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Review Article

Parallel Computing for Efficient and Intelligent Industrial Internet of Health Things: An Overview

Xin Yang[1], **Shah Nazir**[2], **Habib Ullah Khan**[3], **Muhammad Shafiq**[4], **and Neelam Mukhtar**[5]

[1]*Taizhou Vocational College of Science & Technology, Taizhou 318020, ZheJiang, China*
[2]*Department of Computer Science, University of Swabi, Anbar, Pakistan*
[3]*Department of Accounting & Information Systems, College of Business & Economics, Qatar University, Doha, Qatar*
[4]*Cyberspace Institute of Advance Technology, Guangzhou University, Guangzhou, China*
[5]*College of Home Economics, University of Peshawar, Peshawar, Pakistan*

Correspondence should be addressed to Xin Yang; yx726@tzvcst.edu.cn and Shah Nazir; snshahnzr@gmail.com

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Internet of Things (IoT) is expanding and evolves into all aspects of the society. Research and developments in the field of IoT have shown the possibility of producing huge volume of data and computation among different devices of the IoT. The data collected from IoT devices are transferred to a central server which can further be retrieved and accessed by the service providers for analyzing, processing, and using. Industrial Internet of Health Things (IIoHT) is the expansion of the Internet of Health Things (IoHT) which plays an important role in observing, consulting, monitoring, and treatment process of remote exchange data processes. The linkage of computation and interoperability are supported through various intelligent sensors, controllers, and actuators. The role of parallel computing for efficient and Intelligent Industrial Internet of Health Things is obvious to analyze and process different healthcare situations. A detailed overview of this existing literature is needed through which the research community will provide new solutions for efficient healthcare with the help of IoT based on parallel computing. Therefore, the current study presents a detailed overview of the existing literature for facilitating IIoHT.

1. Introduction

The IoT plays a significant role in the society and has made life easy through connecting different devices for smooth communication. The key aims of the IoT based services for healthcare is to bring a rich user understanding at small effort and cost and increase the quality of communication in life [1]. IoT brings connectivity of the network and their devices to provide effectiveness, reliability, and smart digital services to aged and weak patients having any disease. Most of the healthcare systems are integrated with the use of smart devices like smart sensors, remote server, and network of devices for connectivity. The mobile computing supports the services of IoT with the help of mobile applications through the M-healthcare system. These mobile services are used to facilitate healthcare and provide effective and efficient solutions. The mobile healthcare integrates the IoT by providing different services like IP connectivity, compactness, and security and consuming of low power [2]. In the recent years, diverse mobile applications are developed to deliver different services in healthcare based on mobile computing.

With the passage of time, the advances in the field of IoT are rising, and different researchers came across diverse ideas. Kinkorová and Topolčan [3] elaborated the key Horizon 2020 of the projects of financing systems, biobanking, and forthcoming perspectives. Davarzani [4] presents a study of the analysis on 499 elderly patients with congestive heart failure. The study described that the ages were larger than or equal to 60 years. The samples of the study were collected after continued follow-up for 19 months in the clinic. The connection between commonly measurement of

biomarker and treatment effects of loop diuretics, spironolactone, β-blockers, and renin-angiotensin system inhibitors on risk of HF hospitalization was determined in the generation of hypothesis. Golubnitschaja et al. [5] determined diverse issues related to the services of healthcare pandemic with the expansion of recently noncommunicable diseases, lack of specialized education, poor healthcare, and ethical features of treatment, along with inadequate communication of policymakers.

With the distinguishing nature of healthcare, parallel computing of different devices has made it unique from other types of communication. Due to the integration of costly components of hardware, the patient individual and uneasiness makes the devices further expensive. Numerous applications of IoT devices are present in healthcare, disease, and clinical decision support. Researchers face many problems in extracting the enhanced information from the IoT devices in healthcare and applying it in the detection of diseases and treatment.

The existing literature has reported diverse approaches for minimizing the time consumption, cost care, quality of care, and prudence of healthcare facilities at door steps, but no comprehensive study of the current literature in healthcare based parallel computing for efficient IIoHT is reported. Therefore, the current study presents a comprehensive analysis of the existing IoT in healthcare with parallel computing. This study will help the researchers to present novel solutions and is considered as evidence of the literature.

The organization of the paper is as follows: Section 2 describes an overview of the IoT and mobile computing in healthcare. Section 3 gives detail of approaches for facilitating the IoHT. Section 4 presents a comprehensive detail of the big data and IoT in healthcare. The paper is concluded in Section 5.

