Towards a user-level self-management of COVID-19 using mobile devices supported by Artificial Intelligence, 5G and the Cloud

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Abstract. The fatal outbreak of COVID-19 has placed its fear around the globe since it was first reported in Wuhan, China, in November 2019. COVID-19 has placed all countries and governments across the world in an unstable position. Most countries underwent partial or full lock down due to the dearth of resources to fight the COVID-19 outbreak, primarily due to the challenges of overloaded healthcare systems. The tally of confirmed COVID-19 cases via laboratory continues to increase around the globe, with reportedly 60.5 million confirmed cases as of November 2020. Evidently, innovation has an imperative function to empower the omnipresent health technologies in order to counter the impacts of COVID-19 in a post-pandemic period. More specifically, the Fifth Generation (5G) cellular network and 5G-empowered e-health and Artificial Intelligence (AI) based arrangements are of on the spotlight. This research explores the use of AI and 5G technologies to help alleviate the effects of COVID-19 spread. The novel approach is based on the premises that the COVID-19 vaccine may take years to rollout effectively, whereas the AI and 5G technologies offer effective solutions to reduce the Covid-19 spread within weeks. Currently, the approaches such as contact tracing and virus testing are not secure and reliable; and the cost of testing is high for end users. The proposed solution offers a self-diagnostic mechanism without any security risk of the users' data with very low cost using cloud-based data analytics using mobile handsets.

Keywords: COVID-19, Pandemic, AI, 5G, e-Health

1 Introduction

The COVID-19 is a contagious virus family named *Corona viridae*. It is a family of positive-sense RNA, single-stranded viruses. This virus causes the ailments of fever, fatigue, cough and difficulty in breathing by attacking the respiratory system of its victim. The actual source of this virus is still undefined but, the scientists have mapped the sequence of its genome and identified the virus as the member of COVID-19 family with genera of β-CoV and originates its foundation of genes from rodents and bats [1]. The first reported case of this virus to affect the human life was reported in December

2019 from the city of Wuhan in China's province of Hubei. Since then, the COVID-19 virus is spreading like a wildfire throughout the globe and has affected 213 countries and independent territories, and caused 3.5 billion people to stay in some form of self-isolation or restrictions. Around the globe, as of in the second week of November 2020, there have been over 60.5 million confirmed cases of COVID-19, including over 566,355 deaths, reported by the World Health Organization (WHO) [2]. Figure 1 depicts the statistics of the worst affected countries, the total number of cases and tally of fatalities in those countries, respectively. This exponential rise in the number of cases of COVID-19 has stimulated the necessity for instantaneous countermeasures to curtail the cataclysmic effect of the spread. This paper evaluates the role of Artificial Intelligence (AI) and Fifth Generation (5G) telecommunication essential in mitigation of the opposing effects of this outbreak and aid in the recovery phase.

As per the report of W.H.O, the infections due to the different types of Corona viruses are continuously emerging and posing severe community health issues [1].

