health care. 2016 International Conference on Intelligent Systems Engineering (ICISE), IEEE.
27. Vashistha, R., et al. (2018). "Futuristic biosensors for cardiac health care: an artificial intelligence approach." 3 Biotech 8(8): 358.
28. Xu, L. and N. Pombo (2019). Human Behavior Prediction Though Noninvasive and Privacy-Preserving Internet of Things (IoT) Assisted Monitoring. 2019 IEEE 5th World Forum on Internet of Things (WF-IoT), IEEE.
29. Yasin, M., et al. (2017). "Ultra-low power, secure IoT platform for predicting cardiovascular diseases." IEEE Transactions on Circuits and Systems I: Regular Papers 64(9): 2624-2637.
30. Zhou, J., et al. (2019). "AAIoT: Accelerating artificial intelligence in IoT systems." IEEE Wireless Communications Letters.