2. An Overview of the IoT and Mobile Computing in Healthcare

Several approaches have been presented by researchers for healthcare based on the IoT. The IoT devices are interconnected with each other for the smooth communication of devices for human needs. IoT has the applications of using mobile computing and has stayed with substantial role. An interface is provided with the help of mobile application for the data collected from different wearable devices and sensors. Such data are used for different analysis and many other purposes. Mobile app with the use of personalized healthcare system has massive applications in healthcare where the devices are connected through different gyroscopes, accelerometer, altimeter, and other reduced cost device which are portable. With the growth of wearable devices, mobile applications, and its commercial use, the idea of the IoT-based personalized healthcare system becomes more widespread. Such systems in healthcare are linked with each other for creating IoT network to perform different activities like surgeries at distance, monitoring, and identifying disease [6]. The use of mobile computing based on IoT in healthcare provides massive services through interface of mobile phones, apps, or through M-healthcare system. IoT devices are linked to the M-healthcare systems for contributing to the IoT for providing different services such as IP connectivity, consumptions of less power, security, and compactness [2]. Now-a-days, diverse mobile apps are developed for providing services to the users in healthcare system. These applications empower the patients to identify the disease based on the analysis in the field of paediatrics and gynaecology [7].

The idea of smart healthcare arose with the use of mobile computing in the IoT. The services of smart healthcare are linked to the wireless technologies with low power for building the IoT and the concept is called "Smart Health IoT." The history of the patient is monitored through the interface by which the patient is connected to the smart healthcare IoT. Such history shows the patient status either the patient is in move or in home environment. This connection is made through vital-sign sensors linked to the mobile phones. The smart healthcare IoT is useful in situation where the patient required constant care and monitoring for facilitating the services like patient disabilities, aged people living alone, patients with heart attack, patients of blood pressure, and stress patients. The patient location can also be traced with the help of GPS coordinates if any emergency occurs. The smart healthcare IoT provides the services of enhanced care at low cost and better treatment [8]. Several other approaches are available for facilitating healthcare based on the IoT [9–11]. Figure 1 represents the IoT architecture of healthcare system. In this figure, the IoT applications are connected with various IoT devices, users, communication systems, health, security mechanism, and others.

3. Approaches for Facilitating IIoHT

Diverse approaches have been used by different researchers to facilitate healthcare with the support of the IoT devices. These devices are integrated for smooth and efficient running of the activities of healthcare. Parallel computing plays a significant role to efficiently run activities of healthcare. The approaches of IoT use deal different perspectives of the healthcare. Different healthcare documents are used globally. The healthcare companies face numerous issues in its conception and analysis at a large scale. For its semantic transformation and to overcome the problem, Hadoop based approach is adopted and presented clinical architecture standard documents for the case studies [12]. Big data mining has its own role in extracting important information from the big data in order to use it in healthcare for facilitating patients care and to provide better care and treatment. The nature of healthcare data is different such as analytics of heterogeneous and complex data spaces, sensitive data, nontextual information, distributed data, data with constraints of security and performances, analytics to assimilate information of bioinformatics based on clinical interpretations at organ, tissues, and organisms scale to define "physiological envelope" through the patient life [13]. The role of social media is obvious in collecting data about diverse issues of patient in healthcare, with the easy access of