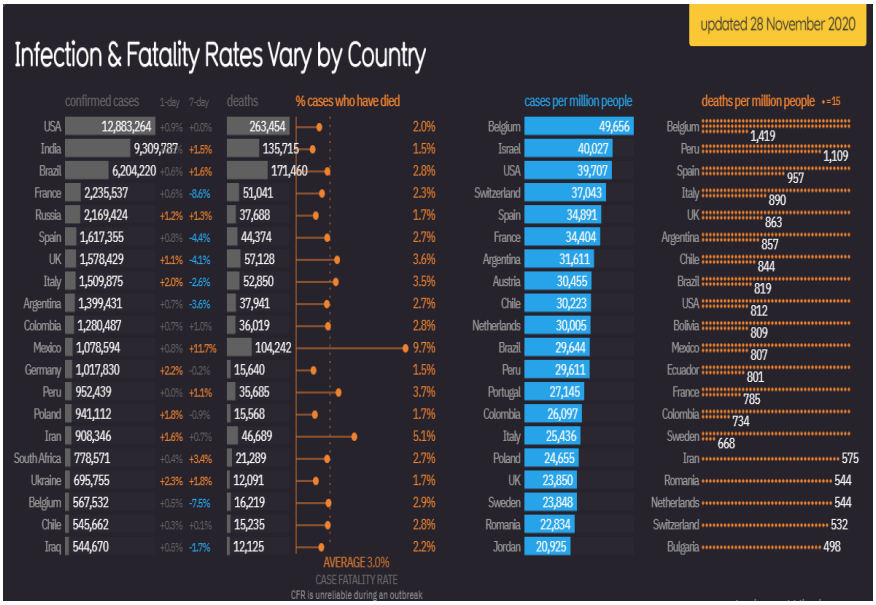

Fig. 1. Statistics of worst affected countries

The rest of the paper is arranged like this. In Section II, we discuss existing status of ongoing activities by researchers on the COVID-19 epidemic. In the following sections, we provide an all-inclusive overview of the use of AI and 5G technologies as a way to effectively manage COVID-19 pandemic. The last section will conclude the paper with the presentation of smartphone-based framework for self-diagnosis which can help in and reducing the COVID-19 spread.

2 Related Works

After the outbreak of COVID-19, different laboratories, researchers, scientists and organizations worldwide were being prompted to conduct the wide-scale research to aid the development of vaccines, drugs and other treatment methodologies. However, there is very less literature available that attempt to provide the role of 5G and AI technologies on the management of COVID-19 pandemic. This presents the need for research which provides every possible view of the COVID-19 in terms of clinical aspects, prevention methodologies, diagnosis and possible treatments to determine the role of technologies to assuage the impact of its outbreak.

3 Incipient technologies for extenuating the influence of the covid-19 pandemic

As the spread of novel COVID-19 continues around the world, the nations are staggering under the weight of struggling economies and other socio-economic setbacks. Sadly, billions of individuals are as yet under a consistent danger of the virus, with the situation not showing any signs of improvement in the immediate forthcoming future. Notwithstanding, an entire host of innovative ideas has been proposed to manage the challenges of the COVID-19 pandemic. Among them, advanced technologies such as AI and 5G have been considered [3]. As per the WHO and the Centers of Disease Control & Prevention (CDC) in the US, advanced technologies can support general public health based on the positive response to the COVID-19 pandemic. In the accompanying segments, we present the previously discussed technology advances in mitigating the COVID-19 pandemic.

3.1 Artificial Intelligence

Since the advent of AI, it has proved to be a milestone in technological advancement. AI can be standing as an extremely effective instrument against the COVID-19 pandemic if used properly. Early detection with AI can reduce the spread of COVID-19 by 40% [4]. Surveillance of ailment, prediction of COVID-19 spread risk, clinical diagnosis and screening, identification of the source hosts, and enforcement of the lockdown measures are some of the genuine measures by which AI can help the government and relevant administrations towards combating COVID-19 challenges.

Contact Tracing. Containing the COVID-19 virus has proven successful with aggressive contact tracing and isolation of suspected or confirmed cases. Published literature have suggested that digital rather than manual contact tracing might be more effective in containing the pandemic.

Contact tracing is a significant process to help decrease the frequency of new instances of virus. Contact tracing applications are being created to help fighting COVID-19 in public and with worldwide scope, such as CovidSafe App in Australia, TraceTogether App in Singapore, StopCovid App in France, and the Application Programming

Interface (API) offered by Google and Apple. In all the applications referenced above, the government control the clusters data and have access to the information's. The data accumulated by Apple and Google, which permits information exchange between mobile phones on iOS and Android frameworks, has incredibly supported contact tracing and determining people who are tested positive with COVID-19. In Canada, the COVI application was created which uses AI towards contact tracing to help the administration of general health strategies. With AI trend of COVID-19 spread can be generated, the infected person data can be used for back tracking for the source and potential outbreak from the infected person while tracing all his contacts.

Monitoring of Ailment. The appropriate forecast and monitoring of the virus is essential. Blue Dot (B-Dot), a health surveillance company based in Toronto was successful to report and impend the outbreak of COVID-19 on December 2019, 9 days prior to W.H.O. announcement. Computer based intelligence model of B-Dot use different AI devices to recognize developing aliments. This AI model of B-Dot had the option to follow the spread of the COVID-19 and figure its episode a long time before the other human associations.

Risk Prediction. One of the possible boulevards of application of AI against COVID-19 is prediction of risk. The AI model for risk prediction of getting infected by disease would be very complex due to the fact that, this model will depend on various functions such as age, medical history of person and his/her family, recent health status, diet habits, hygiene and existing medical history etc. Prolific outcomes cannot be expected from this model if we model it directly using mathematical models of these aforementioned functions. However, more reliable and precise risk prediction profile can be generated as more all-inclusive analysis of all the functions with AI techniques are incorporated.

