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Blockchain and Artificial Intelligence Applications to Defeat COVID-19 Pandemic

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Abstract: The rapid emergence of novel virus named SARS-CoV2 and unchecked dissemination of this virus around the world ever since its outbreak in 2020, provide critical research criteria to assess the vulnerabilities of our current health system. The paper addresses our preparedness for the management of such acute health emergencies and the need to enhance awareness, about public health and healthcare mechanisms. In view of this unprecedented health crisis, distributed ledger and AI technology can be seen as one of the promising alternatives for fighting against such epidemics at the early stages, and with the higher efficacy. At the implementation level, blockchain integration, early detection and avoidance of an outbreak, identity protection and safety, and a secure drug supply chain can be realized. At the opposite end of the continuum, artificial intelligence methods are used to detect corona effects until they become too serious, avoiding costly drug processing. The paper explores the application of blockchain and artificial intelligence in order to fight with COVID-19 epidemic scenarios. This paper analyzes all possible newly emerging cases that are employing these two technologies for combating a pandemic like COVID-19 along with major challenges which cover all technological and motivational factors. This paper has also discusses the potential challenges and whether further production is required to establish a health monitoring system.

Keywords: Artificial intelligence; information privacy; machine learning; coronavirus (COVID-19); SARS-CoV-2; epidemic

1 Introduction

COVID-19 was caused by the SARS-CoV-2 virus, the outbreak started in late 2019 and so far this infectious disease has affected millions of people around the globe. Due to severity levels of this disease,

the World Health Organization (WHO) announced this outbreak as global health crisis on 11 March 2020. The alarming level of this virus spread dramatically and influenced many sectors like healthcare transport, industry, agriculture, education; bringing economy activity to standstill as the only means to break the chain of human- to-human transmission. This pandemic has triggered the lowest growth in economy and the biggest recession of the century. Some extraordinary polices are needed by the governments around the world to navigate this crisis and reverse the recession and – shape the economic and social prospects of the coming decade. The World health organization has also recommended several protective measures like social distancing of 1 meter, wearing masks, cleaning hands frequently, avoid the 3c's that is avoid closed, crowded and close contact and try to stay home to stay safe, as the best means to combat the spread of this disease.

Pandemic has put immense pressure on the healthcare sector and others beyond their capacity. Every possible attempt is being made to ensure help for victims. Apart from these noticeable attempts to handle these problems, further technology empowered solutions can have a great potential to deal with the worldwide health crisis. Blockchain solutions integrated with artificial intelligence technology could have the answers towards identifying, tracing and minimizing the effects of coronavirus. The blockchain solution can be a pivotal technology in the early detection of outbreaks, fast tracking of drugs which is being supplied and the user privacy protection during COVID-19 duration. Moreover AI integration will also provide intelligent approach towards symptom identification and support drug manufacturing. As a means to prevent the coronavirus health crisis, the blockchain and AI may be the key enablers for continuously changing landscape of the present crisis and its management.

1.1 Motivation of Using Blockchain and Artificial Intelligence for Fighting Coronavirus

1.1.1 Limitations of the Current Healthcare Systems

The COVID-19 outbreak has exposed a bleak picture of the public health systems and underlined several shortcomings. Presently, there is no any healthcare surveillance in our healthcare systems that could routinely gather, assess, observe and disseminate data on a health incident for use in public health screenings. Had there been such mechanisms in place, they could have been utilized to keep a track of infectious diseases such as COVID-19, identify disease trends, and detect epidemics and further investigations. A credible source of data is gathered for the possible detection of COVID-19 outbreaks so that correct results can be monitored. Another shortcoming is the coronavirus test technique, which really is a slow process, which can take hours or even days from the retrieval of the sample to the result. Thus, it's a time-consuming process and more difficult to find the disease pattern. Yet another major problem is the security of the privacy of public health records which requires that private information to residents cannot be released without their concern. A feasible solution is therefore needed to track the spread of coronavirus while providing personal data to the patient in better recognizing the emergency situation of the epidemic [1].

