Internet of Things-enabled Infrastructure against Infectious Diseases

Vasileios A. Memos, Georgios Minopoulos, Konstantinos D. Stergiou, Konstantinos E. Psannis*
Department of Applied Informatics
School of Information Sciences
University of Macedonia
Thessaloniki, Greece
{vmemos, gminopoulos, kster, kpsannis}@uom.edu.gr
**corresponding author*

***Abstract*—Nowadays is, unfortunately, more than obvious that conventional medical methods are struggling in finding 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 paper, we 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 make the human population suffer.**

Keywords—5G, Big Data Analytics, Cloud Computing, Internet of Things, Healthcare, Machine Learning, Wireless Sensor Networks.

I. INTRODUCTION

Although nowadays the Science of Medicine has achieved great achievements, many infectious diseases constitute a high risk for humans, especially for those who have serious long-term health problems, such as breathing problems, like triggering asthma, pneumonia, or bronchitis infections.

The integration of emerging technologies, such as the Internet of Things (IoT), Wireless Sensor Networks (WSN), Big Data Analytics (BDA), Cloud Computing (CC), and Machine Learning (ML) along with fifth-generation (5G) networks are regarded to be an urgent need for implementation in the branch of Medicine.

However, state mechanisms of many countries, especially those of third countries, are not ready to apply these technologies to their population. Many research studies, which involve different technologies, have been proposed in the branch of Medicine. Nevertheless, the development of an autonomous robust system, which will make use of all the available immersive technologies, is still under investigation.

The rest of the paper is organized as follows: Section II presents the related work upon emerging technologies against infectious diseases. Section III presents the limitations of conventional medical methods against infectious diseases. Section IV describes the involved immersive technologies. Section V presents the proposed system architecture. Section VI focuses on some challenges of the operation of such a system. Section VII provides a final discussion about the advantages and limitations of our proposed model. Finally, Section VIII concludes the paper and provides some future directions.

II. RELATED WORK

There are many research studies focused on tackling infectious diseases by using emerging technologies like IoT and WSN. As IoT consists of numerous interconnected devices researchers have to face storage, communication, and energy overheads. Several ubiquitous devices have been launched in the healthcare industry due to the increasing acceptance and operation of wearables in sensing the physiological status. The core functions of wearables are to sense, analyze, store, transmit and utilize depending on the wearer and the processing of data gathered from the sensors [1].

An efficient solution is to use Peer-to-Peer (P2P) communication between healthcare detectors and mobile devices like smart wearables to share information with a sink node that transfers the information to a main Fog server, as presented in [2]. The sink node is far away from the fog server and therefore cannot transmit the gathered information directly. However, it is able to share encrypted information with the nearby sink node to transmit the information to the fog server by attaching this to its current collected information. The fog server exports the necessary values from the collected information and stores them in local repositories or clouds.

In [3] patients are allowed to monitor their health status through their own smart portable devices, such as smartphones or tablets. The devices' sensors are in charge of measuring the appropriate physiological parameters and communicate the raw data directly to the cloud to save battery in the smart device. The smart devices can communicate with the cloud servers through the backhaul communications segment via cellular technologies, like 5G, which are the most appropriate for such communications.

The proposal in [4] is a unique method to detect symptoms related to COVID-19. It consists of a soft, safe, and reusable

wearable sensor placed on the suprasternal notch to collect data, and a standardized series of activities, designed to sensitively elicit responses indicative of a diseased state. By gathering and measuring a mixture of physiological signals like body motion, heart beating, breathing, and coughing implications due to COVID-19 could be detected.

For timely prediction of an infection, wearable sensor data can be exploited as suggested in [5]. A Deep Learning (DL) system evaluates wearables data such as anomalous resting heart rate to predict the disease prior to the onset of symptoms. This system was created using retrospective time-series datasets collected among COVID-19 patients, and healthy individuals. The findings demonstrate that wearables data analyzed through DL algorithms could provide trusted information for the early detection of the infection.

Finally, infection diagnosis can be challenging, relying on clinical judgment and non-specific markers of infection. ML algorithm for diagnosing bacterial infection using routinely available blood parameters could provide increased accuracy in virus identification. Hence, in [6] a ML algorithm can classify cases into infection versus no infection using microbiology records and several available blood parameters.

III. Limitations of Conventional Medical Methods

The branch of Medicine is evolving day by day, and of course, conventional medical methods are necessary for combating infectious diseases. Nevertheless, there are many limitations of the traditional methods. The health sector faces many problems for which IoT and the upcoming technologies can give solutions.