Diagnosis and Screening of Patients. Swift identification of the COVID-19 patients can permit governments to acquire effectual reaction procedures to stop the diseases from further spread. The global scarcity of testing kits has made it difficult for the establishments to bear out across-the-board diagnostic testing. Numerous available AI gear are being repurposed, while some new ones are being worked to address this problem. For example, 93% of the Shanghai population was tested with AI based quick scan. In this subsection, we inspect how AI is changing the cycle of COVID-19 infection screening and diagnosis.

Face Scanners. Since Various hospitals, medical centers and heavily crowded areas such as malls, airports etc., are using cameras with AI based scanning technology to decrease the exposure of COVID-19 victims to front line personnel [5]. These AI based cameras not only can monitor the temperature of individuals in crowded areas but can also enable authorities to analyze their movement with face tracking.

Medical Imaging. Various efforts have already been made to deploy AI based medical imaging and screening of COVID-19. For example, a collaboration of an Ontario-based AI start up with the academic researchers of University of Waterloo has come up with

a Convolutional Neural Network (CNN) to identify COVID-19 using chest X-Rays. They named their AI model as COVID-Net and calculation for the framework is made open source by the makers to encourage the improvement of AI instrument over their model.

Enforcing the Lockdown Measures. Several nations and states around the globe, including USA, India, China, and the UK, are using AI-based technologies to enforce social segregation and lockdown processes. One of the largest AI-based companies in China has infrared cameras operated by computers that monitor public spaces. These cameras can not only detect people with high body temperature, but through their facial recognition system, they can also distinguish citizens who do not follow lockdown procedures. The first launch of AI in the USA - Landing AI, given to one of the world's top AI connectors - Andrew Ng developed a public awareness tool similar to contact tracing tool used in Australia and Singapore [6].

3.2 Fifth Generation Cellular Technologies

Fifth Generation Cellular Network, which is commonly known as 5G, is wireless cellular technology [7]. 5G is able to support mobile communication worldwide. 5G has a potential of revolutionizing the healthcare sector like its concomitant technologies such as the Internet of Medical Things (IoMT), AI and Blockchain. The response mechanism of COVID-19 pandemic in China is already transformed by the commercialization of 5G technology. 5G is capable of providing better assistance to the frontline medical staff and government authorities for contact tracing as well as able to facilitate the virus tracking, patient screening, data analysis and data collection. With Network slicing emergency services can be prioritized with 5G, high throughput, low latency, more connections, network efficiency and spectral efficiency will help to deal with COVID-19 type of pandemic with help of 5G. In this subsection we will discuss the different ways, in which 5G technologies has assisted countries impacted by COVID-19 pandemic. 5G with help of other digital technologies like IOT, Big Data, AI and blockchain can be used for monitoring, detection, protection, surveillance and mitigating of COVID-19 [8].

5GC **Telemedicine.** The practice of keeping distance from patients of disease while monitoring them is supported by telemedicine. While the use of drones, smart phone accessories, and mobile apps can provide telemedicine functionality, 5G network technology can enable that functionality. Different emergency clinics in China have introduced 5G telemedicine screens for COVID-19 patients. For instance:

- West China Hospital has propelled the Corona infection 5G-C broadcast communications stage with the help from China Telecom.
- An emergency health facility partnered with Kunming Medical University has propelled an online 5G-based demonstrative stage and free COVID-19 management therapy [9].

5G Medical Imaging. Recent medical imaging processes such as Photo Archive and Communication Systems (PACS) have been identified as an important part of testing and management. Cloud based CT scan were used as an alternate of RT-PCR tests and smartphone surveillance was a key method used for contract tracing. At a particular emergency clinic at the Wuhan Center, Leishenshan Hospital, 5G-empowered clinical stages take into consideration ongoing conclusion of COVID-19 patients, and in doing as such, diminish the workload on clinical staff [10].

5G Thermal Imaging. Thermal imaging technology, originally designed to protect anti-aircraft equipment, is now in full swing in the health care sector, where it has been shown to be particularly helpful in COVID-19 management. The development of 5G networks has facilitated the development of 5G enabled user systems that can have multiple health protection and care systems. The 5GC IR progressed checking framework can empower continuous temperature of moving bodies with more prominent exactness and accuracy. The information gathered by the projects can be moved to the focal test framework through Ultra-low inactivity utilizing 5G systems. With the coming of COVID-19, this activity could mean checking the clock's open temperature. In China, 5G warm hopeful frameworks have been incorporated into robots and Unmaned Arial Vehicles (UAV), which are appropriated in open regions of a few urban areas to lessen the spread of COVID-19 [10].