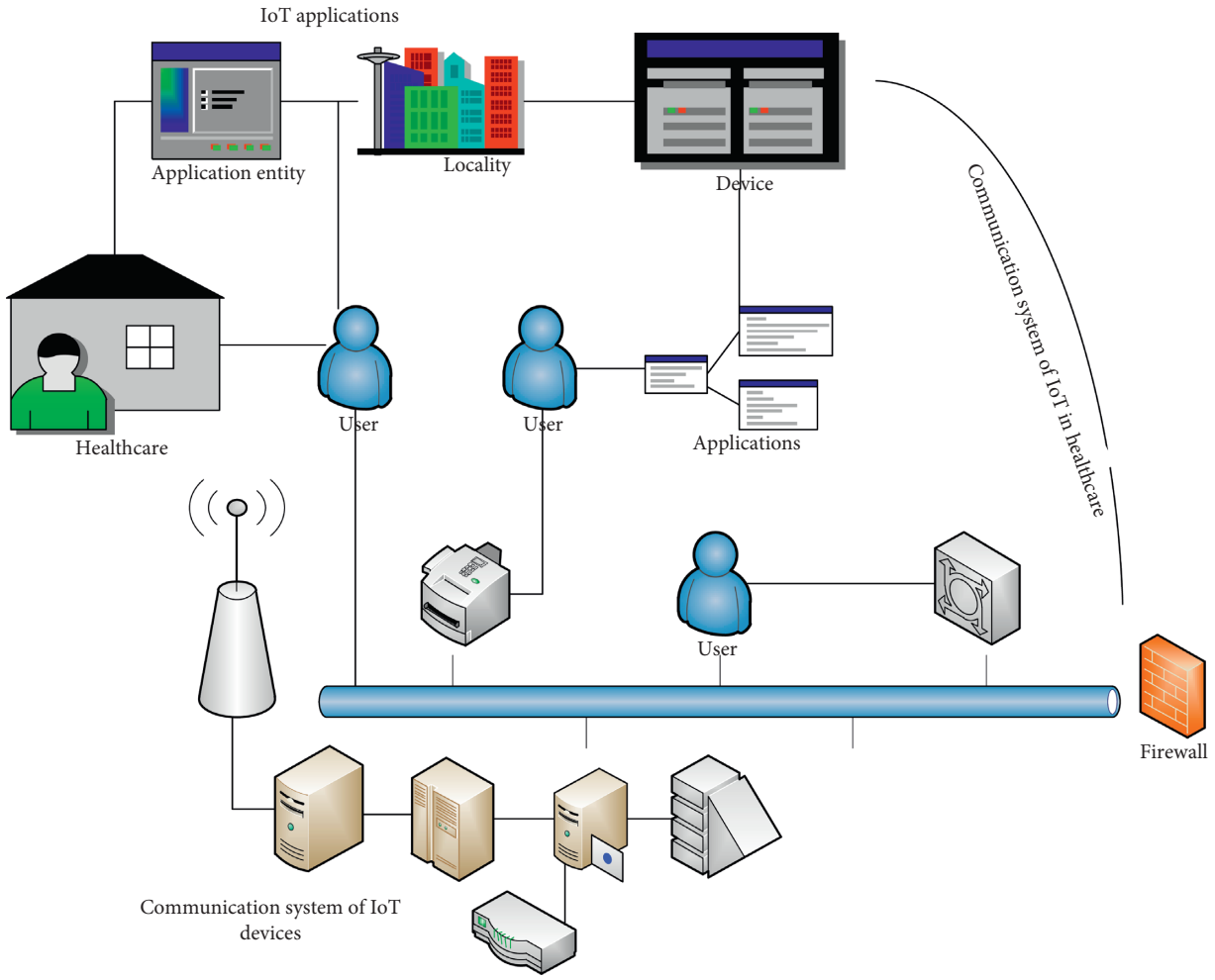

Figure 1: IoT-based architecture of the healthcare system.

social media to all of its users without any disruption compared to the standing in long queue at conventional station of healthcare. With the help of Facebook application, more than 1400 users were engaged for collecting data of their adherence to Mediterranean diet, with cardiovascular risk and neurological degenerative diseases with low adherence to a healthy diet. The data were gathered in less amount of time without delay [14]. A summary of these approaches from the existing literature is analyzed and shown in Figure 2.

4. Research in the Area of Healthcare Based on Big Data and IoT

Huge bulk of data is produced from different electronic devices on daily basis. These devices include imaging, technologies of sensors, electronic health report, and many others. Extracting meaningful information from these devices is a tricky job. Researchers try to come across diverse approaches to handle such data and extract meaningful information. More focus is given to the concept of cloud computing and their services for acting as a benchmark to demonstrate big data for discovering hidden patterns of improving knowledge for expansion of disease [57]. Complex medical information exists in the electronic medical record which is hard to analyze and access in the future use. Annotated conversion of data is required for accessing and use of the data. Xu et al. [58] proposed a model for the conversion of data of electronic medical records to annotated styles without disturbing the data semantics. Phrase sense disambiguation is applied for achieving high accuracy. Table 1 shows the research in the area of healthcare based on big data.

In the organization, most of the data are produced from the devices of IoT, imaging, and many other health reports. The study [72] proposed an ICT-based bioinspired application to provide a smart healthier system the patient and caretaker. The authors discussed the fundamentals and possibilities of data science [73] and the issues and the requirements of the techniques of data science in the field of healthcare for making it green and to proposer. On the basis of statistical data analysis techniques, the Alzheimer's disease detection is made based on the chronic nervous system upon big data. The big data is converted into smart data for effective management and processing [74]. A three-tier architecture for the management of big data through SOA-FOG was presented. The research gives security information based on the client layer, cloud layer, and fog layer [75]. The

Figure 2: Approaches for facilitating IIoHT [2, 7, 8, 15–56].

Table 1: Research in the area of healthcare based on big data.