1.1.2 Benefits of Using Blockchain and Artificial Intelligence in Containing the Spread of the Coronavirus

Blockchain integrated with AI provide a suitable platform for dealing with issues related to tracing and isolating Corona cases and developing effective medications. Blockchain has already proven to be highly advantageous in all aspects of human life; this success encourages the implication of blockchain in containing the spread of the pandemic as well.

Blockchain would be a key enabling technology for tracking coronavirus outbreak rapidly through early detection of symptoms prior the transmission of the infectious disease at the epidemic level. Moreover, blockchain technology gives the advantage of protecting the privacy while tracking the data of the afflicted patients. Blockchain enabled platform, if applied in clinical trials, will ensure the necessary data collection while maintaining the patients' proprietary information. It could be useful in speedier approvals of new therapies so as to reduce the counterfeiting and also minimize the overall expenditure incurred in the process.

Another innovative technology which will also be helpful in quelling the coronavirus pandemic is the Artificial Intelligence. AI could predict the number of new cases and hot spots area of coronavirus so that the travelers can follow safety measures, wear masks, observe social distancing, quarantine to control the spread of coronavirus . AI can be leveraged to help to curb the coronavirus outbreak. Whenever the disease outbreak happens, the crucial phase is to collect the clinical information pertaining to the patients, logistical information and physiological states, critical information and other relevant information from trusted resources [2]. In such situations, AI can help in multi-dimensional ways. AI can be a highly accurate and credible mechanism for identifying those events which can give the answer of unknown questions about the nature of virus. Another possible advantage of AI is that the technology is less time consuming and energy saving. Thus, the health experts can focus on how to deal with the infectious disease risk instead of spending their energy and time on the collection and organization of data.

Artificial Intelligence has become a powerful tool to monitor and track the global spread of the coronavirus outbreak. AI based algorithms are generating very similar results with the real time information for public health official to track the spread of coronavirus.AI can be used to identify, predict, track disease outbreaks and to diagnose of the disease. AI also has the predictive capabilities for proposing drugs which can be useful in curing the disease. AI can be used as tool to identify the drugs, by studying the molecular structure of existing drugs which was developed to fight with other diseases but which could now be repurposed to take on coronavirus. The aim of integrating AI solutions in to health domain is to establish relationship between techniques opted for treatment and patient specific outcome of that treatment. AI based solutions have strong potential towards fields like diagnosis, drug development, personalized medicine and better patient monitoring. AI techniques can also be deployed in better future predictions and management of epidemic like coronavirus under prescribed clinical guidelines.

1.2 Contribution

The objective of this research work is to include a detailed study of possible integration of blockchain and different AI based techniques towards the management and distribution of pandemic like health exigencies. Current literature also lacks concerted and thorough analyses of the usage of innovative technologies like blockchain in combination with various AI techniques to curb coronavirus outbreaks, which has prompted this work. This research work offers a roadmap for researchers by exploring exciting research opportunities related to integration of blockchain and AI for coronavirus management. This paper introduces application of a blockchain and AI approach for monitoring the spread of Coronavirus, defining high-risk areas and potential of these new technologies to detect and identify the infection at its early phases. The contribution of current work is as follows:

- Authors are developing a strategic base infrastructure that facilitates the incorporation of blockchain and AI to identify key solutions and better management of the pandemic
- Several applications have been cited in this study that demonstrate the use of blockchain and AI to solve the problems associated with the pandemic by illustrating the applicability of these technologies altogether through detailed study and discussion of various scenarios.
- The study reflects the new dimensions of blockchain and AI applications in combating the Coronavirus.
- Authors also recognize all potential major research problems and future dimensions to inspire various scientists and scholars to establish novel strategies to manage such exigencies in future.

1.3 Organization

The overall study has been defined in sections for better understanding. Section 2 de- scribes the system's model framework of blockchain and AI to prevent the spread of Coronavirus. Section

3 represents the evaluation of performance of the framework. Finally, Section 4 presents the concluding remarks and future directions in this context.

2 Literature Survey

This section cites the survey of various state-of-the-art studies conducted in this domain and provides summary of blockchain and AI based solutions as effective countermeasures against COVID-19. This paper offers a valuable source for research scholars and academicians who might have the intent to go through the blockchain and AI based solution in the scenario of pandemic. Research endeavors on integration of AI and blockchain have a moderately comprehensive description and are increasing rapidly. Thus, in this respect, the present study attempts to collate and demonstrate the recent research work, specifically in the field of healthcare for the conduct of further research activities.