5GC Robots. Following the spread of COVID-19, a few endeavors have been made worldwide to create and convey robots to lessen the workload of first-line health authorities. This segment centers chiefly around ground-breaking 5G robots. Notwithstanding having extra usefulness, 5G-empowered robots are commonly more proficient at performing errands allotted to them as robot will be working with low latency and high bandwidth which is only possible with 5G technology. Robot can be used for disinfection of surfaces, temperature testing, food delivery and medicine delivery to infected peoples to reduce the direct contact of medical staff.

Thailand's deployed 5G Robots. In Thailand, Advanced Info Services (AIS), the world's biggest versatile administrator, has introduced 5G innovation in different approaches to battle the COVID-19 flare-up. AIS has introduced 5G systems in 20 medical clinics and conveyed a few 5G robots to assist medical clinics with extending their broadcast communications offices. Apart from acting as a connection with medical staff and patients, these robots can perform autonomous health examinations [11].

Wuhan's Cloudminds' 5G Robots. A field clinical facility, with various 5G-engaged robots, opened in Wuhan, China. These robots, given by a Beijing-based association called Cloud Minds, can clean and disinfect the zone, pass taking drugs to patients, and measure their temperature. The workplace, for the most part known as Smart Field Hospital, has used the use of other IoT devices to lessen the workload on the center staff. Patients at the center wore wristbands and arm groups agreed with the Cloud Minds 'man-made insight stage so medical specialists could continue watching their patients'

basic signs, including temperature, heartbeat, and blood oxygen levels, without requiring steady physical contact with them [12].

Patrolling Robots in Several Cities of China. A robot organization situated in Guangzhou, China deployed robots with 5G connections along with AI, IoT, and distributed computing. These robots have five infrared thermometers and high-end cameras that permit them to gauge internal heat levels of up to ten individuals concurrently. Furthermore, using characteristic sensors, these robots can decide if an individual is wearing a mask or not. At whatever point a robot experiences an individual who isn't wearing a mask or has a high fever is quickly alerted to the nearby specialists. These robots have been circulated in open territories of numerous Chinese urban communities, including Shanghai, Guangzhou, and Guiyang [13].

Challenges. Since the spread of COVID-19, various technological arrangements have been proposed to decrease its effect. Among them, IoT, drone innovation, and AI are at the bleeding edge. To understand the groundbreaking capacities of this innovation, there is a requirement for a portable system that can beat transfer speed, idleness, and adaptability issues related with current system innovation. The capacity of this lays on the up and coming age of portable systems. The combination of devices, for example, UAVs, robots, and 5G-with zero contact. Currently, however, the use of 5G networks faces a number of challenges, some of which are discussed below:

- With the launch of 5G is still in its early stages, one of its difficulties is the absence of foundation to help its tasks. Furthermore, the significant expenses related with the establishment and upkeep of 5G systems have made worldwide transportation hard for governments and telecom administrators.
- 5G systems cannot impact the health sector by itself. They can just appear to work, when utilized pair with other accessible advancements, for example, Internet of medical things (IoMT), AI, and distributed computing.
- Currently, there are no agreed rules overseeing the utilization of gathered patient protection utilizing 5G social insurance frameworks. Apart from information classification, a couple of other security issues identified with utilization of 5G are yet to be settled. While the far and wide applications of 5G systems in the social insurance industry may take few years, a developing number of clinical establishments are thinking about 5G-empowered wellbeing frameworks to improve clinical assistance quality and patient experience, diminish clinical consideration costs, and lessen trouble on human services [14].

5GC Internet of Things. With Internet of things, there will be millions of connected devices and sensors in smart cities which is not possible with 4G network as per GSMA. Mobile IOT is considered the trusted IOT and sensor data can be transmitted to cloud solutions with help of 5G networks. With IOT contact tracing, robotic interviews, crowd temperature sensing with cameras, use of drones for surveillance and IOMT for medical Internet of things are few examples to help and reduce the COVID-19 spread

[15]. This kind of technology advancements bring up astonishing possibilities outside the pandemic scenario. Some examples are IoT based electrocardiograms that can be used to detect early arrhythmias [16] and other systems with the goal to improve the accessibility to health records [17, 20] and even predict web page accesses, which can benefit the health industry [18, 19].

