Athens Journal of Technology & Engineering 2023, 10: 1-18
https://doi.org/10.30958/ajte.X-Y-Z

Machine Learning Solutions in Combating COVID-19: State of the Art and Challenges

By Muhammad Bin Abubakr Joolfoo[*] & Mussawir Ahmad Hosany[±]

COVID-19 is a toxic virus that emerged in China and caused an epidemic globally. COVID-19 virus patients are placed in isolation so that the virus does not blow out widely. The only approach to secure people from this deadly virus is by maintaining social distance among people, wearing gloves and masks, and sanitizing and washing hands regularly. The law enforcement agencies and Government are included in prohibiting people movement in varied cities to control the virus spread. It is not feasible for government to supervise all places namely hospitals, shopping malls, banks, government offices and direct people to following the safety guidelines prescribed by government. The COVID-19 virus has been spreading in a drastic way with the feasibility of a restricted amount of testing kits rapidly. Therefore, the diagnosis of COVID-19 model is important to recognize the occurrence of disease from radiological images. The major aim of the research is to review different machine learning solutions in combating COVID-19. Various machine learning models are implemented to combat COVID-19 virus. The proposed models with the along computer vision algorithm are used as a corresponding device to be fixed at varied places and supervise people to adopt secure guidelines which are suggested by the government. By following the precautionary steps and using the solutions of machine learning, people are capable to succeed with the fight against COVID-19 virus.

Keywords: *COVID-19, machine learning, social distancing, face mask, hand hygiene, deep learning*

Introduction

The disease of Corona Virus (COVID-19) is spreading and affecting people globally in present times. It is a malicious and highly severe disease affected by virus that belongs to Beta Corona Virus family known as SARS-CoV-2 (severe acute respiratory syndrome Corona Virus 2) which is a new Corona Virus in 2019 (Liu et al. 2020). COVID-19 is a deadly virus which impacts the lungs and respiratory tract of people severely and causes pneumonia and causes several other diseases related to lungs. There is no vaccination or medicine available for COVID-19 in November and December 2019 (Subhalakshmi et al. 2021). The Corona Virus initiated from China in 2019 December but the spread of virus initiated in January and it was recognized first on January 2020. Since it is

[*]PhD Candidate, Department of Electrical and Electronics Engineering, Faculty of Engineering, University of Mauritius, Mauritius.
[±]Associate Professor, Department of Electrical and Electronics Engineering, Faculty of Engineering, University of Mauritius, Mauritius.

increasing vastly from China to other nations, World Health Organization declared COVID-19 as a pandemic (Cohen and Normile 2020). COVID-19 is a big family of viruses which causes huge number of deadly diseases. People affected by this virus would have moderate or mild illness in respiratory. The most common symptoms of COVID-19 are cough, difficulties in breathing, head ache and fever. Sometimes this virus causes serious syndrome of acute respiratory, pneumonia, failure in kidney, blindness and even death (Majumder et al. 2021). The toxic virus is spreading widely from the transmission of human to human. The non-occurrence of virus makes the circumstance much challenging. The only approach invented to secure this transmission of human to human is to break all kinds of commuting or travelling (Wang et al. 2020).

According to Stokes et al. (2020) the Centers for Diseases Control and Prevention's (CDC) report 2019-2020 on corona-virus informs that it takes about minimum 2-14 days for corona-virus to spread in human after they are exposed. Once the affected individual suffers from symptoms like fever, cough, breathing discomfort, tastelessness, loss-of-smell, sore throat, headache, body-aches and muscle cramps, they are advised by medical practitioners to prevent or recover from COVID-19. The method for combating corona-virus includes, social distancing, timely vaccination, avoiding crowded commutes, transportation and places, avoiding outing or travelling with families, wearing masks, washing hands frequently, coughing into elbow, not touching one's face often and maintaining minimum 3-feet distances between people prior diagnosed and post diagnosed one should combat the infection with plenty of rest, hydration, medication (like: Tylenol, Paracetamol, Advil, Motrin). Though the symptoms vary from one to another, it has been advised by the CDC that when an individual has similar symptoms they are to be checked by medical practitioners within 3 days.