Citation	Technique
[59]	Model of wearable sensors
[60]	Machine learning techniques for bioinformatics
[61]	Multimedia based mobile health application
[62]	Hybrid model
[63]	Unsupervised machine learning techniques
[64]	MF-R and GC architectures
[65]	Distributing and self-organizing algorithm
[66]	Fog-Cloud based architecture
[67]	Policy development toolkit
[68]	Adaptive clinical decision support system
[69]	Model of cognitive data transmissions
[70]	Multiobjective programming and prospect theory
[71]	BrownBoost Classifier

study presented a comprehensive report of the industry 4.0 for addressing the challenges in the existing mHealth system and then provided a mobile smart health system known as mHealth 4.0 for providing effective solution based on big data for healthcare [76]. The study presented an approach which focuses on designing a new storage architecture which has the ability of providing ease in read, update, or write function opposing the conventional models of databases. For retrieving data from user and storing purpose, the mechanism of application was used [77]. With the use of wearable devices and technological age, big data is produced in the shape of smart healthcare, transportation, smart cities, and so on. Analyzing such huge bulk of data, its processing, and storage is critical task and is becoming a challenging issue for the researchers. Apache HBase and Apache Pig are the databases which provide primary opening for the researchers to save their records for forthcoming determinations [78]. The authors presented an intelligent hospital appointment system in which the patient takes the doctor appointment according to their knowledge through healthcare big data. It was a solution to overcome the existing conventional patient and doctor appointment. The system is confirmed by the universal first-come-first-serve method [70]. Table 2 shows the applications and approaches used in healthcare.

Table 2: Applications of approaches used in the healthcare.

Reference	Technique	Description	Year	Type
[79]	Health risk assessment of patient and models of stratification	The study offers a comprehensive review of diverse applications of eHealth and delivers the model of assessing patient health risk and stratification.	2017	Journal
[80]	R-programming	The study presented R-programming tool for the analytics of big data and used the features of blood sugar, Glasgow coma rate, pulse rate, respiratory rate, and CNS. With the help of R- programming tools statistical and visual tool, the classification model is developed.	2017	Conference
[81]	EVOTION	The aims are to offer a hybrid solution for the patients of hearing loss. A holistic management to the patients of hearing loss is provided with the policies of public health and prevent patients from disease in the future.	2017	Conference
[82]	DocDx	The study used formal methods for developing the framework of medical care. The framework consists no programming phase. Sum up the intelligence of the medical; they rehabilitated the pathways of medical to multipartite the directed weighted graph. The autonomous interpreters in the server offer natural language generator pathophysiology questions a doctor would usually ask a patient to know the disease symptoms and signs.	2018	Conference
[83]	Apache Spark	The study presents the data processing engine (Apache Spark) positioned in cloud mostly emphasising on employing techniques of machine learning for identifying status of health of patient's according to the tweets.	2018	Journal
[84]	Hadoop framework	The study presents an assessment process based on statistics for analysis of diabetic's through big data. Various measures of performance such as F-measure and accuracy values are assessed from the projected statistical evaluations through Hadoop framework.	2018	Journal
[85]	IoT	With the current overpopulous and technological age, the accessing and processing of fundamental caretakers for the purpose of treatment is a big concern for patients and specifically for the aged patients. The IoT-based applications plays an important role and provide fundamental treatment at the door steps	2019	Journal
[86]	Smart HIV/AIDS digital system	A smart HIV/AIDS digital system is developed by gathering the data from numerous sources regarding the mentioned disease. After this, apply the collected data to an explicit location for monitoring the patients of HIV/AIDS in the explicit region. The system and the data eventually support the government, researchers, doctors, patients and many others for appropriate treatments.	2019	Conference
[87]	Detecting Parkinson disease	Huge data exist in the form of big data which are produced from different devices such as from the transportation system to healthcare systems and robotics. The sensor is fixed in the affected patient of Parkinson's. The robot is planned to move with the patients based on the sensor data for communications. Artificial neural network is used for the purpose of detection	2019	Journal

Table 3: Existing research in terms of the method/approach used along with the description.

Reference	Method	Description	Year	Type
[88]	Health and Industry 4.0	The paper elaborates the following: (a) Key paradigms and technologies associated with Healthcare 4.0 (b) Applications scenarios (c) Benefits (d) Challenges (e) Derivations	2020	Journal
[89]	IoT in healthcare	The research determined the challenges associated to security and privacy of healthcare based on IoT which operated on the architecture of Fog and Cloud computing.	2019	Chapter
[90]	Wearable and implantable body sensor network	The study has concentrated the learning evaluation of the IoT parameters related with the domain of e-healthcare.	2019	Chapter

Table 3: Continued.

