Insights of Artificial Intelligence to Stop Spread of COVID-19

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Abstract  COVID-19, a pandemic that has pushed down human civilization in a severe threat. As viruses of COVID-19 like diseases are transferable from human to human, so it becomes very challenging to stop spreading these pandemics. These challenges are not only limited to the treatment of infected patients but also maintaining systematic social distancing to stop spreading the disease. However, maintaining social distancing is not entirely possible everywhere, like in hospitals, emergency sectors, etc. Some critical issues such as: carefully handling the Intensive Care Unite (ICU), patient care, hygienic practice, and systematic social distancing have become very necessary to slow down the spread of the new virus as appropriate vaccines or drugs are not yet available. In this time of crisis, Artificial Intelligence (AI) could assists in many more ways in addition to assisting diagnosis, drug or vaccine discovery. Therefore, this AI, especially algorithms of machine learning, deep learning, and computer vision along with edge computing and IoT technologies could be smart solutions for such challenges. This chapter brings such solutions through some insights of AI to assist to stop these COVID-19 like pandemics.

Keywords  AI · Computer vision · COVID-19 · Deep learning · Edge computing · IoT · Sars-cov-2 pandemic
1 Introduction

A novel influenza corona-virus named ‘SARS-CoV-2’ is the reason for COVID-19 deceases [1]. Presently over 23 millions people are infected, and over 800 thousands died throughout the world and are increasing this pandemic rapidly. As it was spreading very fast globally since it’s first appearance Dec 2019 the World Health Organization(WHO) declared it a ‘Pandemic’ [2]. To cope with such unexpected pandemic, researchers from all over the world are trying hard to invent vaccines, drugs, equipment, forecasting models, etc. [3–5]. As viruses of COVID-19 like diseases are transferable from human to human, so it becomes very challenging to mitigate [6]. These challenges are not only limited to patient handling, treatment, and care but also maintaining systematic social distancing to stop spreading of COVID-19 [7]. However, maintaining social distancing is not entirely possible everywhere, like in hospitals, emergency sectors, etc. Some critical issues such as: carefully monitoring ICU room, patient care, monitoring hygienic practice and systematic social distancing have become very necessary to slow down the spread of the new virus as appropriate vaccines or drugs are not yet available [8].

Therefore, in this situation, we could be benefited from Artificial Intelligence (AI), as AI could do many more things in addition to assisting to diagnose and drug or vaccine discovery. These days AI has become popular mainly based on the recent success of machine learning, deep learning, and big data, and these are very successful in computer vision tasks [9]. Therefore, these AI techniques along with other technologies such as IoT, edge computing, data science, and sensor network could deliver possible smart solutions for cope with such challenges and stop spreading this deadly COVID-19 like pandemics. This chapter brings some insights thought of AI for assisting to mitigate some challenges mentioned above. This chapter also described brief relevant technical backgrounds and literature review of some current state-of-the-art. The main contribution of the chapter are:

- Describe some selective insights of AI to assist in stopping COVID-19.
- A review of some recent state-of-the-art that related these insights for knowing the recent trends of this area.
- Four critical areas where outbreaks are mostly affected are described with possible solutions through these insights thought of AI.
- Briefly described a possible future scope.

The rest of the chapter is organizing as follows: In Sect. 2, a brief technical background is described. A review of some recent state-of-the-art is done in Sect. 3. In Sect. 4, some insight into AI to stop spreading this kind of pandemic is described. Finally, the conclusion and future scope are mentioned in Sect. 5.
2 Brief Technical Backgrounds

Artificial Intelligence (AI) is one of the greatest inventions despite some drawbacks in the modern era for Information and Communications Technology based intelligent automation. Although the journey had begun in the 1950s, but it has been gaining popularity for the last two decades [10]. The recent development of innovative algorithms, computing devices, and big datasets are the main driving force of this recent progress [9]. This section briefly describes four insights sub-areas of Artificial Intelligence which are relevant to the discussion topic of this chapter as below.