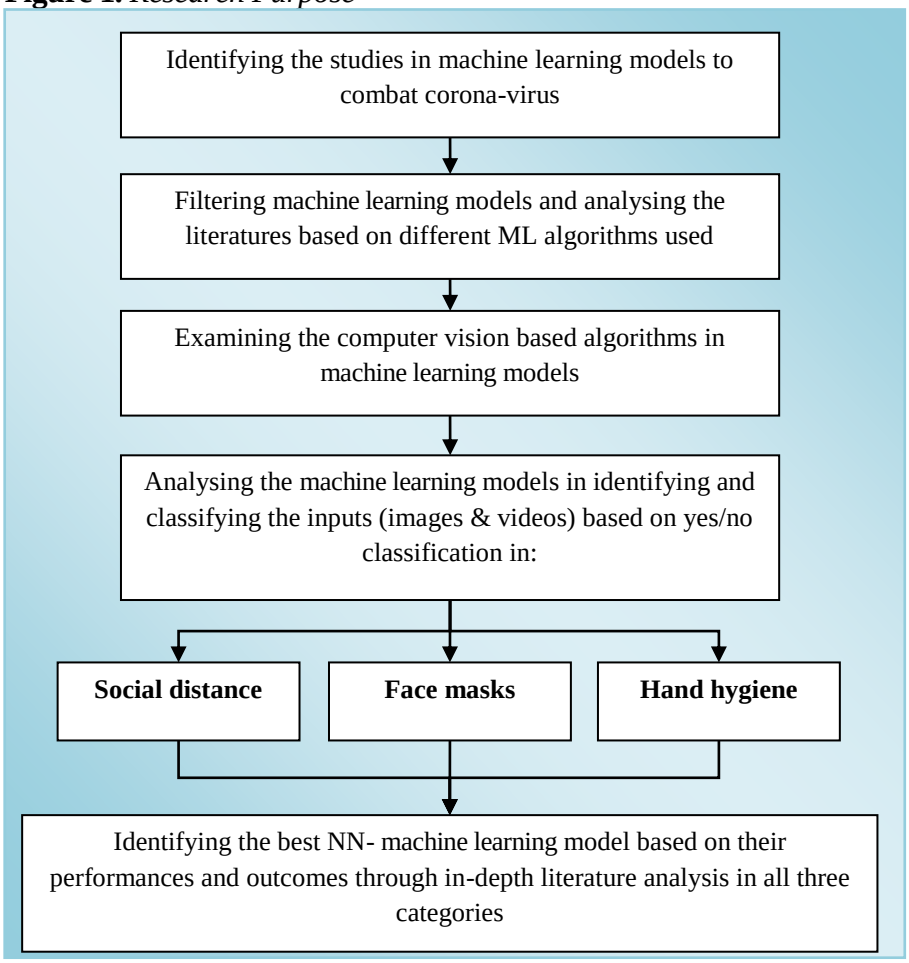
An Artificial Intelligence system has predicted the unknown kind of pneumonia disease outbreak in China before the world was aware of the damage posed by COVID-19 virus. Though the pneumonia outbreak has become a worldwide pandemic, the technologies and tools of artificial intelligence can be used to assist efforts of medical community, policy makers and society at large to handle each crisis stage and its consequences (OECD 2020). The health sector is looking for new techniques and technologies to control and track the development of the COVID-19 epidemic in this global crisis of health. One of the biggest global techniques now is artificial intelligence which can predict the growth rate and track the speed of Corona patients (Li et al. 2020). Corona patients have been developing every day an efficient model named Artificial Intelligence is an automatic prediction method that is considered to be essential towards a dense limitation of testing duration. Artificial Intelligence can also expect the death possibility by examining the earlier data of patient (Pathak et al. 2020). Machine learning is a helpful technique and this can be seen in different areas to recognize the existing drugs which seem beneficial for COVID-19 patient's treatment. Machine learning is advantageous to find the risk in healthcare during the Corona situation. Machine learning also examines the threat factors as per climate, age, location and social habits (Kushwaha et al. 2020). Several applications of machine learning have been evolved to manage different problems associated to the virus.