Reference	Method	Description	Year	Type
[91]	Data provenance and formation of trust in the IoT	The study provided solution for management of provenance-based trust to establish a mechanism for IoT device communication.	2019	Journal
[92]	Microservice-based method for enforcing IoHT-oriented architecture	The study presented RO-SmartAgeing architecture to monitor the noninvasive and assessment of elderly health. The architecture contains technologies of IoHT and cloud computing. The approach offers decision support at multilevel.	2019	Conference
[93]	Healthcare and IoT applications	A systematic literature review is presented for the IoT applications in healthcare, key technologies of IoT, cloud-based architecture characteristics, components of IoT, challenges and interoperability and security of IoT, and healthcare challenges based on IoT.	2019	Journal
[30]	HIoTSP	The IoHT service framework is implemented with people through wearable technology of sensors. The development goals were as follows: easy to use, low in cost, and pervasiveness to monitor healthcare with service integration.	2018	Journal
[94]	Model of distributed behavior orchestration in cognitive solution of IoT	The cognitive computing was applied on instrumented world and calls out the system of trends among diverse but interdependent worlds and application of dynamic data driven-system for advanced analysis, understanding, and decision abilities with full accuracy.	2018	Journal
[43]	IoHT technologies	The research presented a review of the techniques of IoT for ambient-assisting living and healthcare based on the existing literature. Advances made in field was identified, the issues and challenges were analyzed, and an approach of future trends was given.	2018	Journal
[95]	IoT-based e-health systems	The impact and concept of IoT on the growth of e-health solution and identified the key challenges of the IoT based e-health.	2017	Chapter
[96]	Health data of children through digitalized toys	The study presented a ubiquitous identification ecosystem to children care and early stimulation with growing disorder aims to investigate, design, and evaluate solution for society to detect changes in the developments of psychomotor through the natural children interaction with toys and other objects. The evaluation of ethical impacts is carried out in association with minors' data protection rights.	2018	Journal
[97]	Wearable IoT data stream traceability in a distributed health information system	The study presented an approach for rationalizing the process using wearable IoT architecture-based data streaming providing data routes of traceability from originating sources to the information systems of health. The service of extended Petri Nets were considered to overcome the complexity of mapping and comparing the data of devices to the users.	2017	Journal
[98]	Big data complex event processing for IoT provenance	The research reported the approaches for influencing the big data techniques for improvements of IoT provenance	2016	Chapter
[99]	A security- and quality-aware system architecture for IoT	The study proposed the architecture of IoT which has the ability of supporting security, privacy, and data quality guarantee.	2016	Journal
[100]	Fog-based middleware for compliance with privacy principles of OECD in IoHT	The study presented an approach of utilizing the cloud based in healthcare services for generating an accurate health insights and reserve privacy of the user health sensitive information	2016	Journal
[101]	Framework of human security through IoT, Fog, and Cloud Computing	A framework is presented for security integrating pervasive and wearable computing, fog and cloud computing, and IoT for protection of individuals	2015	Conference
[102]	IoT-based monitoring of Health system	The study reviewed the existing health monitoring systems which are based on IoT aiming advanced rises and trends in health monitoring for parameters of health and frameworks, issues of security, and wireless communication.	2015	Conference
[103]	Cooperative end-end key management for e-health based on IoT	The study proposed a key management scheme for session keys establishment of resources that are constrained for ensuring protection of security using robust authentication and encryption mechanism.	2014	Conference

Table 3: Continued.

Reference	Method	Description	Year	Type
[104]	Noncontact health monitoring based on the IoT and evidential reasoning	A method of noncontact health monitoring system based on IoT and evidential reasoning is proposed for supporting practitioners in patients' security evaluation.	2012	Conference
[105]	Architecture of community health service based on the IoT on healthcare	The study proposed community architecture of healthcare services for safeguarding medical care on real time for the elders with chronic disease and improves the quality of community hospital.	2012	Conference

Tables 3 shows the existing research in term of method/approach used along with the description.

5. Conclusions

The innovation in IoT is rising in all aspects of the life specifically with the healthcare. Research and developments in the field of IoT have the possibility of producing huge information and computation. The IoT devices communicate with each other and transfer data to a central server which can further be retrieved and accessed by the service providers for analyzing, processing, and using. The IIoHT is the extended version of the IoHT which plays an important role in observing, consulting, monitoring, and treatment process of remote exchange data processes. Parallel computing plays an important role in the efficient and intelligent IoHT. A comprehensive analysis report of this available literature is a dire need for the research community on the basis of which the researchers will provide new solutions to the efficient healthcare with the help of IoT. Therefore, the proposed study presents a comprehensive overview of the literature on supporting the IIoHT.

Data Availability

No data are available.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding this paper.

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