Such problems are the fast aging of the population because of the demographic problem, the chronic diseases like heart failure, diabetes, hypertension, etc., the rare diseases like Alzheimer, the lack of health personnel and infrastructure, the hereditary diseases, the difficult healthcare of emergency cases like accidents, COVID-19 cases, etc., the organizational problems, the mild illness, and in the corruption of health data in some cases [7].

Besides, in the case of infectious diseases that are being spread with a geometric progression like the new Coronavirus COVID-19, a visit to hospitals or medical centers even for a simple medical or clinical examination for any reason is risky enough, because these buildings have a high viral load and hence, they could be infection centers for the patients who visit them. Moreover, patients who have some symptoms of this epidemic virus are discouraged to visit hospitals, transmitting potentially the virus to other people too.

On the other hand, other medical examinations and surgeries are postponed or canceled due to the fullness of the hospitals and the lack of doctors and other medical staff. It should be mentioned that apart from patients, there are problems for doctors, nurses, and ambulance crews. Due to their contact with many coronavirus' cases and the incomplete telemedicine, they take a chance, and often, they are infected with the virus, and thus they stop working for two weeks following the guidelines by the global medical community for tackling the virus. This results in the overtime of existing medical and nursing staff, and consequently, the reduction of their effectiveness.

Finally, nowadays, due to this pandemic of COVID-19, many medical centers and companies employ human resources to check the body temperature of the incoming individuals, both employees, and visitors. This means lost working hours and more duties for some employees.

IV. Involved Technologies

Our proposed model is the integration of emerging technologies that will constitute a robust integrated system, as shown in Fig. 1.

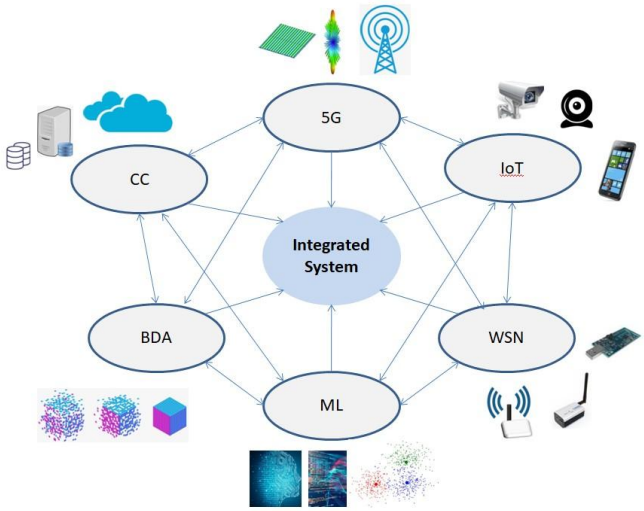

Fig. 1. The integrated system with the involved emerging technologies.

These technologies are the following:

- Internet of Things

IoT is a new networking concept that can connect all everyday physical things to the internet. The aim of such interconnection is the creation of a global huge network composed of unique things that communicate with each other to accomplish specific scheduled procedures, bringing many advantages in many scientific fields, like Medicine.

In medicine, many IoT-based wearables are applied in healthcare and offer a full range of new capabilities thanks to pervasive connectivity. Such medical wearables include medical devices, sensors, smartphones, imaging devices, Personal Digital Assistant (PDA), and Electronic Health Record (EHR) [8]. These medical wearables can have a huge impact on the branch of medicine as they can provide important potential in enhancing the patients' lives and doctors' jobs worldwide. Healthcare wearables have applications in cardiology, sleep disorders, diabetes management, infectious diseases, changes in mood and behaviors, etc. Besides, IoT-based wearables can be used to monitor from distance patients (remote health monitoring) and hence, contribute to an early diagnosis (remote diagnostics) of an epidemic disease or pandemic [9].

Furthermore, IoT technology can also have applications in medication and treatment by healthcare suppliers. This

process can be supported by using various IoT features, such as patient authentication models, tracking drug supplies, and providing effective resource planning to healthcare providers in order to make the best use of them for more patients. Finally, IoT-based applications can minimize the time required for remote healthcare and improve the quality of service (QoS) by reducing costs with an increased user experience [8].

- Wireless Sensor Networks

A WSN is composed of many sensor nodes that are densely located in a specific area or environment. Such small devices are usually low-cost and have constrained resources in terms of battery and storage capacity. The objective of WSN is to interconnect the IoT-based devices (e.g. of a patient) to deliver useful information whenever and wherever is needed, such as in a medical center. WSN comprises sensors that function close to an individual's body and transmit measurement data wirelessly through communication protocols.