2.1 Deep Learning:

Deep Learning is an Artificial Neural Network-based Machine Learning model under the domain of AI [11]. After the success of a Convolutional Neural Networks (CNN) based model [12] called AlexNet [13], deep learning become a popular machine learning paradigm in modern-era. It was the first successful deep learning-based model in computer vision for the image classification tasks. After that, many improvements come in the domain of this deep learning [14].

Deep learning is a learning model based on multi-layer neural networks that capable of extracting features from data without features engineering. It is trained using a backpropagation algorithm [15] and an optimizer (such as Stochastic Gradient Descent, ReLu, etc.) using a labeled dataset. There are many varieties of learning models such as Convolutional Neural Network (CNN), Recurrent Neural networks (RNN), Long short-term memory (LSTM), Boltzmann Machine, Encoder decoder, Generative Adversarial Neural Networks (GAN), etc [11]. In Fig. 1 a typical CNN based deep learning pipeline is shown, where a trained CNN has used to draw an inference of input X-ray image to find COVID-19 pneumonia or not.

In the time of the COVID-19 crisis, deep learning can assist in many ways [16]. It can classify chest X-ray images to detect COVID-19 pneumonia, such as the study [17] have proposed a Convolutional Neural Network-based model. This model assists screening COVID-19 pneumonia, influenza pneumonia, or no infection in present

![Fig. 1 A typical deep learning model to classify X-ray images to find COVID-19 pneumonia](image-url)
in a chest X-ray image. In another study [18], a deep learning-based drug selection search have proposed where the model could assist to drug discovery system. A deep learning based forecasting model proposed in a study [19]. This model has tried give a forecast of spreading of COVID-19 pattern and possible resources requirement which are mentioned that study. In addition to these types of works, deep learning can assist in other critical tasks such as patient monitoring and care, social distancing, hygienic practice monitoring, etc. Among them four selective critical areas as mentioned are main focus of this chapter and these are discussed in Sect. 4.

2.2 Computer Vision

Computer Vision is a sub-area of AI which gives powers to a machine to see inside of an image. Computer vision is changing human life by assisting them in various ways. Through computer vision algorithms machine could classify images [20], segmentation of an image [21] and detect objects within an image [22]. With computer vision, we can process thousands of image frames at once and assist humans to their do jobs a better, faster, and automated way. Computer vision has various applications in multiple domains including medical image analysis, self-driving care, remote sensing, crowd management, and many more.

In the COVID-19 outbreak, computer vision could assist many ways including assisting to diagnose, patient monitoring, automated systematic social distance monitoring, etc, to control this pandemic [23]. It can do many remote sensing work using webcam, drone, IoT, etc which made them powerful and widely used for such challenges. Computer Vision with machine learning and deep learning has huge potentialities to mitigate any pandemic or epidemic, some of which are described in section 4.

2.3 IoT or Edge Device

Now we are living in the era of the Internet of Things, in short IoT, as it works at the site of the environment, so it may be called edge device. IoT is a system where many numbers of small to large devices with embedded sensors connected to each other as well as with a server and work as a system. The sensors sense the environment and collect required data and send it for processing or some time it processes locally through edge computing which also described in the next subsection [24]. IoT devices along with wireless sensor networks, 5G networks, edge-cloud computing are reducing human efforts with efficiency [25]. The idea of IoT is highly interdisciplinary in nature because it assembled a wide variety of sensors, computing, protocols, applications, disciplines, etc. in one umbrella called IoT.

IoT is the end device that may work on-site, so it shall assist many ways to cope with this pandemic [26]. With many sensors, IoT can collect all running details within
its footprint then transmit with the help of sensor networks. Therefore, COVID-19 related activity also could be easily monitored through IoT and Edge Computing. In a study [27] Li Bai et.al have proposed the IoT-aided diagnosis and treatment of COVID-19. In their IoT-based intelligent diagnosis and treatment assistant program, they mentioned better diagnosis and treatment of COVID-19 patients with different doctors. This chapter mentioned four critical areas for COVID-19 disease which are also get benefit by this technology is discussed in Sect. 4.