2.1 Role of Blockchain in Coronavirus

In this section, the authors have addressed various methods to control the spread of coronavirus,

2.1.1 Disease Monitoring

Preventing new epidemics and containing the current infectious diseases remains an ongoing and challenging problem in healthcare. While all appropriate measures have been taken by the government to monitor the outbreak of the coronavirus, yet there are several difficulties in sharing the information with local and international health agencies because conventional systems are not capable of obtaining the reliable information. A very important matter to be dealt with is the privacy of the patients' information that must be protected.

It also offers insight in identifying and comprehending various trends in data for tracking coronavirus. Blockchain is a distributed database which contains data among the nodes of the network [3,4]. Every transaction in the distributed ledger is unique with a time stamp and hashed value which makes the ledger unique. Blockchain assures features like mutual ledger, trust, record keeping, documentation and validation. Coronavirus outbreak has a major impact on the data collection process. Blockchain may serve as a stable and reliable solution in addressing client records in the healthcare sector. It produces real time data on where the infected individuals are and where those that are symptom free live. Such data can be circulated around the world and published on blockchain at regular intervals. Based on risk profile, the lists of green zones can be updated so that sufficient quarantine zones can be created in order to protect people affected by viral outbreaks. In order to avoid the virus from spreading, people should be more vigilant as to who is entering the quarantine center. They need to be given proper training on infection control measures. In this case, the correct and reliable data are important in order to understand the spread of coronavirus. Blockchain provides the simple access to such health data, making the containment of the outbreak a highly efficient process [5].

Blockchain is a potential tool to provide a secure and reliable source for government and health centers to track health records of the patients [6]. It generates the real time data about the infected zone and infection free zone as well. In the wake of such outbreaks, information about virus free zone can be regularly updated on blockchain. Based on the risk profile, the list of green zones can be updated on a weekly basis or earlier as required so that appropriate quarantine arrangements can be made available for the infected. Preventing and controlling the infection in such quarantine centers is a strategic point. Such centers need to be identified including the details of all the persons entering inside quarantine premises to get proper awareness and training on infection measures otherwise the of movement and activities performed in quarantine buildings may become the cause of infection in the other healthy persons as well. Thus to monitor and control the transmission of coronavirus, accurate and reliable data are required. Blockchain technology

allows the quick access to such data, the control of the epidemic becomes manageable, and the health authorities have a stronger crisis management strategy in place [7].

There is one bigger problem which is the spread of misinformation on social media sites, which can be detrimental to people's wellbeing [8]. The internet has become the most resourceful source of information now and is accessible at ease. The survival of information in a system depends on the proper processing of the information. The government needs to alert social media on more or less impartial sharing of news about such a dangerous pandemic. Social media can be used to build awareness in such a situation about an outbreak of the coronavirus [9]. In this league, blockchain ensures the verification of data integrity, the immutability of data, and the updating of real time data. Blockchain will transform the future of health practitioners. Blockchain provides great reliability and security features [10]. Blockchain offers a highly secure network without chances of data falsification. In case of a pandemic, social media may play an important role in gathering information precisely. One major difficulty that most governments are facing is the inability to recognize and classify contaminated cases of outbreak of infectious disease. Features like decentralization, immutability, and openness can be of use in managing infectious disease [11,12].

2.1.2 Outbreak Tracking

In order to fight the pandemic, the government has taken a range of steps, such as most contaminated sites, set guidelines for the health professionals, identifying protection measures minimize population movements, raise awareness among people, and allocates care resources. This decision would have an effect on the transmission rate of corona virus spread (Fig. 1) [13].

Insight into the spread of the disease may help to respond effectively to the pandemic. In such situations, the government must act rapidly and effectively to save lives. Data will address the problem with a view to recognize vulnerable populations. However, when using data, modern technologies must comply with the Privacy Protection Regulations. Blockchain will be the solution to the privacy crisis during the war with Coronavirus.

