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The Role of IoT in COVID-19

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Abstract

The Internet has become an essential part of our daily life. It has fundamentally changed the way we live, interconnecting people at a virtual level in a variety of ways, ranging from professional life to social relationships. The next technological mega-trend of the Internet is the Internet of Things. It uses networking and ubiquitous computing to upgrade physical objects to be intelligent objects .Medical care and smart healthcare systems can be considered one of the most interesting application fields of the Internet of Things. The IoT revolution is reshaping modern healthcare systems by incorporating technological, economic, and social Prospects. It is evolving healthcare systems from conventional to more personalized healthcare systems through which patients can be diagnosed, treated, and monitored more easily. Since the end of 2019, the world has been facing the threat of COVID-19 pandemic. Controlling and managing this virus can be achieved with the aid of smart healthcare systems based on Internet of Things technology. This will also help in slowing its spread through early detection, prediction, and monitoring (tracking) of new cases. This paper surveys the most fundamental concepts of new technologies such as fog computing, cloud computing, and the role of IoT-based technologies in COVID-19. It also discusses the definition, the characteristics, the main goals, and the overall vision of smart healthcare systems.

***Keywords**: Smart healthcare system, Internet of Things, Fog computing, Cloud computing, Covid-19*

1. Introduction

Smart healthcare is an essential aspect of connected living. Healthcare is one of the main pillars of human need, and it is projected to generate several billion dollars in revenue in the near future. There are various components of smart healthcare, including Internet of Things (IoT), medical sensors, the Internet of Medical Things (IoMT), edge computing, cloud computing, artificial intelligence (AI), and next-generation wireless communication technology.

Smart healthcare refers to health systems platforms that utilize wearable appliances, IoT sensors, the mobile Internet, etc., to quickly access health documents and connect individuals, resources, and organizations. Intelligent medical care involves a number of actors, including doctors, employees, hospitals, and research institutions. It incorporates a dynamic framework with many aspects, including disease prevention and recognition, assessment and evaluation, healthcare management, medical research, and patient decision-making [51].

Smart healthcare is not only a simple technological development, but it is also an all-round and multi-level improvement. This improvement is reflected in the following: medical model differs from disease-centered to patient-centered care, information construction differs from clinical informatization to regional medical informatization, differs in medical management from general management to personalized management, and changes in the idea of prevention and treatment from focusing on disease treatment to focusing on preventive healthcare. These changes focus on accommodating the individual needs of people while at the same time enhancing the effectiveness of medical care, which significantly increases the medical and health service experience, and represent the potential advancement direction of modern medicine [1] .

2. Internet of Things

IoT is the interconnection between the physical objects or things that are attached with sensors and software to gather and deliver information among them and primary servers with least human mediation. IoT has been widely accepted in various fields, including the field of health care, smart homes, smart parking, smart city, industrial sites, smart climate, and agricultural fields as shown in Fig.1 .IoT healthcare is modern worldview that conveys the services and medical data associated indeed farther areas. The IoT system in medical is now in an advance setup that contains so many varieties of mechanism like smart sensors, medical equipment, big data, cloud computing, telemedicine, clinical information system, and many more. IoT technique is categorized into; remote monitoring of patients, remote tracking and monitoring of health, sensor based devices for hand wash monitoring, and monitoring of interactive RFID activities [2].

In healthcare field, there are many smart devices and IoT sensors that can measure some of human body's physiological parameters (e.g. blood flow, blood glucose levels, heart rate, respiration rate ,temperature ,blood pressure, muscle contraction, weight...) .The devices using various technologies and distributed software architectures for communication purposes. The technologies of IoT facilitate the healthcare progress from face-to-face consulting to telemedicine [3]. It has enhanced people's lives by assisting the physicians to track effectively the patient's medical diagnostic status. This has the main effect on people living alone and their families. Also, if there is a problem or change in a person's routine activities, an alert mechanism will send signals to concerned health providers and family members.