3.3 A Proposed Framework for Covid-19 Management Using AI & 5G

Future management of the COVID-19 and similar virus can be done with the help of mobile device. End user can have full access to their own assessment and tracking without going to medical centers and hospital for testing. Accessing and storing personal data on cloud can help to combat spread of COVID-19. Similar to patient fall detection technologies implemented by Apple and researched almost a decade ago, the individuals' mobile handset data will be easily available which can be used for diagnosis of COVID-19 virus. The current diagnostic process is expensive and not available for everyone especially in remote areas of third world countries. Likewise, in advance economies like Australia and Singapore, the end users were reluctant to use the tools like contact tracing. Therefore, this proposed solution is more cost effective and easily available to everyone. Comparison of voice and photos with AI based apps can help the patient to monitor and diagnose the symptoms of COVID-19 virus. A high-level framework and journey of COVID-19 control is presented in Fig 2.

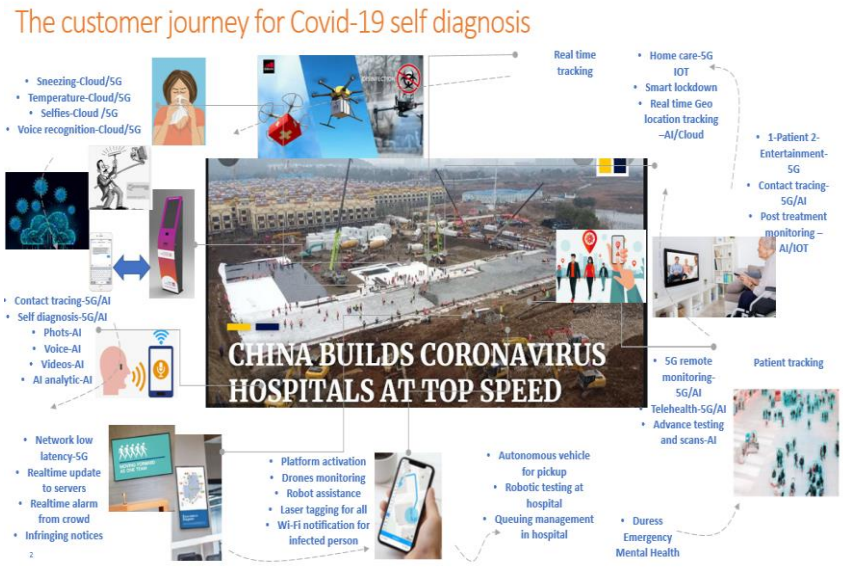

Fig. 2. Covid-19 self-diagnosis system

The framework explains the process from the initial symptoms to the post treatment. Each setup in the framework is linked with use of Cloud, AI, 5G with smartphones. The

tracking, monitoring, diagnosis, robot control, patient tracking, in room entertainment, homecare the contact tracing etc. are all dependent on use of smartphones with cloud computing platforms.

The proposed framework consists of Smartphones, 5G network, Cloud computing storage, AI analytic using the data collected from the smartphones and finally linking it to the government databases like census data, demographic of people living in a geographic area and then pushing the data through mobiles apps to the users again for self-diagnosis.

The smartphones will have the capabilities to run the analytic from cloud in real time using the high speed 5G networks. The cloud storage will have enough storage for photos, voice recording, and health data uploaded by the end users. The data analytic part is the most critical one as mobile phones will be used for uploading the data to cloud and retrieving the data from cloud but the AI analytic will be done using the cloud computing.

A high-level data flow is given in Fig 3 below.