In the event of a coronavirus pandemic, blockchain technology may be used to monitor the details of the COVID-19 victims [14]. It allows tracking of coronavirus incubation time and symptoms, location, patient's health history with privacy and accuracy. Blockchain al- lowed health records are time stamped chain blocks containing permanent records that avoid alteration and malicious attacks by intruders. Blockchain offers anonymity, confidentiality and protection in the sense of health related information that affects health professionals, government and consumers. Decentralized blockchain is permanent, which implies that the entered data is irreversible, regulated and monitored by all users in that chain of network.

Public health surveillance can be used to track disease patterns and epidemics, and in certain countries such surveillance is used to monitor the spread of COVID-19 [15]. Blockchain technology has the ability to improve disease monitoring networks in cases of disease outbreaks that result in local and global health emergencies. In addition, blockchain can be used to recognise health safety issues, analyze preventive measures and promote quick and efficient decision-making [16].

2.1.3 Medical Supply Chain

Blockchain can add trust, transparency and accurate end-to-end tracking in supply chain application for example it helps in record price, location, date, quality and other relevant information to effectively manage the supply chain. Such information is stored in chains of blockchain that can increase the traceability of material supply chain, improve visibility, offer new opportunities to reduce sourcing risk, improve stakeholder engagement, decrease administration cost and fast flow of supply to the origin to the destinations in a trusted and reliable manner [17].

The pandemic necessitated the demand of rare production items such as mask, sanitizers, gloves, face shields to a great extent. This scenario calls for flexible manufacturing system to fulfill the requirement of

such essentials [18]. To handle such requirements, the government, health institutions and manufacturing companies should be prepared beforehand to control the production of all such needed items [19]. A sufficient buffer plan should be developed that accounts for the prevalence of life saving items such as ventilators, vaccines, sanitizers and face shields. Blockchain technology is a feasible solution to track the demand and supply chains of medical supplies. Fast supply chain and prompt response is required to control the spread of Coronavirus out- break [20]. Blockchain technology is a cost efficient emerging platform to tackle such global health emergencies.