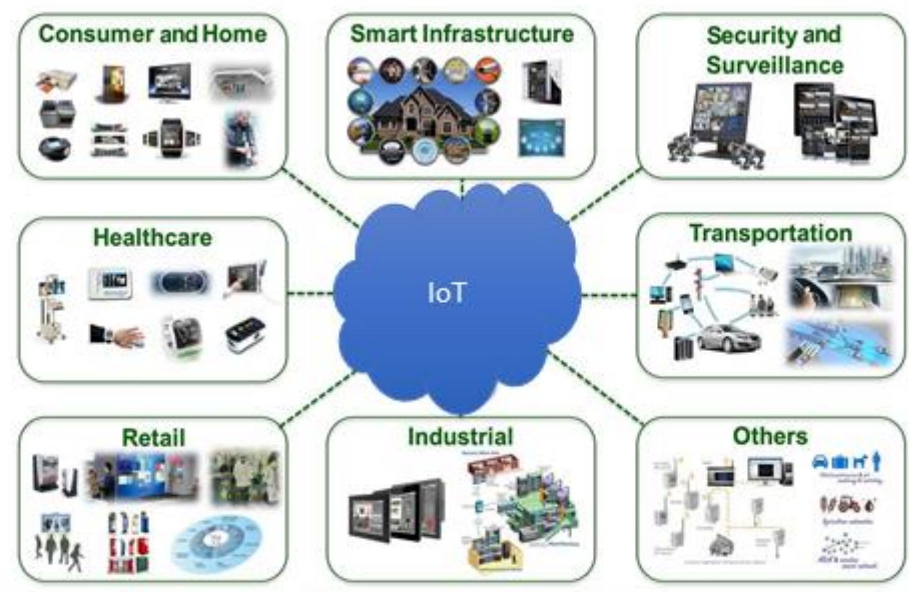

Fig.1: IoT application domains

3. Internet of Things Layers

The IoT architecture consists of four main layers that identify all the functionalities of IoT systems. These layers are: the sensing layer, network layer, middleware layer, and application layer as shown in Fig.2 [4]. The sensing layer consists of physical objects, i.e. sensors, RFID chips, wearable sensors, and other physical devices connected to the IoT network. These devices work as units for data acquisition in order to transfer it to the network layer. The network layer acts as a transmission medium to take the data from the sensing layer to the information processing system. This information can be transmitted by using different types of technologies which may be wired/wireless medium along with 3G/4G, Wi-Fi, Bluetooth etc [5]. The next level layer is known as the middleware layer. The main function of this layer is to process and analyse the information and make decisions based on the results accomplished by ubiquitous computing. Next, the application layer uses the processed information for smart application management [4].

