



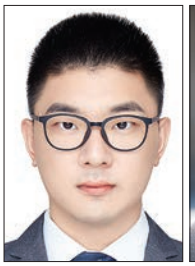


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Internet of Medical Things in the Context of COVID-19

The COVID-19 pandemic has affected all parts of our daily lives, including the way we interact, work, educate, travel, conduct business, deliver healthcare services, and many other activities. COVID-19 has resulted in millions of deaths and severely impacted the economies of many nations worldwide. The significant global impact of the pandemic throughout the world has pushed scientists in various areas (health, technology, and so on) to accelerate the development of an influential and persistent vaccine to protect people all around the world from being infected with COVID-19. In particular, the healthcare, manufacturing, and technology sectors have been working as fast as they could do to develop various types of solutions, including new vaccines, protection equipment, and technologies to minimize disruptions to our normal daily lives.

Today, it is widely accepted that a multi-disciplinary solution is needed to enhance diagnostic/detection of COVID-19 cases, efficiently monitor and track COVID-19 patients, and develop efficient supply chains for a wide range of products used to manage and cure COVID-19. Emerging technologies such as Internet of Medical Things (IoMT) and Internet of Things (IoT) are expected to play a pivotal role in this multi-disciplinary solution by supporting IoT-based intelligent approaches, which may include approaches that use industrial manufacturing of ventilation tubes, masks, and other medical devices to support patients at healthcare facilities or their self-isolation at home in a secure manner; deploy novel and efficient mechanisms for passive, privacy-preserving liaison-tracing solutions; and help diagnose COVID-19 cases based on IoMT and smart phone data gathering and analysis, develop intelligent reliable, cost-effective testing kits.

Although, presently, scientists in various sectors, continue their efforts to bring the existing COVID-19 pandemic under control, the global COVID-19 threat and vaccine production and administration challenges will continue to need innovative solutions to be developed by researchers and scientists worldwide to better manage this pandemic. IoT will continue to play a significant role in logistics and supply chain management. In addition to the use of connected vehicles for tracking, IoT sensors and actuators can be embedded in vaccine cooling pallets or boxes along with a communication module to collect and analyze data on humidity and temperature. The temperature sensor will be especially significant as some vaccines need low temperatures. In addition, the vaccine's distribution can be secured by using scannable barcodes that send data to IoT-based systems in the cloud, or an IoT-enabled crypto seal that also enables tracking.

This special issue focuses on novel technical and industrial solutions that address research challenges in IoMT-based COVID-19 monitoring, diagnosing, vaccine distribution, vaccine tracking, vaccine cooling, vaccine storage monitoring, vaccinated person identification and relevant studies.

In "IoMT and DNN-enabled Drone-assisted Covid-19 Screening and Detection Framework for Rural Areas," Narel *et al*. propose a Covidrone system using state-of-the-art technologies, such as IoMT, drone, and Deep Neural Networks (DNNs) to detect COVID-19, authenticate a user, and disinfect sensing equipment. Covidrone's intelligent and automated path planning and battery recharging features enable secure, reliable, and affordable COVID-19 contactless diagnosis and testing. Covidrone has a strong potential for managing COVID-19, especially in rural areas where specialized medical facilities are often limited.

In "An IoT-based Secure Vaccine Distribution System through a Blockchain Network," Rathee *et al*. propose an IoT-based blockchain-enabled vaccine distribution architecture wherein every activity is performed by the IoT system maintaining a blockchain network. The proposed system efficiently maintains security and improves the efficiency of vaccine distribution with low delay and complexity. The authors evaluated the IoT-based blockchain architecture using synthesized data where vaccine units are supplied by various distributors and demonstrated accurate report generation over existing methods.

In "Eaves: An IoT-based Acoustic Social Distancing Assistant for Pandemic-like Situations," Deb *et al*. propose an IoT-based acoustic solution which ensures social distancing in public areas during pandemic-like situations. Most recently proposed solutions based on images, radio signals, or GPS information require all parties to have the application or have line-of-sight constraints. The Eaves system overcomes such limitations by using audio to ensure social distancing. The varying amplitude of the audio signals from different distances is the core idea of the proposed method. Following the training of multiple machine learning models, the authors selected the random forest model as their final model based on its ability to predict distances accurately with low delay. Eaves can be deployed in public areas and surveillance systems where visual clarity is a challenge.