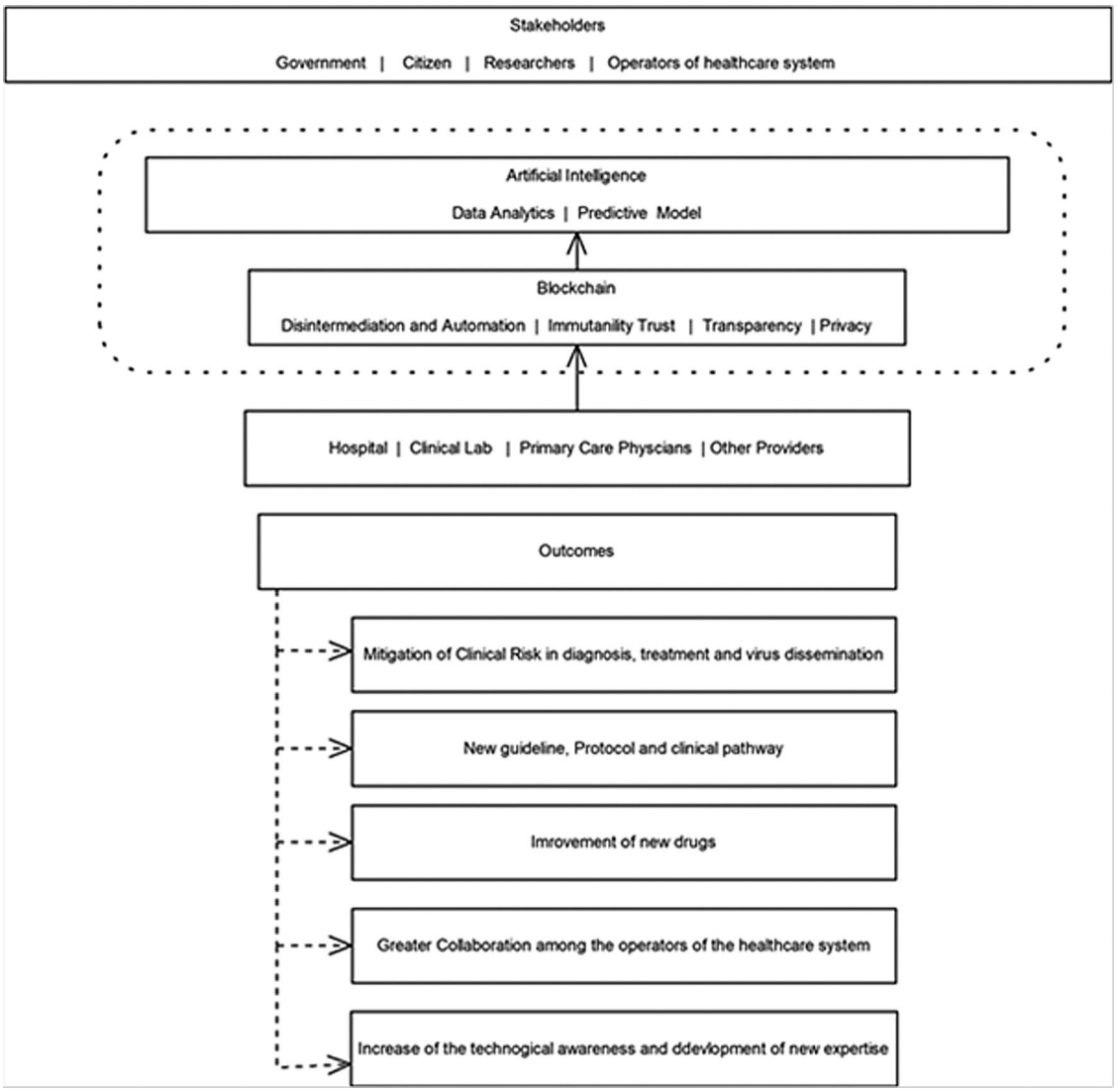

Figure 1: Role of blockchain and artificial intelligence in combating COVID-19

2.1.4 Donation Tracking

In current time, blockchain donation tracking application has shown its importance. Do- nation is one of the important ways to support financial health of health services for infected victims, but at the same time it is essential to track such donations as to ascertain whether the amount has been received for whom it was meant for. In coronavirus pandemic scenario, one of the major issues is the lack of transparency and accountability

surrounding the donation itself. To solve such massive problem in case of infectious disease, a donation tracking application on blockchain can be a feasible solution. Blockchain allows all the parties like health professionals, suppliers and charity organizations to monitor the progress of donation. Blockchain provides the ability to track exactly where the donations are going, when they arrived and who is/are the beneficiaries [21]. Bitcoin based charities use distributed ledger platform which gives ability to transfer, track and visibility across the globe.

2.2 Role of Artificial Intelligence in Coronavirus

This section defines the role of AI in containing the spread of Coronavirus. Artificial Intelligence applications have been used in this context with remarkable success. Different branches of AI have been utilized in a few disease outbreaks earlier. Artificial intelligence can assume a crucial part in the battle against COVID-19. Artificial intelligence is being used in identification of disease outbreak and its prospective reach, monitoring of inactive cases and disease spread, training program, identification of the pattern of spread of the disease [22]. Various applications of artificial intelligence in battle against COVID-19 are as follows:

2.2.1 Artificial Intelligence in Tracking COVID-19 Pandemic

Artificial intelligence is now becoming an effective tool for controlling and managing the COVID-19 crisis that has plagued the planet since the beginning of 2020. Several countries are developing advanced artificial intelligence tools and are using current technologies to track and manage coronavirus outbreaks (Fig. 1) [23]. These AI-based applications provide a surveillance system for detecting COVID-19 outbreaks, which may also be used by the general public to collect real-time updates on the incidence of disease in the population, which helps to recognize potential infectious zones and safe zones where they can travel [24]. COVID-19 monitoring tools or contact-tracking technologies are being developed at a rapid rate by various governments in their respective countries.

The online data obtained from suchan application is not widely disclosed and is only used by the government for reporting, monitoring and control purposes. These apps are designed in such a manner that, if they cross paths with a good individual they warn the user by a warning mechanism. With the aid of Bluetooth technologies and the Global Positioning System (GPS), tracking is carried out, revealing and notifying the user of interaction with anyone detected positive for coronavirus [25]. With the aid of GPS and Bluetooth sensors, it detects and tracks the motion of the device. It would also discover other nearby smartphones that also have an application enabled, and then send out an alert if they use their database and algorithms to contact infected individuals. The software also contains valuable guidance about how to self-isolate and what can be done if other individuals show symptoms. The application indicates that Bluetooth and localization services should be maintained at all times. In order to use the program, one must register with a mobile number by searching with a mobile number.