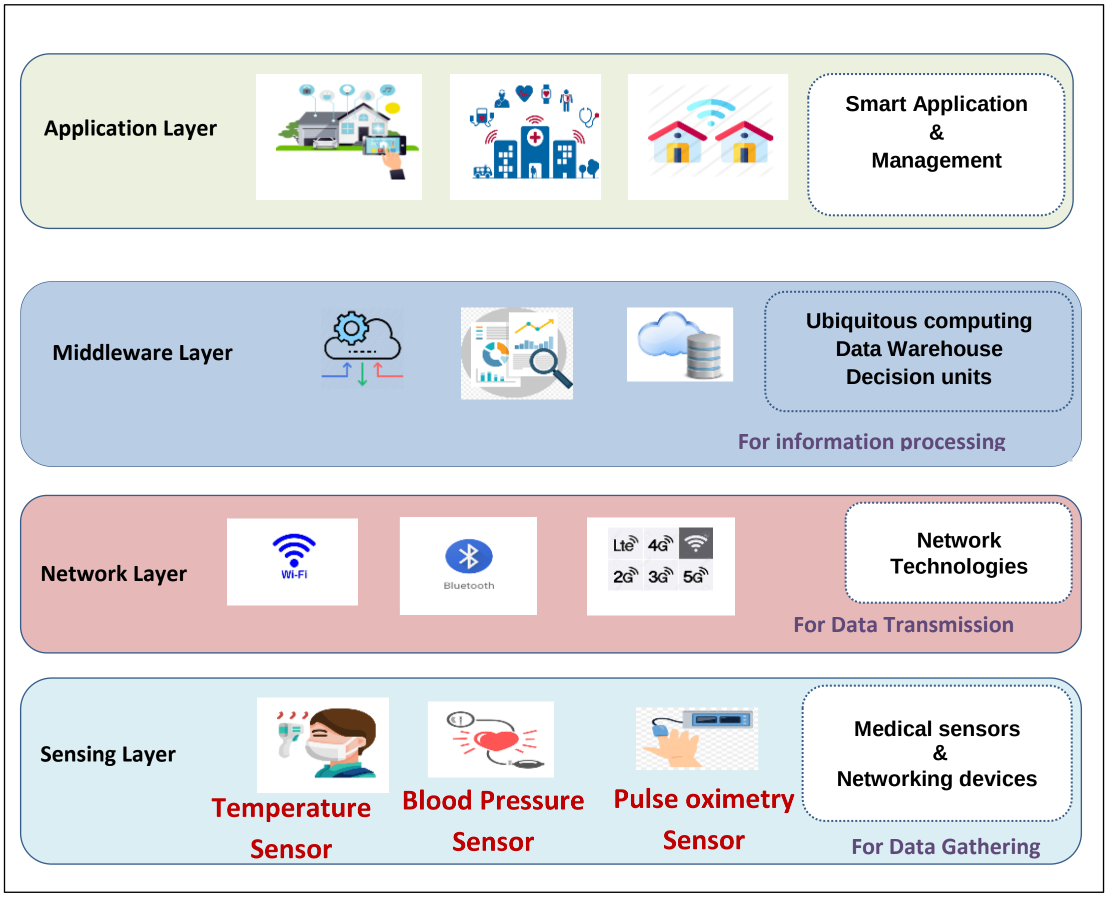

Fig. 2 :IoT Four Layers Architecture [4]

4. The Role of Cloud and Fog Computing in Healthcare

The cloud framework is distributed computing model where computing resources and services are given to end users whenever they need them from anywhere. In recent years, much research has been conducted regarding the advantages of cloud for many applications. Cloud computing can recognize the problem of scalability and the enormous increase in IoT devices. However, as the continuous data transfer and retrieval process increases, it poses much stress to the cloud and the network. In fact, if there is no appropriate bandwidth allocation, network failure, low latency, the cloud can lead to unacceptable delays causing a total failure of the smart health service. Moreover, the long distance between the cloud and the edge of the network, continuous communication or network load with the cloud, etc., leads to large energy consumption. Therefore, some alternatives to cloud computing are needed for providing the required smart healthcare services.

In 2012, a group of Cisco researchers proposed a new computing model, called fog computing, in which IoT devices can be given efficient and enhanced support by extending the computing resources of the Cloud to edge or near edge devices. Carrying out these tasks near or at the end users devices will minimize the latency since it's obvious that getting data from cloud takes far longer than getting it from the network edge itself. Similar to cloud, the fog server can also store different contents such as images, videos, audios, local information and in our case, it can be health data. The comparison between fog and cloud computing is shown in Table 1.

5. Fog Computing Architecture

Many architectures have recently been introduced for fog computing, and three-tier architecture is now considered to be the prevalent structure [6,7]. The basic fog computing architecture shown in Fig. 3 is divided into the following three main layers which are:

- Sensing layer: The sensing layer is the nearest layer to the end-users/devices. It consists of a variety of smart devices and sensors. These devices are responsible for periodically capturing the physiological information and transmitting data to the upper layer for processing and storage [6].

- Fog layer: The second layer is the fog layer which placed at the edge of the network, it consists of many of fog nodes, which commonly includes a collection of edge devices such as; routers, switches, gateways, base stations, and access points. Fog nodes are computational resources deployed in a geographically widely distributed manner, so that end devices can usually connect to a closest fog node [8]. The most key features and advantages of the fog layer are local data analytics, data pre-processing, distributed computing, decentralized storage, temporary storage, data security, and privacy [6].