IoT-enabled WSN is applicable in the medical sector for monitoring a patient by using sensing devices that may interface and operate any kind of biomedical sensor such as heart-rate, electrocardiogram, blood oxygen level, blood pressure, blood glucose, body weight, temperature, oxygen saturation, drop detection, and step counting [2]. The sensors are generally applicable for use to provide feedback to maintain an optimal health level. Data can be collected from a variety of situations and processed over and over again by doctors and caregivers to assess health status. In addition, residential areas can be monitored for air pressure, sound, light, and vibration to analyze the conditions of a healthy environment [2].

It is of great importance that WSN can offer ubiquitous real-time or close to real-time information about vital patient's state. Moreover, it may send alerts and notifications to the patient based on the sensor measurement values using specific thresholds or limits [3]. This will lead to the production of large amounts of data. The benefits of the WSN are the fact that there is no need for wires, consist of autonomous devices, while they are energy efficient since the right algorithms and mechanisms are used.

- Big Data and Analytics

A large-scale data set from various types of data could be produced by IoT devices that are embedded in a patient. These data are known as Big Data (BD) due to their high velocity and wide variety, and can be collected and transmitted by various devices like sensor nodes, or can be stored in cloud servers [8].

BDA is the use of sophisticated methods for a thorough analysis of large and diverse data sets which include structured, semi-structured, and unstructured data, from multiple sources, and in different sizes to reveal important information that can assist an organization like a medical research institute to make decisions for example about the solution to an epidemic infectious disease. Thus, BDA is a well-promising technique that can be integrated into Cloud Servers to analyze the collected data from patients' wireless sensors and IoT devices and hence, improves the quality of the e-health data, gaining in-depth knowledge of the many facets of human life.

Even in the clinical research branch, which is highly regulated, the industry makes steps towards substitution of manpower for measurements and surveys using electronic Patients Reported Outcomes (ePROs) and electronic Clinical Outcome Assessment (eCOA) [10]. Furthermore, a point-of-care test based on an IoT platform can be used to provide a higher quality yet affordable healthcare solution worldwide and minimize the workflow of healthcare staff [11].

- Cloud Computing

CC is a technology that shares network resources maximizing its efficiency. Specifically, cloud resources are shared among many users but there is also a dynamic redistribution based on demand. This has the effect of maximizing power on the computer as well as reducing energy costs. Users can access and retrieve their data from a single server without having to obtain licenses for different applications.

CC offers to the branch of Medicine the chance to store, manage, and transmit sensitive health data through platforms based on this technology. With the implementation of integrated information systems based mainly on various variants of the client-server model and relational database systems to arrive at a system based mainly on the idea of collaboration and multiple access methods such as remote, wireless, mobile, with extensive application of telecommunication methods, networking, and technologies based mainly on the Internet. This practice in hospitals is served by the implementation of cloud computing projects, as it is a service that combines, develops, and uses the existing technologies, which are transformed into a self-service program.

Due to its basic characteristics, CC could allow doctors and nursing staff to have access to these personal health data from wherever and whenever. Moreover, the medical staff can run complicated applications through Cloud platforms, without the need for heavy hardware systems [8]. Another important benefit of CC is that it can improve the quality of health services provided at all stages and all levels involved (patients and doctors). This is because they can access the necessary knowledge to make better decisions from different sources in a uniform and comparable way which can provide important knowledge about the spread of disease, the design of new drugs, and the conduct of the required clinical trials to improve efficiency and productivity.

- Machine Learning

ML is an application of Artificial Intelligence (AI) which offers computer systems the ability to automatically learn and enhance from experience without being explicitly programmed. ML refers to any program or information system that performs functions that a human would normally perform. AI technologies can conclude the information they receive and can learn from the data patterns they process, naturally interacting with humans. ML focuses on the development of computer programs that

can access data and use it to learn for themselves without human intervention or assistance.

In recent years, the continuous development of ML algorithms in the medical sector focuses to explore the potential impact of systems such as decision-making by clinicians who manage infections with the support of various decisions. ML has huge potential to improve productivity and efficiency in health systems and makes them more sustainable and, most importantly, has the potential to provide better outcomes for patient health. It can do this in many ways, from providing preventive care to allowing health professionals to spend more time in the immediate care of patients.

In the branch of Medicine, an important problem in hospitals is the monitoring and detection of nosocomial infections. The goal with the assistance of ML will be to identify patients with infection, based on the clinical data collected by the patient [12].

ML can promise not only better quality but also more economical medical care, emphasizing that AI can solve many health problems such as lack of doctors, misdiagnosis, ineffective health care systems, etc. Besides, the development of AI can significantly help governments that are called upon to cope with an environment of cost constraints because pathologies can be prevented and epidemics prevented. This will enable the identification of a patient's disease and the evolution of their state of health with an effective surveillance system. Monitoring will be performed by a supervised ML algorithm, integrated into a clinical decision support system to diagnose infection during hospital presentation [6].