2.2.2 Development of Drugs and Vaccines

Through quickly analyzing vast volumes of study results, AI methods and strategies will enable decision makers and the medical profession to grasp COVID-19 and enhance treatment centric research [26]. The history, dissemination and detection of the virus, prevention steps, and lessons learnt from previous epidemics can be found in AI text and data mining applications. Deep learning models can help forecast old and experimental treatments or interventions that could be used to treat COVID-19.

Some companies used AI [27] to identify treatments and construct sample vaccines. By using the power of AI, the speed of exploration can be improved by several times.

2.2.3 AI Role in Reducing the Work Load of Health Workers and Medical Staff

By automating many processes such as educating clinicians, deciding the mode of treatment and care by analyzing clinical data using pattern recognition methods, digitalizing patient records and also providing solutions that minimize their interactions with the patient, AI based applications may help reduce the job workload of medical personnel and healthcare employees. Victims of coronavirus can be classified based on severity of their symptoms, clinical reports and can be grouped as mild, moderate and extreme, so that different measures can be taken to treat patients in the most appropriate manner. In telemedicine AI may also be used to eliminate the need for regular and unnecessary remote monitoring visits to hospital [28]. Some AI based medical Chabot's also help to curb COVID-19 by providing the consultation, thus reducing the physical crowding of hospital thereby preventing the spread of coronavirus. Many leading companies and organizations have been deploying Chabot's to provide COVID-19 information [29]. The WHO and CDC both have also launched Chabot's on their websites, offering instant and accurate information of COVID-19. Moreover AI is being used to enhance the quality of healthcare delivery and to solve previously intractable health concerns.

2.2.4 Early Identification of the Infection and Diagnosis

AI can evaluate abnormal symptoms rapidly and thus alert the patients and health authorities. It permits for quicker decision making in cost effective manner. It also helps to build models by using learning algorithms for a new diagnosis and management framework for the COVID-19 cases [30]. AI technology escalates the progress in medical diagnosis as well as possible treatment.

2.2.5 Monitoring the Treatment

AI can provide a platform for automated monitoring and prediction of the spread of COVID-19. In order to extract the visual features of this disease, a network can also be developed and this would help to properly monitor and treat the affected individual. It has the ability to provide patients with daily updates and also to provide solution to be followed in COVID-19 prediction [31].

2.2.6 Prevention of the Disease

AI will be helpful in preventing this disease at its early stages with the aid of real time data analysis. AI can be used in such situations to predict the possible sites of transmission, red zones of virus spread, need of beds and healthcare professions. AI is effective in potential prevention of viruses and disease in near future by analyzing the previous existing pattern of viruses [32–34]. It recognizes patterns, causes and triggers for the spread of infection. This will become an important technology for fighting other epidemics and pandemics in the future. It can provide preventive measures for many more communicable diseases and ways to fight with them in the future. Challenges

Bblockchain and Artificial Intelligence technologies are already being used to contain COVID-19. The overall survey, however, also reveals important problems and open concerns that should be carefully addressed when implementing these technologies in the context of epidemic healthcare [35–37]. The key issues and challenges are as follows:

2.3 Privacy Preservation

The highly essential application in coronavirus monitoring is to protect the privacy of individuals. To monitor the spread of the pandemic, the mobile applications data can be a solution but this approach must protect user data privacy, particularly sensitive information [38,39]. In comparisons to many hospital agencies and facilities today, electronic health records capture data from their patients that help track signs of the COVID-19 condition and help in recovery. In such healthcare operations, it is likely that the issues related to the users' privacy, which needs to be overcome by legislation and reinforced by relevant authorities, is inherent in such health practices.