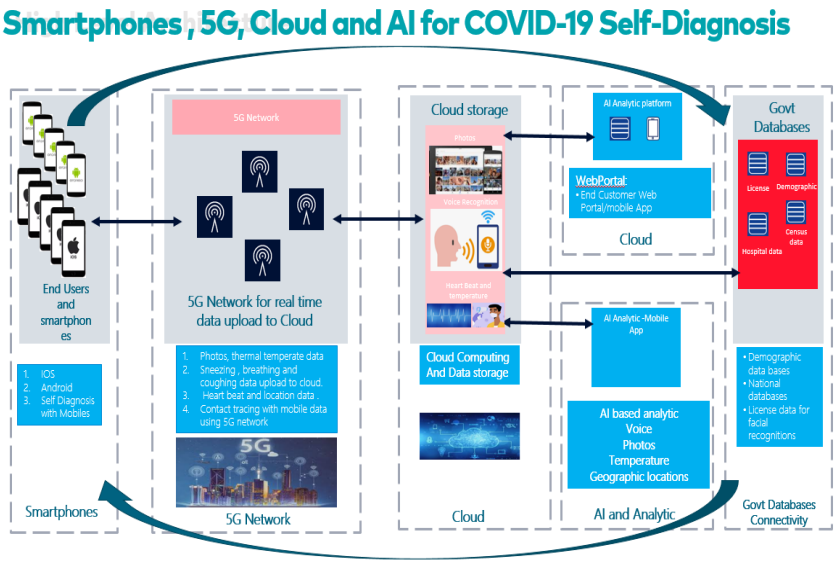

Fig. 3. Data flow for self-Diagnosis using smartphones

1. Image processing with comparison of selfies: similar to crowd monitoring with high-definition fever detection thermal imaging system, in the future this can be done by mobile phones with help of AI, old selfies and new ones can be compared to identify infected people and end mobile users will be able to compare old photos from google cloud, this will allow mobile user to self-identify and diagnose the COVID-19 symptoms. Just like Google photos are uploaded and kept on google drive by end users, the selfies and AI based algorithm can be used to run a comparison of the photos and generate the reports. Similar to Thermal imaging

cameras by Remark Holdings, Feevr, FLiR, UniView, Hikvision, Chubb Fire & Security, Bytronic Automation, Athena Security have launched thermal security cameras for fever detection for crowd monitoring but deployment of these at a high scale is impossible. Smartphones specially IOS and Android with AI, thermal cameras and combining the contact tracing, voice recognition with AI, facial recognition and apps like Therm-App and FlirOne can be used to upload the real time data to cloud with high speed 5G network and AI based computing on edge of the 5G for fast analysis and results.

2. Voice recognition and comparison for breathing difficulties, sneezing and coughing. The banking sector in Australia is already using voice recognition for customers verification and same technology can be used to store the personal data to cloud and run the AI based analysis for COVID-19 symptoms detection. The smartphone users can manage the recoded data and compare it with old calls for self-detection. The sampling of infected people can be used to optimize the AI based tool for better prediction and further research in this area can be focused by government similar to contact tracing apps. The focus is on smartphones, real time data transmission with 5G network and AI based application on public cloud for storage and analysis purpose of voice recoded.
   The end users' voices call, and data will be recorded in the cloud storage. Comparing the old calls with new recorded calls from cloud to compare the sneezing and coughing during a fixed duration of two calls may detect the symptoms of COVID-19. Mobile users will be able to run a report with their phones apps and self-diagnose the problems.
3. Temperature sensing while on call and holding the phones. Mobile phones will have the built-in sensors to keep the temperature history data similar to walk and exercise data on phones. Now we can check the total steps and history for many years using our Android or IOS mobiles. Similar data will be stored and can be used to diagnose the COVID-19 symptoms.
4. Temperature sensing from selfies and photos using the built-in apps with thermal cameras and health data from mobile history stored on cloud. While keeping the photos and data on cloud, mobile users will be able to use the thermal image processing to check the temperature changes and track and monitor the COVID-19 virus.
5. Heart beat comparison with normal and infected person. Using the smartphones apps specially built for COVID-19 the infected people with history of heart problem can compare the heart beat in conjuction with the temperature and voice recognition tools. AI, Cloud and 5G will be the key tools for processing the data in real time.
6. Social distancing alarms with mobiles and keeping track of full day report using Wi-Fi and cellular technologies for connecting to nearby devices.
7. People counting, location tracking, geographical movement, international traveling and all other kinds of travelling history can be available from telecom operator's big data, and end user will have full control of managing their own data.

4 Conclusion

As the individuals around the world keeps on understanding the effect of COVID-19 pandemic, blending endeavors of an assortment of cutting-edge advancements, for example, AI and 5G, are trying to minimize its adverse impact. Recognition of that as the supporting of this exertion, we present the absolute most up to date approaching on the COVID-19 pandemic. This paper begins with a comprehensive appraisal of the COVID-19 itself, in which we see the sights of its clinical highlights, transmission system, and diagnosis techniques. Following this, we list the different treatment endeavors being made to stop the pandemic and the preventive measures to be followed till the time that is conceivable. Finally, we propose the use of cutting-edge advancements in AI and 5G to self-manage COVID-19 using mobile handsets. Until a formidable solution for COVID-19 is presented, the responsibility to self-regulate and manage this pandemic may be undertaken with the use of our smartphones on a very basic level using the benefits of Cloud, AI and 5G.