2.4 Edge Computing

Computing is the main backbone to make required inference automatically from the data sensed by IoT or edge devices. As edge devices have very limited computing resources, so, cloud computing or sometimes fog computing may be required. But such an edge-cloud scenario, latency, privacy, and security become a huge problem [28]. Therefore, edge computing, a computing methodology where most of the computing will perform near to the devices, has made them powerful and widely used [29, 30]. Edge computing sometimes said it ‘fog computing’ although technically it is different, but both are pushed computing near to edge devices. A typical Edge-Fog-Cloud hierarchical dependency is shown in Fig. 2.

![Fig. 2 Cloud, fog and edge computing and relationships](image-url)
Privacy and security of data of COVID-19 disease as other health data is a very challenging issue. In addition, latency in computing is also a problem. Therefore, to cope with these challenges, edge computing shall be useful [31]. This edge computing along with other AI technique shall assist to mitigate this COVID-19. Some glimpses of these technologies in perspective some critical areas are mentioned in Sect. 4.

3 Review of Some Recent State-of-the-Arts

After the success of AlexNet [13], a lot of machine learning researchers and practitioners has been switched to deep learning areas [14]. This deep learning is very successful in the computer vision area, as a result, many working algorithms and models successively developed [32]. These deep learning and computer vision techniques when merging with edge computing, then many application areas open up such as through drone, IoT, web camera-based applications, etc. Therefore, in this COVID-19 like pandemics, such combined AI techniques would be beneficial. This section reviewed some recent state-of-the-arts works which are related to four critical areas that are mentioned in Sect. 4 through the technologies mentioned in Sect. 2.

In a study Deep Eye-CU (DECU) [33], proposed a pose and motion summarization model in ICU. DECU combines multimodal Hidden Markov Models, extracted frames from multiple sources, and features from multiview multimodal data to monitor the motion of a patient in ICU. The pilot work [34], proposed a non-intrusive computer vision-based system for tracking people’s hand hygienic activity in hospitals. This study spatial analytic to analyze human movement patterns to monitor this practice. A study [35] propose a breathing pattern recognition of patient in ICU using computer vision technique. That work used RGB-D camera to the spatial coverage of patients without physical interfering. Another study proposed a pilot model using AI and pervasive sensing technology for autonomous and granular monitoring of patients and the environment in the Intensive Care Unit (ICU) [36]. They used computer vision tasks such as: face detection and recognition, facial action unit detection and expression recognition, head pose detection and recognition, sound and light level detection, and other activity detection. A research multi-view multi-modal systems for sleep monitoring of patients [37]. Sleeping position is very vital for the recovery of a patient for some diseases in ICU, so their model has concentrated this kind of detection in ICU. They used three RGB-D cameras to capture visual data. The Hidden Markov Model and pose recognition algorithm used for processing. The study [38], proposed a privacy-preserving action recognition model for smart hospitals. They first degrade the resolution of video frames to hide privacy then used computer vision algorithms to recognized actions. Here, they used a privet trained model to recognized hand hygienic practice and other actions in ICU. In [39], a work proposed a 3D-Point Cloud-Based Visual Prediction for ICU activities. Their model combines multiple sensors depth data to form a single 3D-point cloud and then used a neural network-based computer vision algorithm. A research work proposed an edge-based deep learning model through IoT for healthcare systems used the cloud to the
edge computing model and try to used CNN for classifications [40]. In a study [41], image segmentation technique for Neonatal ICU is described. They used a transfer learning approach to use a trained CNN to process video overhead RGB-D camera. A research study proposed to monitoring patients and visitors based on instance image segmentation [42]. Each instance of ICU is quantified by Mask-RCNN [21] model.