The parameters determined by the doctors to know if the patient is ill are introduced in the supervised ML algorithm. This provides an automated assessment of the chances of being diagnosed with the infection. The available data should provide personalized pollution management recommendations to doctors. In this way, we achieve optimal recovery of the patient as well as the prevention of non-spread of the virus.

A supervised ML algorithm is proved that it can be effective and is accepted by most scientists to be incorporated into a tool for supporting clinical decisions that can support the diagnosis of infection in hospitalized patients [13]. With the right rules, the right equipment, and the right specialization, artificial intelligence will very soon change the form of future medicine [14].

- 5G Networks

5G networks are anticipated to establish a new age of agile and amazing fast connectivity with excessive operation and applications designed accurately consistent with the miscellaneous desires of users. 5G Networks are the next generation of mobile networks that will allow a theoretical maximum speed up to 10 Gbps, which signifies that 5G technology will be a hundred times faster in comparison with the current 4G technology, as its theoretical maximum bandwidth is up to 100 Mbps. Moreover, 5G will achieve a considerably reduced latency, as low as 1 ms, and hence, less loading delay and better responsiveness [15].

5G will blend much more innovative technologies than those already engaged by Long-Term Evolution (LTE). One technological revolution is the exploitation of millimeter-wave bands to deliver improved mobile communication to confront today's human-centric obstacles. Several novel applications are expected to be empowered by 5G as it incorporates low-latency and ultra-reliable communications, and massive machine-type communications for a substantial quantity of linked sensors and devices.

5G will also provide abundant throughput to the end-user. Thus, it paves the way for an entirely pervasive and ubiquitous society with numerous innovative healthcare applications. A greatly thicker network of sensors and devices, as well as the tiniest ones, will be able to exchange data, by the time 5G will become publicly accessible with enhanced connectivity and cloud-based storage. Due to the overpowering cloud-based computations, new ideas of mobile IoT will arise that will offer a broad variety of prospects, particularly in healthcare.

The imminent 5G infrastructure will unveil an inexperienced, yet, set of capabilities to face a number of technological limitations and constraints. Poor connectivity, inadequate data rates, and security breaches will become past, as the next generation of cellular networks will bring transmission reliability, higher bandwidth, and increased security along with ubiquitous access. This will offer constantly accessible communication services for health monitoring systems, with a considerable boost in transmitting capacity among health service providers, medical staff, and patients. Already, there has been sensational progress in terms of the capability to effortlessly execute both in-home and remote health monitoring.

Contrasted to former practices that typically required a visit to the hospital, these days, patients can track their physical and mental state at home using low-cost mobile devices with more convenience, The development of 5G technology can effectively decentralize the healthcare services, which can be distributed in homes, clinics, rehabilitation places, surgery operation rooms, remote areas, and ambulances. Also, 5G will open the door of novel prospects for radar technologies, which can easily locate the patients and monitor their health either in a home or in a medical facility [8].

A crucial matter for healthcare applications that need to be addressed will be the obstacle of antennas' placement licensing, to offer a widely reliable network coverage, due to radiation issues that many voices claim against. Particularly, it is fundamental for enabling a range of e-health applications to provide reliable guarantees that the extensive network coverage does not straightforwardly affect human lives [8].

V. Proposed System Architecture

Our proposal is the implementation of a smart monitoring system based on the aforementioned six emerging technologies which have many benefits, as it is shown in Table I. This Table concludes the above technologies, states their configurations, and highlights their advantages.

TABLE I. THE INVOLVED TECHNOLOGIES AND THEIR BENEFITS

Technologies	Configurations	Device types	Advantages	Benefits in our proposed model
IoT	+ IPv6 + Wi-Fi + RPL + CoAP + LPWAN + MQTT + AMPQ + IoTivity	+ Smart devices + Mobile robots + Environmental monitors	+ Internet access from any "thing" + M2M communication + Information exchange	+ Smart monitoring system + Smart Wi-Fi camera + Smart wearables + Smart hospital
CC	+ SaaS + Paas + IaaS	+ Cloud servers + Cloud data centers + Cloud database platforms	+ Improved accessibility + Data storage + Data recovery	+ e-health data storage + BDA support + ML algorithm support
BDA	+ TCP + UDP + UDT + RoCE + Hadoop	+ Database Servers + NAS Servers + PFS + DFS	+ Data management + Data analysis + Data optimization + Information discovery	+ e-health data management + e-health data analysis + Deep health insights
WSN	+ 6LowPAN + Zigbee + ISA100.11a + WirelessHART + OCARI	+ Sensors + Arduino + Raspberry Pi + Wi-Fi systems + Drones	+ Interconnectivity between different devices and platforms + Remote access + Fast data movement	+ Wireless on-body sensors + Remote work for doctors + Connectivity with Smart hospital
ML	+ k-NN + DT + Random Forest + NN + SVM + Bayes' Theory + HMM + k-Means + SOM	+ GPU + FPGA + ASICs + SoC + DSP + Microchips + Mobile robots	+ Prediction mechanism + Improved productivity + Enhanced accuracy + Continuous learning	+ Disease prediction (detection of infectious diseases) + More accurate results (case or not) + Optimized feedback from continuous case learning
5G	+ 5GTF + 5G-SIG + 3GPP 5G + 5G NR + 5G eMBB + 5G URLLC + 5G mMTC	+ 5G mobile phones + 5G routers + 5G mobile Wi-Fi + 5G base station + 5G MIMO antennas	+ Immediate response + Precision + Gearing	+ Immediate transfer of thermal images and exhaled data + Immediate transfer of the decision to the individuals and doctors