Several solutions of software based on AI are presently in use to trace the virus spread. Machine learning has been employed to direct scientists to new inventions in pharmacology (Kamalov et al. 2021). AI is an automatic method of prediction that is considered to be essential towards a dense restricting of testing (Togacar et al. 2020). AI is used in combating the virus by verifying individuals, information and data, medical support and suggestions regarding control of disease. In order to solve the complex issues in people lives artificial intelligence is a wide term that comprises of searching, learning, preparation and thinking. The subset of artificial intelligence is machine learning that comprise of many algorithms that offers intelligent models to cluster or recognize specific tasks (Alafif et al. 2020). The Corona Virus liable for COVID-19 has made havoc among people presenting a huge number of complications in compelling healthcare researchers around the world to discover new solutions of technology and treatment plans.

A machine learning technique is playing an essential part in solving these complications and many healthcare firms are adopting and customizing them in response to the barriers posed by the COVID-19 virus (Syeda et al. 2020). The pandemic has made negative influence on health, political and socioeconomic surroundings globally. The ways of handling the COVID-19 spread are identifying initially, putting in quarantine, quick management, prediction of spread of virus and system execution for tracing of contact (WHO 2020). The major barriers are virus test delay, medicines or drugs and offering services to difficult zones. The main aim is early identification and detection of virus, contacts nursing, continuous checking, examination of medical and epidemiological reports from patients and development of drugs and procedures (Rahman et al. 2021). Several firms are guiding people to follow proper strategies to control the spread of this severe virus. These strategies namely: 1) to maintain social distance from one people to another people at least one metre; 2) to avoid social contacts namely touching, hugging or handshaking; 3) to stay at home if the individual has fever; 4) to avoid spitting, sneezing and coughing in the open air; 5) to wear mask to secure the respiratory system from virus through air and use gloves to handle the virus blowout; and 6) to sanitize and wash hands regularly and disinfect used items regularly (Uddin et al. 2020). Other preventive measures are also taken by government by putting lock down in countries, minimizing and/or closing migration within cities and among countries as well, quarantining foreign returned passengers, suspending offices, schools, restaurants, shopping malls etc. This deadly virus has made huge loss in economy among several countries. Though this disease is spreading quickly timing is an essential factor for controlling the disease as early as feasible. Hence from the beginning stage itself monitoring is needed for authorities to manage this pandemic situation (Dutta and Bandhopadhyay 2020). Government has stated to spend in COVID-19 vaccine enthusiastically and generously. Huge number of R&D activities is being planned pertaining to COVID-19 pandemic situation so deep learning and machine learning methods have been an essential option for the recognition of disease (Zhang et al. 2020). The technique of image processing has acquired huge familiarity in all healthcare sectors particularly in detection of cancer in smart cities. Hence these methods have been an essential option for combating COVID-19 virus as well (Khan et al.

2020). World Health Organization has framed a worldwide strategy to combat COVID-19 virus namely: 1) mobilization of human life to keep social distancing and hand hygiene; 2) monitoring periodic cases to hinder spread among community; 3) defeating spread of community by imposing similar limitations; 4) offering services of healthcare to lessen mortality; and 5) vaccine growth and therapeutics for big scale monitoring (Bhattacharya et al. 2020). Thus it can be inferred that among different results to fight COVID-19, Machine learning has been regarded as a great technology to offer smart solutions. Thus, in this research the usage of different computer vision algorithms (object detection, image classification, image processing, feature extraction, object tracking, instance segmentation, semantic segmentation, image reconstruction, and more) in machine learning models, to identify the social-distances among the people, through neural networking models to combat COVID-19 will be focused, where the social distancing, wearing face masks and hand-wash as hygiene will be the norms of filters (refer to Figure 1).