- Cloud layer: This layer contains many centralized data centers which are responsible for permanently storing all data from pervious layer and provides an extensive computational data analysis. Unlike classical cloud architectures, in fog computing, the cloud layer is accessed in controlled and periodical way, leading to the effective use of all available resources [6] .

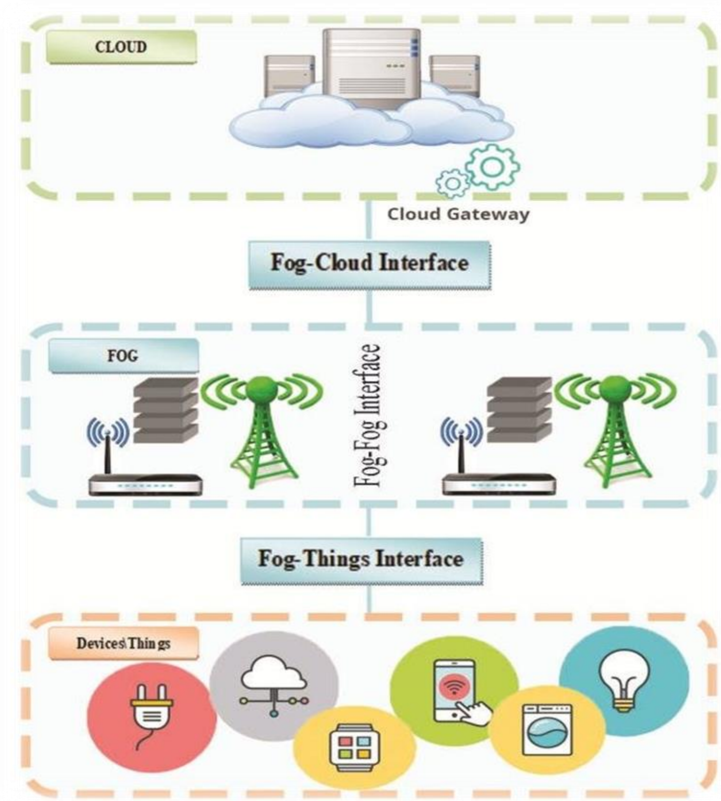

Fig .3: Three Tier Architecture of Fog Computing

6. A New Smart Medical System Based on Fog and IoT

Traditionally, diagnosis of patients in the medical system requires a direct examination of them by doctors [9]. Thus, there is a direct contact between patients and doctors, and the nursing staff to diagnosis them by examination their symptoms. In spite of the effectiveness of this traditional system, it takes great efforts from doctors and the nursing staff to achieve the most accurate diagnosis for patients. Also, this system consumes a great deal of time, whether from doctors or patients [1, 9]. The biggest problem is that some patients may suffer from serious and contagious diseases that may be transmitted to doctors and the nursing staff, which puts their lives at risk.

Nowadays, COVID-19 is considered a serious infectious disease, as it is rapidly spread through direct contact between people and no medicinal drug has proven its effectiveness to overcome this disease [10-12]. Hence, the direct diagnosis of corona patients by the doctors and nurses is extremely dangerous because it may expose their lives to death [10-12]. To overcome these challenges, traditional medical systems (e.g., hospitals) should be transformed in all-round way to be Smart Medical Systems (SMSs) by using new technologies such as IoT, fog, and cloud computing as shown in Fig.4. The main objective of using these new technologies is to enable SMS to automatically collect the patient's data via IoT sensors at the nearest fog to remotely examine the symptoms of the patient and then give him the diagnosis. Thus, this system tries to reduce the risk of dangerous diseases that are rapidly spreading (e.g., COVID-19) by diagnosing patients without direct contact with the doctor [10-12]. As illustrated in Fig.2.5, SMS consists of three main layers, which are; IoT Layer , fogs area layer, and cloud layer.