The proposed monitoring system can be established at the entrance of various buildings, especially in hospitals and medical centers, and will automate the procedure of virus detection of individuals who try to enter the building. Moreover, it will guide the potentially infected individuals to provide them treatment solutions, preventing the virus spread.

The monitoring system will be equipped at the entrance of a building with a high-definition (HD) infrared thermal imaging camera and megaphones, as is shown in Fig. 2. The thermal camera will scan the head of the individuals to counter their body temperature. Besides, breath sensors that use protein-encapsulated nanocatalysts may be embedded in the system to spot certain biomarkers of diseases, by collecting the exhaled volatile organic compounds. These images and exhaled data can be sent directly - thanks to 5G networks - to a robust Cloud Server. In the Cloud Server, a ML algorithm will run a thorough analysis of the collected Big Data to determine if these image data match a body temperature of over 37°C.

Furthermore, the exhaled particles will be compared by the ML algorithm with known infected cases to conclude about an individual's health state. When the temperature is above the threshold and the breath analysis shows a possibility of infection, the Cloud Server will return a notification to the appropriate staff to protect the building from a potential case of COVID-19. Moreover, the system will lock the entrance protecting the people inside the building.

The positive notification will be sent to the individual's mobile phone, wireless body sensor, or any other wearable IoT-based device and then an available doctor from distance will be notified about this case to guide him/her. Notably, the doctor does not need to be in a hospital, which means the decongestion of medical buildings. However, thanks to the IoT network, he/she will have access and constant communication to the smart hospital in many ways and various devices.

As it is expected, the main focus of this implementation model is set to be in public buildings, as they are buildings with high traffic and mass attendance. Therefore, it is fact that our proposed model can be applied to medical centers,