Acknowledgment

The statements made here are the sole responsibility of the authors.

References

1. Cascella, M., Rajnik, M., Cuomo, A., Dulebohn, S.C., Di Napoli, R.: Features, Evaluation, and Treatment of Coronavirus. , Statpearls [internet], StatPearls Publishing (2020).
2. WHO: Coronavirus disease (COVID-19) pandemic. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019 on July 25, 2021 (2021).
3. Bakshi, S.K., Ho, A.C., Chodosh, J., Fung, A.T., Chan, R.V.P., Ting, D.S.W.: Training in the year of the eye: The impact of the COVID-19 pandemic on ophthalmic education. Br. J. Ophthalmol. 104, 1181–1183 (2020). https://doi.org/10.1136/bjophthalmol-2020-316991.
4. Zhong, L., Mu, L., Li, J., Wang, J., Yin, Z., Liu, D.: Early Prediction of the 2019 Novel Coronavirus Outbreak in the Mainland China Based on Simple Mathematical Model. IEEE Access. 8, 51761–51769 (2020). https://doi.org/10.1109/ACCESS.2020.2979599.
5. Obeidat, S.: How Artificial Intelligence Is Helping Fight The COVID-19 Pandemic. Entrep. Middle East. 19–21 (2020).
6. Naudé, W.: Artificial Intelligence against COVID-19: An Early Review. IZA Discuss. Pap. (2020).
7. Qualcomm: Everything you need to know about 5G . Q : What is 5G ? , Retrieved from https://www.qualcomm.com/5g/what-is-5g on July 25, 2021 (2021).
8. Ting, D.S.W., Carin, L., Dzau, V., Wong, T.Y.: Digital technology and COVID-19. Nat. Med. 26, 459–461 (2020). https://doi.org/10.1038/s41591-020-0824-5.
9. Chunming, Z., He, G.: 5G Applications Help China Fight Against COVID-19. China Acad. Inf. Commun. Technol. 1–4 (2020).
10. Deloitte Consulting: Combating COVID-19 with 5G Opportunities to improve public health systems. (2020).

11. Tortermvasana, K.: AIS uses 5G, robots in pandemic war. (2020).
12. Charles, A., Ruan, S.: In China, robot delivery vehicles deployed to help with COVID-19 emergency | UNIDO. (2020).
13. Happich, J.: 5G edge patrol robots deployed in China to detect Covid-19 cases. (2020).
14. Li, D.: 5G and intelligence medicine—how the next generation of wireless technology will reconstruct healthcare? Precis. Clin. Med. 2, 205–208 (2019). https://doi.org/10.1093/pcmedi/pbz020.
15. Vaishya, R., Haleem, A., Vaish, A., Javaid, M.: Emerging Technologies to Combat the COVID-19 Pandemic. J. Clin. Exp. Hepatol. 10, 409–411 (2020). https://doi.org/10.1016/j.jceh.2020.04.019.
16. J. He, J. Rong, L. Sun, H. Wang, Y. Zhang, J. Ma. A framekwork for cardiac arrythmia detection from IoT-based ECGs. World Wide Web, 23 (5), 2835-2850, 2020.
17. F. Khalil, H. Wang, J. Li. Integrating Markov model with clustering for predicting web page accesses. Proceeding of the 13th Australasian world wide web conference (AusWeb07), 63-74.
18. P. Vimalachandran, H. Liu, Y. Lin, K. Ji, H. Wang, Y. Zhang. Improving accessibility of the Australian My Health Records while preserving privacy and security of the system. Health Information Science and Systems, 8 (1), 1-9, 2020.
19. S. Supriya, S. Siuly, H Wang, Y Zhang. Automated epilepsy detection techniques from electroencephalogram signals: a review study. Health Inf Sci Syst **8,** 33 (2020). https://doi.org/10.1007/s13755-020-00129-1.
20. R. Sarki, K. Ahmed, H. Wang,. Y Zhang. Automated detection of mild and multi-class diabetic eye diseases using deep learning. Health Inf Sci Syst **8,** 32 (2020). https://doi.org/10.1007/s13755-020-00125-5.