In IoT layer, medical IoT sensors as a new generation of information technology are used in medical systems (e.g., hospitals) to make them more efficient, more convenient, and more personalized [1]. IoT sensors enable the hospitals to perform many procedures at a remote location in a real-time manner. These procedures such as blood testing, diabetic monitoring, and pressure monitoring. Thanks to IoT technology, real-time monitoring of patients can be provided without direct contact with the doctor by using wireless networking connections such as Bluetooth, Wi-Fi, etc. [1,13]. While IoT supports the medical systems with real-time data, it cannot formulate this data in appropriate form for analysis. Additionally, the generated data volume through IoT will be increased to be larger in size [13].

In fog area layer, fog can perform two main processes on the received data, which are; data representation and data summarization before analysing it [13]. Data representation means that each fog can connect to the nearest hospitals in its area to receive the patient's data from IoT sensors and then represent it in a suitable form (e.g., 2-dimensional form). Data summarization means that fog can summarize the received data to remove ineffective data and prevent the data replication before using it to give real-time diagnosis [14,15]. In fact, hospitals can communicate to the nearest fog through a cluster of the networking devices such as smart gateway, routers, switches, etc. [13].

Accordingly, fog can support the medical system to give fast and accurate diagnosis of patients based on the stored data in its cache. Fog can summarize the data in its cache to be more informative before sending it to the master fog in its area. In each fogs area, the master fog can communicate with all fogs of its area for collecting and then storing the most significant data from these fogs in its cache server in a temporary manner. In fact, master fog plays two main roles in the system in which it can give all fogs in its area the ability to support the nearest hospitals to provide a fast and accurate diagnosis of patients. Additionally, it can only send the most significant data to the cloud to reduce the load on the network. Hence, the main aim of providing the fogs area as a middle layer between the medical system layer and the cloud layer is to give a fast and accurate diagnosis of patients coping with real-time monitoring.

Sending the complete captured data from IoT sensors to the cloud will saturate network bandwidth and not be scalable [13]. Additionally, the cloud is unable to support hospitals in the medical system layer to make real-time actions. Thus, master fogs can communicate with the parent cloud to send the collected data from their cache servers to the cloud servers to be permanently stored according to many rules from the cloud.

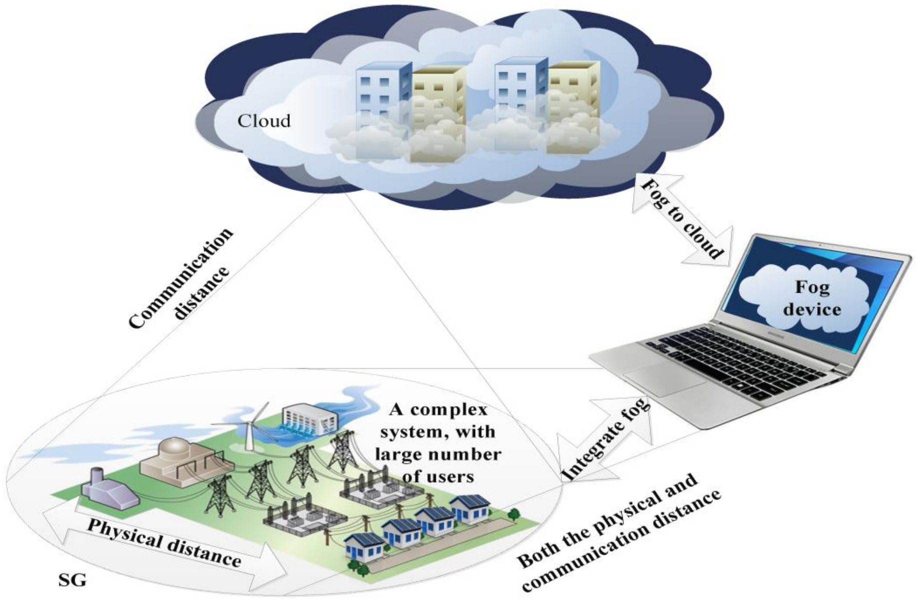

Fig.4: Architecture of the Smart Medical System.

7. Related work for the Role of IoT against COVID-19

This subsection tried to bring some potentiality and scopes which shall help to mitigate COVID-19 like pandemic. Table 2 has mentioned some Edge computing (EG) based studies on COVID-19 and related healthcare.