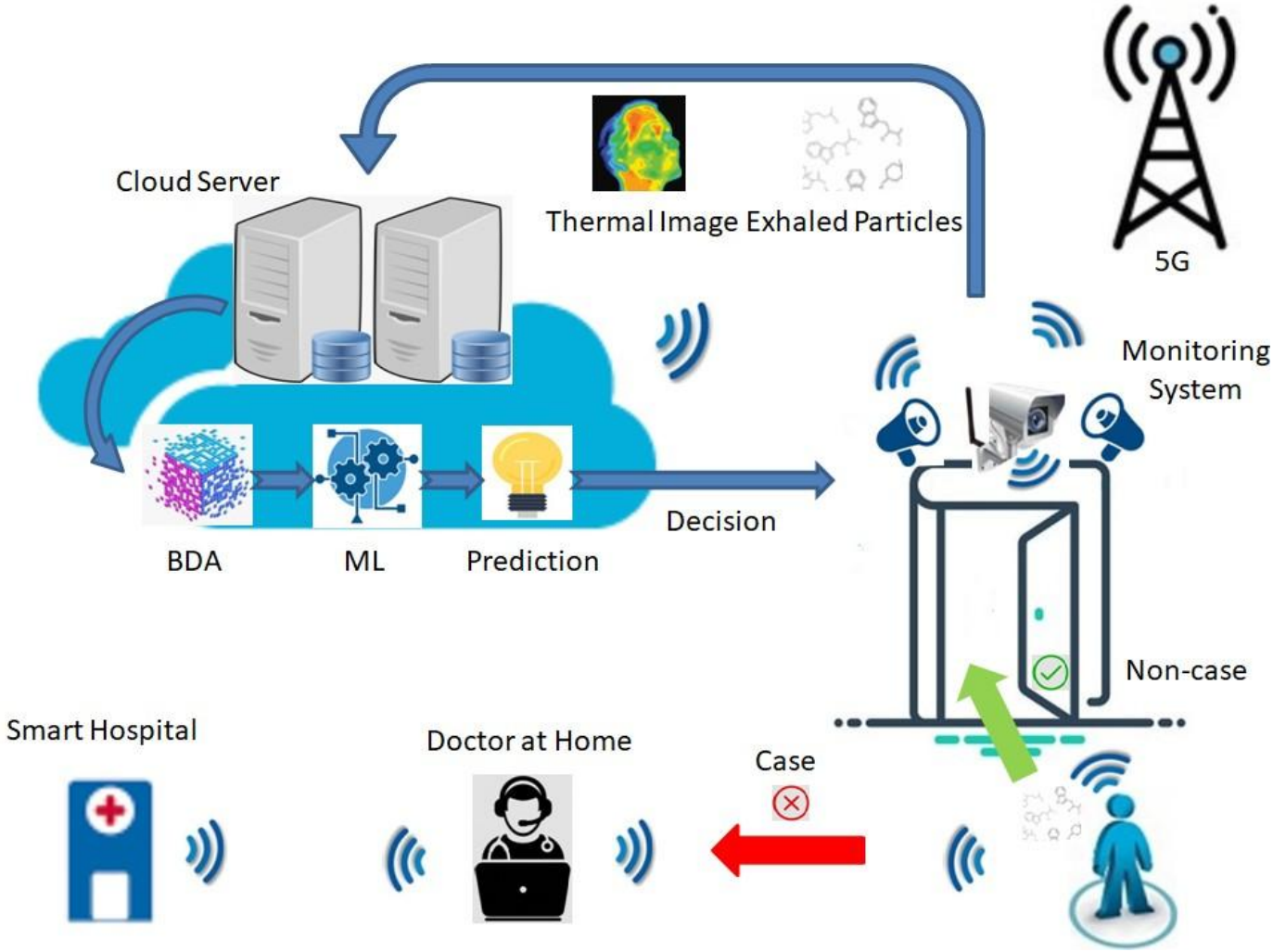

Fig. 2. The proposed approach.

hospitals, universities, entertainment halls, and outdoor parks, providing an effective way to combat not only well-known viruses but also new types of spreading viruses, like the fatal COVID-19.

VI. Challenges

In 2021 and beyond, such a system has to face several major challenges. Since the health data of individuals are sent, collected, and analyzed in a remote server, or between doctors and hospitals, there are cybersecurity and privacy concerns that should be taken into account. Hence, it is necessary to be clearly known what personal data will be collected and for what use. Implementation of multi-factor authentication methods and application of security tools is also recommended for protection from malicious actions and attacks.

Moreover, ethical and legal issues arise, since some individuals may want to enter buildings without check, invoking privacy issues. This means that such a well-promising infrastructure should be examined from several different aspects.

Finally, the economic costs of the supply, establishment, operation, and maintenance of the necessary technological equipment should be evaluated before its application. Sometimes, this cost may be a bit prohibitive, especially for countries dealing with an economic crisis.

VII. Discussion and Final Thoughts

Like any system, our proposed system model should meet some specifications. From the hardware aspect, our model needs smart wireless sensors and devices with IPv6 support (IoT-based devices), and 5G mobile devices to unlock the 5 GHz Wi-Fi band and maximize internet speeds. It is obvious that 5G network coverage is necessary for the area where the system will be placed.

Another important factor that should be taken into account is the constant 24/7 internet access with low latency and without network instability and transmission errors. We consider that at least a 50 Mbps / 50 Mbps download/upload speed is necessary for the operation of our proposed system, but a 100 Mbps / 100 Mbps download/upload speed is ideal. Moreover, we consider that the end-to-end round-trip-time (RTT) delay or simply latency should be up to 10 ms and ideally up to 1 ms so as to achieve instant communication

between individuals-monitoring system, individuals-doctor, and doctor-smart hospital with an almost 0% packet loss which can be regarded as negligible. Any network congestion in the communication channel of the above parties may cause the system to malfunction.

In addition, robust multi-core cloud servers are necessary to take up and balance the data load and the process of data analysis. Besides, the predictive analytics and the ML algorithms applied in the cloud servers should have low computational costs in terms of run-time, complexity, and required processing power so as to operate without causing problems on the cloud servers.

It is notable that the overall system runtime should be as minimum as possible. An ideal runtime for monitoring every individual who wants to enter a building can be defined at 5 sec. In the case of an individual who is potentially COVID-19 case, the additional runtime for immediate communication with a doctor on duty can be defined at about 2 sec. Finally, the communication between doctor and smart hospital depends on the severity of the individual's health and his/her possible impending diseases.