In "Internet-of-Things-enabled Infrastructure against Infectious Diseases," Memos *et al*. argue that nowadays, it is more than obvious that conventional medical methods are struggling to find a treatment for infectious diseases, like the novel Coronavirus, COVID-19. Upcoming technologies can renovate a healthcare system in order to overcome the problem of new diseases. Thus, in this article, the authors propose the integration of state-of-the-art emerging technologies that can be successfully used alongside conventional methods to detect and combat various diseases. Such a robust infrastructure can offer

accuracy and speed in terms of detection and treatment of different infectious diseases that cause the human population to suffer. Therefore, the integration of different cutting-edge technologies, such as the Internet of Things, wireless sensor networks, big data analytics, cloud computing, machine learning, and 5G networks, into a smart monitoring system is urgently needed worldwide.

In "AI and Blockchain-based Cloud-assisted Secure Vaccine Distribution and Tracking in IoMT-enabled COVID-19 Environment," Das *et al*. propose a cloud-assisted IoMT-enabled blockchain solution aimed at vaccine distribution and tracking for the COVID-19 pandemic. They described how AI-algorithms, along with blockchain technology, can enable the proposed framework to maintain transactions related to vaccine order requests and distribution. This framework can also keep track of healthcare staffs about their vaccinations including any side effects by applying the accurate and valid information stored in the blocks residing in the blockchain. A blockchain-based simulation study conducted on the framework demonstrated its potential in practice.

In "Blockchain-empowered Edge Intelligence for Internet of Medical Things against COVID-19," Dai *et al*. argue that the integration of IoMT and blockchain technologies can provide an effective solution to address the COVID-19 crisis. But to achieve this integration, issues such as privacy, latency, and context absence must be addressed. In this context, they propose an architecture that leverages blockchain-empowered edge intelligence for IoMT. This architecture can provide solutions that include: monitoring and tracing the COVID-19 pandemic's origin, traceable supply chain of injectable medicines and COVID-19 vaccines, and support for telemedicine and remote healthcare services.

In "Random Forest for Data Aggregation to Monitor and Predict COVID-19 Using Edge Networks," Adhikari *et al*. propose an edge-centric e-healthcare model over B5G networks that can monitor and analyze the risk level for COVID-19 patients remotely using a standard random forest technique. The main goal of this work is to minimize the latency and power consumption during the transmission of the monitored health data through a local gateway device using a statistical data aggregation technique. The model analyzes the monitored data at a local medical edge server using data preprocessing and a random forest technique to identify the risk factor of each patient with 97 percent accuracy. The use of this model can potentially reduce overcrowding in hospitals by evaluating COVID-19 patients remotely.

The use of technologies such as Internet of Things (IoT), Internet of Medical Things (IoMT), edge computing, and blockchain is currently being explored by many researchers to develop efficient, robust, accurate, cost-effective, practical solutions that will help address various issues and challenges brought about by COVID-19. This Special Issue presents state-of-the-art solutions that could be deployed to help fight COVID-19.

We believe that this Special Issue is delivering cutting-edge research in eHealth, addressing the contributions from the Internet of Medical Things in the context of the pandemic caused by COVID-19, by proposing very interesting works and brand-new ideas. We, as Guest Editors, would like to encourage all the authors to keep on pushing in this direction by addressing the remaining open issues. Finally, we would like to sincerely thank Dr. Rath Vannithamby, the Editor-in-Chief of *IEEE Internet of things Magazine*, and Dr. Maurice Khabbaz, the Associate Editor-in-Chief, for supporting this Special Issue, and Joseph Milizzo for the great help in the whole production process.

Biographies

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Sherali Zeadally earned his bachelor's degree in computer science from the University of Cambridge, England. He also received a doctoral degree in computer science from the University of Buckingham, England, followed by postdoctoral research at the University of Southern California, Los Angeles, CA. He is a professor in the College of Communication and Information, University of Kentucky. He is a Fellow of the British Computer Society and the Institution of Engineering Technology, England.