Table 2: Recent IoT based works to mitigate COVID-19 .

Reference of proposed works	Dedicated task related to a pandemic or healthcare	Main contributions
A.Sufian et.al [16]	EC based model to stop spread COVID-19	-An EC based ICU, Critical Areas monitoring model. - Proposed DL and Computer Vision-based surveillance model.
C.Hegde et.al [17]	An open-source EC for clinical screening system.	-Fever and Cyanosis detection using visible and far infrared cameras emergency department. -This image segmentation-based EC uses hardware.
A.A.Abdellatif et.al [18]	Data and application specific energy-efficient smart health systems	-An optimizes medical data transmission from edge nodes to the healthcare provider with energy efficiency and quality-of-service. -Managing a heterogeneous wireless network through EC to provide fast emergency response.
P.Pace et.al [19]	Efficient Applications for Healthcare Industry 4.0	-Proposed BodyEdge, an architecture suited for humancentric applications in context of the emerging healthcare industry. -A tiny mobile client module with EC for better health service.
M.Chen et.al [20]	Smart Healthcare System.	-Edge cognitive computing-based smart healthcare mechanism to dynamic resource allocation in healthcare.
H.Zhang et.al [21]	Smart Hospitals Using Narrowband-IoT.	-An architecture to connect intelligent things in smart hospitals based on Narrowband IoT. -smart hospital by connecting intelligent with low latency.

In recent years, IoT has gained powerful research ground as a new research topic in a broad range of academic and industrial applications such as smart cities and smart healthcare. IoT is an advanced technology that can connect all smart objects with each other within a network without any human interventions. The IoT revolution rebuilt modern healthcare systems by integrating technological, economic, and social insights. Healthcare services are changing from traditional to more personalized healthcare systems, making it easier for patients to be diagnosed, treated.

understanding of the use of these devices, applications, and services not only help patients know how to deal with their health and life well but help healthcare providers to decrease emergency situations ,monitor patients, staff, and inventory, improve drug management for the overall control of pandemics. In addition, the understanding of the use of these technologies helps in parallel reporting and monitoring, data assortment and analysis, remote medical assistance, end-to-end connectivity and affordability, tracking, and alerts. After the outbreak of the COVID-19 pandemic in 2019, there has been a rapid effort in various research communities to utilize a wide variety of technologies to tackle this global threat, and IoT technology is one of the pioneers in this area.

In the context of COVID-19, IoT-based healthcare systems may be useful for decreasing the possible spread of COVID-19 to others through early diagnosis, monitoring patients, and applying defined protocols after patient recovery. In this paper, many topics had been discussed such as the most fundamental concepts of new technologies such as fog computing, cloud computing, and the role of IoT-based technologies in COVID-19. It also discusses the definition, the characteristics, the main goals, and the overall vision of smart healthcare systems.

References

[1] S. Tian, W. Yang, J. Grange, P. Wang, W. Huang, and Z. Ye, *"Smart healthcare: making medical care more intelligent,"* Global Health Journal, Volume 3, Issue 3, 2019, PP.62-65.

[2] S. Swayamsiddha,and C.Mohanty, "*Application of cognitive Internet of Medical Things for COVID-19 pandemic* , Diabetes & Metabolic Syndrome: Clinical Research & Reviews , Volume 14, Issue 5, 2020, PP.911-915.

[3] Md. Islam, A. Rahaman ,and Md. Islam ," *Development of Smart Healthcare Monitoring System in IoT Environment* ," SN Computer Science ,2020, https://doi.org/10.1007/s42979-020-00195-y.

[4] L. Antão , R. Pinto , J. Reis , and G. Gonçalves , "*Requirements for Testing and Validating the Industrial Internet of Things* , In processding of 2018 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW), Västerås, Sweden, 2018, PP. 110-115, http://doi: 10.1109/ICSTW.2018.00036.

[5] M.Azzawi, R. Hassan ,and Kh.Abu Bakar," *A Review on Internet of Things (IoT) in Healthcare*," International Journal of Applied Engineering Research , Volume 11, Issue 20, 2016, PP. 10216-10221.