A key weakness of this initial phase of the system is that it cannot provide reliable information about illness prediction, yet. Due to complexity constraints, the use of specific sensors record data related to the temperature and respiration of the individual from which the ML algorithm is "trained" to export a documented result about the current health state of the people. The processed data in the Cloud Server are compared with a specific dataset that may conclude to a decision about a positive or negative result. Hopefully, the data gathered from this process could be exploited in the next stage of the system's development to indicate a potentially infected individual.

Although there are some barriers for our proposed model to be reality and operate harmoniously without problems, the advantages are multiple for human society, improving their Quality of Health (QoH) and hence, their Quality of Life (QoL). The world's enduring difficulties like healthcare disparities, the imbalanced allocation of healthcare resources, the growing number of patients with chronic diseases and infectious diseases due to pandemics like the new Coronavirus variant, and the rising medical costs will be significantly moderated by tomorrow's mix of emerging technologies into a robust integrated system.

Finally, the implementation of such a system will contribute to sensor-based diagnostics and nanomedicine-based treatment since it can reduce the overall diagnosis time and improve the accuracy of the clinical examination. Therefore, our system model can be used in conjunction with other diagnostic and treatment methods, providing many benefits in the field of Medicine.

VIII. Conclusion & Future Work

The offensive spreading of the new type of Coronavirus, known as COVID-19, motivate us for this research paper. Although conventional medical approaches are necessary for the fight against infectious diseases, there are many limitations of the traditional methods related to both the early detection and better treatment of viruses and diseases. Therefore, the integration of different cutting-edge technologies, such as the Internet of Things (IoT), Wireless Sensor Networks (WSN), Big Data Analytics (BDA), Cloud Computing (CC), Machine Learning (ML), and 5G Networks, into a smart monitoring system, tends to be an urgent need worldwide.

Our potential future directions include the implementation of such a robust and accurate monitoring system for quick detection, prevention, and treatment of different types of infectious diseases. Furthermore, future work incorporates the usage of wearable devices which may provide blood pressure, saturated oxygen, and electrocardiogram giving useful information that could be utilized in addition to advanced DL algorithms to provide more accurate infectious disease detection. Finally, DL models that receive information from multiple sensors in real-time have the prospects to alert individuals about their illness before symptom onset. This prediction could greatly help to avoid the disease spreading.

Acknowledgments

This research was supported by the Research Group Mobility2Net Lab JAPAN-EU R&D and the authors would like to thank its Director Dr. Konstantinos E. Psannis.

References

[1] A. Channa, and N. Popescu, "Managing COVID-19 Global Pandemic with High-Tech Consumer Wearables: A Comprehensive Review", 12th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT) pp. 222-228, IEEE, October 2020.

[2] A. Ullah, G. Said, M. Sher, and H. Ning, "Fog-assisted secure healthcare data aggregation scheme in IoT-enabled WSN", Peer-to-Peer Networking and Applications, Vol. 13, pp. 163-174, Springer, January 2020.

[3] V. Custodio, F. J. Herrera, G. López, and J. I. Moreno, "A Review on Architectures and Communications Technologies for Wearable Health-Monitoring Systems", Sensors, Vol. 12, Issue 10, pp. 13907-13946, October 2012.

[4] L. Lonini, N. Shawen, O. Botonis, M. Fanton, C. Jayaraman, C. K. Mummidisetty, S. Y. Shin, C. Rushin, S. Jenz, S. Xu, J. A. Rogers, and A. Jayaraman, "Rapid Screening of Physiological Changes Associated With COVID-19 Using Soft-Wearables and Structured Activities: A Pilot Study", IEEE Journal of Translational Engineering in Health and Medicine, Vol. 9, pp. 1-11, February 2021.

[5] G. K. Bogu, and M. P. Snyder, "Deep learning-based detection of COVID-19 using wearables data", medRxiv preprint, January 2021.

[6] T. M. Rawson, B. Hernandez, L. S. P. Moore, O. Blandy, P. Herrero, M. Gilchrist, A. Gordon, C. Toumazou, S. Sriskandan, P. Georgiou, and A. H. Holmes, "Supervised machine learning for the prediction of infection on admission to hospital: a prospective observational cohort study", Journal of Antimicrobial Chemotherapy, Vol. 74, Issue 4, pp. 1108-1115, April 2019.

[7] A. P. Plageras, K. E. Psannis, B. B. Gupta, C. Stergiou, B. G. Kim, and Y. Ishibashi, "Solutions for inter-connectivity and security in a smart hospital building", 2017 IEEE 15th International Conference on Industrial Informatics (INDIN), Emden, pp. 174-179, July 2017.