2.4 Security of Blockchain and Artificial Intelligence Ecosystem

In COVID-19 scenario, blockchain is commonly considered as a secure surveillance tool to ensure healthcare protection and privacy application. Nevertheless, new study findings have exposed the underlying security flaws in medical and healthcare networks linked to blockchain. In order to manipulate the blockchain, data threats or competitors may access the blockchain app, which may contribute to severe consequences, such as modifying medical transaction or patients' personal details, thus increasing the privacy specific concerns. In the context of COVID-19 crisis, security is also a critical concern of artificial intelligence for healthcare implementation. Data gathered from various resources like patients, hospitals, pathology laboratories may be modified by unauthorized or unintended access [40,41]. In addition, malicious attacks can be carefully adjusted to enable the algorithm to misclassify, allowing the attacker to prevent detection, and training data can also be changed in a way that the training of the model leaves it weakened or inaccurate. Security concerns related to blockchain and artificial intelligence should therefore be given high priority during the design and development process when solving the healthcare problems. Lack of Unified Databases

The absence of a unified database related to Coronavirus pandemic is a critical challenge in the fight against coronavirus. Most of the new database linked to coronavirus comes from private channels, by emails, in closed group, and via messaging apps, social media and so on but they are not enough for large scale artificial intelligence operations that could have a greater effect on the battle against COVID-19 relative to the current findings. Global cases reflect the number of confirmed cases registered by countries. The ability and technique of laboratory research, thus the interpretation of the number of recorded events, should take this into account. In order to fight the spread of COVID-19 effectively, countries are therefore required to provide the data released by the WHO in this context. A community of experts, doctors, funding agencies and suppliers are required to provide appropriate a device for public health.

3 Concluding Remarks and Future Direction

We explore some of the potential study directions for the combat against the COVID-19 pandemic on the blockchain and artificial intelligence. In this paper we discussed in depth about how the emerging feature and advantages of blockchain and artificial intelligence technologies can be leveraged to battle against the COVID-19 battle. We evaluated the prospective blockchain technologies and cited how it plays a central function in battling against the health crisis as that of COVID-19 In this paper we have listed the main criteria for implementing the blockchain based healthcare emergency services network by various organization. AI helps in tracing the status of patients who are infected. By designing useful algorithms, it can greatly improve medication quality and decision making. AI is not only useful for the treatment of patients afflicted with COVID-19, but also controls their fitness. It will track the COVID-19 crisis at various levels, such as medical, molecular and epidemiological application. We addressed blockchain and Artificial intelligence based application recently established to incorporate numerous services related to data privacy and security, remote testing, automated communication tracing and remote healthcare monitoring of patients. We addressed many research challenges that delay the effective deployment of blockchain and AI based technology insight of COVID-19. Our main conclusion and future remarks include:

- Privacy, security, confidentiality, traceability and accountability, the advantages of blockchain technology will significantly aid authorities to formulate strategies to tackle the COVID-19 pandemic. For example immutable data relating to the outbreak of COVID-19 in a city can be used by authorities to better classify hotspots for infection. Entry to such vital knowledge will help the authorities devise strategies to block the further spread of the virus.
- The effectiveness of intelligent healthcare data analytics, the study of virus knowledge, depends mainly on algorithms of AI. Developing a medical application specific AI architecture may be the

secret to enable future intelligent data analytics with the potential to manage multimedia health data. In reaction to COVID-19, adaptive AI model should be built like patient monitoring should be developed.

- The efficiency of digital contact tracing solutions relies greatly on the speed of information gathered related to person location, travel history, and test results of COVID-19. It is strongly advised that contact tracing solutions should protect the privacy of user's de- tails. In solving epidemic related issues, blockchain and AI can be incorporated with other technologies to build secure and comprehensive healthcare systems.
- Blockchain infrastructure is designed to provide the parties participating in the supply chain of vaccine with a shared, accountable and interactive environment. The supply chain and logistics process will immensely benefit from AI and blockchain.

The most prominent current healthcare management is that of artificial intelligence and blockchain. To build the proper framework for an efficient and effective evidence based decision making process, the blockchain is gradually applicable to healthcare. Blockchain is a valid solution to secure data exchange between groups of people, regardless of their reliability and cross checking. With special attention to risk control, blockchain and artificial intelligence can be used in a modern workflow or in enhanced protocol. We may say, based on this that in healthcare, blockchain has a strategic position, particularly for safe clinical practice in fighting against COVID-19.

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