[6] L. Minh Dang, Md. Jalil Piran, D. Han, K. Min,et al. "*A Survey on Internet of Things and Cloud Computing for Healthcare*," electronics, Volume *8*, Issue 7, 2019, PP.1-49.

[7] P.Hu, S.Dhelim, H.Ning, and T.Qiu, "*Survey on fog computing: Architecture, key technologies, applications and open issues*," Journal of Network and Computer Applications, 2017, Volume 98,PP. 27–42.

[8] J.Bellendorf , and Z.Mann ," *Classification of optimization problems in fog computing, Future Generation Computer Systems*,", Volume 107, 2020, PP. 158-176.

[9] J. Varma and K. Deeba, *"Mapping of terms between healthcare providers and patients,"* Proceedings of the 2017 International Conference on Trends in Electronics and Informatics (ICEI), IEEE, Tirunelveli, India, 2018, PP. 773-776.

[10] A. Cortegiani, G. Ingoglia, M. Ippolito, A. Giarratano, and S. Einav, *"A systematic review on the efficacy and safety of chloroquine for the treatment of COVID-19,"* Journal of Critical Care, Elsevier, PP.1-5, https://doi.org/10.1016/j.jcrc.2020.03.005, 2020.

[11] Nisha and P.Kaur, "*Survey of clustering techniques and algorithms*," in the proceeding of 2nd International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, 2015, PP. 304-307.

[12] A. Narin, C. Kaya, and Z. Pamuk, *"Automatic Detection of Coronavirus Disease (COVID-19) Using X-ray Images and Deep Convolutional Neural Networks,"* 2020, arXiv:2003.10849.

[13] V. Jagadeeswari, V. Subramaniyaswamy, R. Logesh, and V. Vijayakumar," *A study on medical Internet of Things and Big Data in personalized healthcare system,*" Health Information Science and Systems, Springer, Volume 6, Issue 14, 2018, PP. 1-20.

[14] A. Rabie, S. Ali, H. Ali, and A. Saleh, *" A fog based load forecasting strategy for smart grids using big electrical data,"* Cluster Computing, Volume 22, Issue 1, 2019, PP. 241–270.

[15] J. Jestes, *" Efficient Summarization Techniques For Massive Data,"* A thesis submitted to the faculty of the University of Utah in partial fulfillment of the requirements for the degree of Doctor of Philosophy, School of Computing, The University of Utah, 2013.

[16] A. Sufian, D. S. Jat, A. Banerjee, "Insights of Artificial Intelligence to Stop Spread of COVID-19." , Big Data Analytics and Artificial Intelligence Against COVID-19: Innovation Vision and Approach, volume 78 ,2020, PP.177–190, doi:10.1007/978-3-030-55258-9_11

[17] C. Hegde, P. B. Suresha, J. Zelko, Z. Jiang, Eet.al , "*Autotriage-an open source edge computing raspberry pi-based clinical screening system*", medRxiv, 2020, doi: https://doi.org/10.1101/2020.04.09.20059840

[18] A. A. Abdellatif, A. Mohamed, C. F. Chiasserini, A. Erbad, et.al , "*Edge computing for energy-efficient smart health systems: Data and application-specific approaches*", Energy Efficiency of Medical Devices and Healthcare Applications, Elsevier, 2020, PP. 53–67.

[19] M. Chen, W. Li, Y. Hao, Y. Qian, I. Humar, "*Edge cognitive computing based smart healthcare system*, " Future Generation Computer Systems , Volume 86 ,2018, PP. 403–411.

[20] P. Pace, G. Aloi, R. Gravina, G. Caliciuri, et.al , An edge-based architecture to support efficient applications for healthcare industry 4.0, IEEE Transactions on Industrial Informatics 15 (1) (2019) 481–489.

[21] H. Zhang, J. Li, B. Wen, Y. Xun, J. Liu, Connecting intelligent things in smart hospitals using nb-iot, IEEE Internet of Things Journal 5 (3) (2018) 1550–1560.