[8] S. Latif, J. Qadir, S. Farooq, and M. A. Imran, "How 5G Wireless (and Concomitant Technologies) Will Revolutionize Healthcare?", Future Internet, Vol. 9, No. 93, December 2017.

[9] M. Al-Khafajiy, T. Baker, C. Chalmers, M. Asim, H. Kolivand, M. Fahim, and A. Waraich, "Remote health monitoring of elderly through wearable sensors", Multimedia Tools and Applications, Vol. 78, Issue 17, pp. 24681-24706, Springer, September 2019.

[10] V. A. Memos, K. E. Psannis, S. K. Goudos, and S. Kyriazakos, "An Enhanced and Secure Cloud Infrastructure for e-Health Data

Transmission", Wireless Personal Communications, pp. 1-19, October 2019.

[11] W. N. Ismail, M. M. Hassan, H. A. Alsalamah, and G. Fortino, "CNN-Based Health Model for Regular Health Factors Analysis in Internet-of-Medical Things Environment", IEEE Access, Vol. 8, pp. 52541-52549, March 2020.

[12] C.F. Luz, M. Vollmer, J. Decruyenaere, M.W. Nijsten, C. Glasner, B. Sinha, "Machine learning in infection management using routine electronic health records: tools, techniques, and reporting of future technologies", Clinical Microbiology and Infection, Vol. 26, Issue 10, pp. 1291-1299, October 2020.

[13] P. Tiwari, J. Qian, Q. Li, B. Wang, D. Gupta, A. Khanna, J. J. P. C. Rodrigues, V. H. C. de Albuquerque, "Detection of subtype blood cells using deep learning", Cognitive Systems Research, Vol. 52, pp. 1036-1044, December 2018.

[14] A. S. Ahuja, "The impact of artificial intelligence in medicine on the future role of the physician", PeerJ, Vol. 7, Issue: e7702, October 2019.

[15] G. Minopoulos, G., Kokkonis, K. E. Psannis, and Y. Ishibashi, "A Survey on Haptic Data Over 5G Networks", International Journal of Future Generation Communication and Networking, Vol. 12, Issue 2, pp. 37-54, July 2019.

AUTHOR BIOGRAPHIES

Vasileios A. Memos received the BSc degree in Technology Management and the MSc degree in Applied Informatics with specialization in Computer Systems and Network Technologies from the School of Information Sciences, University of Macedonia (Thessaloniki, Greece), in 2012 and 2017 respectively. He is currently a Ph.D. Candidate in the Department of Applied Informatics, University of Macedonia (June 2018 – today), where he has teaching experience in several courses. His doctoral thesis focuses on "Algorithms for Energy Efficiency and Data Security in IoT Environments". He is also a member of the Research Group Mobility2Net Lab JAPAN-EU R&D (Director Dr. K. Psannis).

Georgios Minopoulos holds a B.Sc. in Electronics Engineering. He received the M.Sc. in Information and Communication Technology Systems from the International University of Greece and the M.Eng. in Wireless Communication Systems from the Open University of Cyprus. Currently, he is a Ph.D. Candidate at the Department of Applied Informatics of the University of Macedonia. Georgios has working experience at the Gas Distribution Company and the Hellenic Telecommunications Organization as an IT Internal Auditor. He is a Cisco Certified Network Associate Routing and Switching (CCNA). He is a member of the Institute of Internal Auditors (IIA), and the Information Systems Audit and Control Association (ISACA).

Konstantinos D. Stergiou received the BSc degree in Electronic Engineering and the MSc degree in Applied Informatics with specialization in Computer Systems and Network Technologies from School of Information Sciences of University of Macedonia. He is currently a PhD student in the Department of Applied Informatics, School of Information Sciences, University of Macedonia, Greece. His doctoral thesis focuses on "A combinatorial framework of machine learning algorithms and high-speed communication". His additional research interests include computer networks, wireless and mobile communications, multimedia transmission over 5G networks, Big Data Analytics (BDA), Wireless Sensor Networks (WSNs), Internet of Things (IoT), Artificial Intelligence (AI), Network security.

Konstantinos E. Psannis is an Associate Professor in Communications Systems and Networking at the Department of Applied Informatics, University of Macedonia, Greece, Director of Mobility2net Research & Development & Consulting JP-EU Lab, and member of the EU-JAPAN Centre for Industrial Cooperation. He is serving as an Associate Editor for IEEE Access and IEEE Communications Letters. Dr. Psannis will be TPC Co-Chair at the International Conference ICCCI 2021 in Japan (http://iccci.org/), and Conference Chair at the WSCE 2021 in Greece (http://wsce.org/). He has also been included in the list of Top 2% Scientists in the world (Stanford University USA, October 2020).