A Pervasive Sensing and Deep Learning-based ICU patient monitoring strategy proposed in [43]. They used many sensors including a camera to capture patient activities and the environment in ICU. A further study used deep learning to understand posture, gesture, facial expression and many more to reduce the burden of nurses and staff. Another research proposed a deep learning-based patient mobilization activity in ICU [44]. Here, the work used 67% data of 98,801 video frames for training a computer vision algorithm. The data are capture in a hospital using seven depth sensors from walls with hiding the privacy of patients. They classified 563 instances in ICU and patient. The study [45], proposed a 3D body pose estimation of a patient from pressure imaging. In that pressure sensor image-based approach they used deep learning to retrieve human poses. In a patent work [46] designed a framework to measure all the major activities in an ICU room. That non-invasive sensor-based works can do Person Localization, Patient Identification, Patient Pose Classification, and Context Detection, Motion Analysis, and Mobility Classification. IRIS [47], an AI model for continuous monitoring and caretaker in the ICU was proposed. That model simultaneously monitors many activities in ICU including ECG electrode, intracranial pressure, etc. Another research proposed an automated hand hygiene monitoring based on CNN [48]. That work used the transfer learning approach to classify region of interest of an image to classify whether a person rubbing his/her hand or doing other actions. A study [49], proposed a model to human activity from video sequence data captured by UAV. In that two-phase model, authors initially trained a CNN to recognized human or non-human which is the first phase. The inference phase, the second phase of the model, detect human and it’s activity. The classification of their model maybe in per video frame or entire video sequences.

From this review of the recent state-of-the-art, it could be drawn a conclusion that some critical areas including those four of Sect. 4 of COVID-19 pandemic could be handled in a smart and automated way. Some insights of AI techniques used in the above state-of-arts including those which are mentioned in Sect. 2 could assist to build a resistance to stop spreading COVID-19 pandemic.

4 Some Critical Areas Through AI to Stop Spreading COVID-19

In COVID-19 like pandemics, where vaccine or proper drugs are not available on the right of the moment, stopping the spread is the primary actions that need to be taken. The virus of COVID-19 is ‘SARS-CoV-2’ which is transferring from human to human through the human droplet. Therefore, finding critical areas and sectors where
risk is more to be infected is essential. Mainly the hospital sector, quarantine center, crowded public places are the hot-spot among many. So, interaction with infected persons with non-infected persons needs to be handle carefully and try to be reduced in these hot-spots. Besides that, maintaining systematic social distancing and hygienic practice also becomes necessary. This section brings some AI-based thoughts in mainly four areas which are: monitoring ICU room, patient care, hygienic practice, and monitoring social distancing. These are briefly described in the following subsections in the focus of how AI can assist to mitigate COVID-19 like pandemics in those areas.

### 4.1 Monitoring Intensive Care Unit (ICU) with AI Technologies

ICU is a critical area that is necessary to treat a severe patient. On the other side, this is one of the hot-spot, may spread this COVID-19 to the important persons who are most essential like doctors and nurses if sufficient protection is not taken. Here, AI can assist to monitor ICU room in a non-intrusive manner, so that physical human interaction may be reduced. Monitoring the ICU room does not mean just a person looking through CCTV or Webcam; instead, it beyond that. There could be many sensors including cameras which would play as a receptor. These receptors shall capture or sensed every running detail in an ICU room, including patient activities. These data will process by an edge computing model with or without the help of for and cloud computing to make inferences. Then according to the inference respective doctors or nurses will decide required actions.

Section 3 mentioned some recent proposed AI techniques for these issues in general. Among them, edge computing-based are most useful [29, 40]. In Fig. 3 an Edge-Fog-Cloud computing-based working model has shown. Here, an ICU room embedded with many IoT or Edge devices, and these devices continuously sense the ICU to collect visual, non-visual data of running environment including activities of patients. These data are processed by an edge, fog, and cloud in tandem based on AI algorithms. These algorithms could be based on machine learning, deep learning including transfer learning which makes many inferences including clustering, classification, object detection and segmentation in image, activity recognition, facial expression recognition, and many more. Based on these inference required actions could be taken. Therefore, through this AI-based practice risk of doctors and nurses are reduces being infected.
4.2 Patient Care with AI Assistant

Recent progress in robotics technology is very fast. Many intelligent robots are applying as pilot trials, some are already using in real cases including the medical sector [47]. Many studies and experiments are already undergoing that how robots could assist medical practice including robotic surgery [50]. A robot could assist in many ways in this pandemic situation including COVID-19 patient handling, care, etc [51]. Recently a news report mentioned that robots are taking care of COVID-19 patients.\footnote{https://www.pri.org/stories/2020-04-08/tommy-robot-nurse-helps-italian-doctors-care-covid-19-patients.} With those motivations, we shall see many robots will be in action for such kind of works very soon. Patient care could be done based on AI as ICU monitoring but here robots could be more useful [52]. These robots need to be intelligent enough to assist a doctor or nurses to care for patients of COVID-19 like diseases quickly and safely. AI will play a huge role to make such intelligent robots.

Here, deep learning, computer vision, edge Computing, sensor network, and obviously IoT play major roles to make a robot more intelligent. These AI techniques along with bio-mechanical and electronics technologies together produce intelligent robots. In addition, these IoT enabled robots to have to be visual and voice understanding capabilities so that they can understand and respond to the patient.

4.3 Monitoring Hygienic Practice

For the COVID-19 pandemic, hygienic practice is one of the main steps to stop spreading this infection. According to some studies ‘SARS-CoV-2’ virus is inactive until it goes to our mouth or nose [3]. So, frequently washing hand and face are effective to mitigate spreading. Nevertheless, as a human being, we sometimes forget to do this practice. So, monitoring is necessary especially in critical areas such as
hospitals, clinical, etc. However, human intervention monitoring is hectic and some times it biased. Therefore, AI-based monitoring is a better option for this solution [48]. Here, IoT and sensor network-based computer vision algorithms would be very effective. In a research study [34], a group of researchers has proposed an AI-based hand hygienic practice monitoring model in a hospital. Human action recognition algorithms are in use to process video streams capturing by visual sensors. That model automatically detects movement patterns of human and generate an analytical measurement. These types of AI technologies will assist to monitor hygienic practice which would be very effective to stop infected and spreading COVID-19 like diseases.

### 4.4 Monitoring Systematic Social Distancing

According to the nature of the ‘SARS-CoV-2’ virus, social distancing is very necessary to restrict this pandemic [53]. Most of the countries where this pandemic is going on are maintaining it. In order to properly maintain, some countries have declared lockdown. But as expected all people those countries are not obeying it for many reasons. So, respective authorities are trying hard to maintaining this social distancing. Police are patrolling, sometimes, they are using drones (UAV) for observing many areas, quarantine centers, etc. But as usual practice, they are seating in a control room and watching those live video streaming via drones. Therefore, this is hectic as well as accuracy depends on the humans level. As you know as a human we have limitation to do continuous works, so, AI will be very useful in this scenario as it brings intelligence for auto-monitoring.

Computer Vision-based action recognition algorithms [54] could be used to automatically detect such indecent where such necessary social distancing is violating [49]. Here, a drone could capture video streaming and send it to the cloud for processing, from there inference comes to the control room for taking actions. Here, human efforts will be less, and accuracy will be better. In Fig. 4 a possible working pipeline has shown. A drone could be operated from a control room whereas it will capture the video stream and it shall be processed by edge computing before sending it to a cloud server via fog server. The cloud server with the help of the fog server will make inferences then send it to the control room. This AI-assisted auto-generated inference will help respective authorities to maintain social distancing.

### 5 Conclusion and Future Scope

This chapter tried to bring some insightful thoughts of AI to assists stop spreading COVID-19 like pandemics. Here, a background, as well as a review of the current state-of-the-art are also done. Four critical areas that are most vulnerable to spreading this virus are described with possible AI-based solutions. This chapter also described
how IoT, Edge, Fog, and Cloud Computing could work with tandem for remote sensing-based smart solutions to assisting to stop the spread of this COVID-19.

This COVID-19 is not an only pandemic human civilization is facing, the pandemic had in the past, or it may come future. Hopefully, this war-like situation shall be mitigated but it forced the world to think differently. Every associated machineries of this world has to be upgraded to cope with this COVID-19 as well as any future pandemic or epidemic if arises. Many careful measurements have to be taken. Many AI-based techniques need to be invented and adopted in addition to the existing techniques which some of them mentioned in this chapter. Therefore, more interdisciplinary collaborative research involvement will be required to make possible precautionary.

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