Figure 1. *Research Purpose*



Review of Literature

Machine Learning Models for Predicting Social Distancing

According to the study of Ahmed et al. (2020) a deep learning framework is proposed for tracking social distance using an overhead prospect. The deep learning framework uses the platform of YOLOv3 for recognition of object to recognize people in sequences of video. Hou et al. (2020) proposed a method for detection of social distancing using deep learning model to estimate the distance between people to resolve the effect of this COVID-19. The instrument for detection was evolved to warn people to keep safe distance with each other by estimating the feed of video. The results of the method are capable to determine the measures of social distancing between several people in a video. In the research of Rezaei and Azarmi (2020) a hybrid YOLOv4 based DNN and Computer Vision model is proposed for automated detection of people in the crowd in outdoor and indoor surroundings using similar security cameras of CCTV. The proposed deep neural network model integrates with an adapted technique of IPM (inverse perspective mapping) and algorithm of sort tracking leading to detection of robust people and monitoring social distance. Contrary to that Soures et al. (2020) proposed a new hybrid machine learning model named SIRNeT for predicting the spread of a virus that integrates with epidemiological frameworks. The model assists in learning non-pharmacological methods and interventions that reduce societal collateral loss and control methods for a prolonged period of time. The study of Ahmed et al. (2021) proposes a framework for social distance based on the architecture of deep learning as a step of precautionary that is used to monitor, maintain, reduce and handle the physical communication between people in top view surroundings at real time. This study used faster Recurrent Convolutional Neural Network for human detection in images. The results of the study indicate that the framework supervises social distance between people efficiently. Ansari and Singh (2021) proposed a structure that tracks people for supervising social distancing which is being trained. To achieve this objective of social distancing supervision an algorithm is evolved using the object detection method. Convolution Neural Network based detector of object is used to predict the existence of people. The study of Khamis and Samee (2021) uses artificial intelligence algorithm to maintain distance between people to reduce the virus exposure. Genetic Neural Network is used as a neural network algorithm in handling with varied characteristics. The genetic algorithm is better at developing the features choice leading to good outcomes. Kumar et al. (2021) presents a method for predicting social distancing using computer vision and deep learning between people to manage the spread of virus. This application is evolved to provide warnings to people for maintaining social distancing in crowded places. Mathurkar et al. (2021) proposed the YOLOv3 model which is a fully convolutional neural network algorithm to predict people in frames of video. The proposed system offers a systematic method for tracking violations of social distancing. The proposed model is advantageous rather than physical supervision which decreases the efforts of people needed and provides a wide enclosure of areas for the purpose

of detection. Punn et al. (2021) proposed a deep learning structure for enhancing the activity of supervising social distancing using surveillance video. The proposed structure uses the YOLOv3 model for detecting objects to segregate humans from the background and uses deep sort method to track the recognized people with assigned Ids and the use of bounding boxes. Rahim et al. (2021) uses the YOLOv4 model for detecting objects in real-time and social distancing measuring method is established with a motionless Time of Flight camera. The proposed model denotes better performance with a 97.84% (Mean Average Precision) score and the acquired (Mean Absolute Error) between measured and actual values of social distance. Shukla et al. (2021) propose a system that is helpful in supervising public places like hospitals, malls, and ATMs for violations of social distancing. This study proposed a deep learning model which can be connected for coverage within some restricted distance. The model uses DL algorithms with library of open CV to evaluate the distance between people in the frame and a model of YOLO is trained on a dataset of COCO to recognize people in a fame, contrary to that Shalini et al. (2021) used YOLOv3 model for examining social distance among people using pedestrian's clusters during neighbourhood by obtaining the video feed. The proposed system was inserted into a pre-filmed video. By finding the space between two people a safe distance is handled which can be helpful to resolve the virus spread.

Table 1 shows the reviews of machine learning models for predicting social distancing.

Table 1. *Reviews of Machine Learning Models for Predicting Social Distancing*

S.No.	Author	Year	Model	Performance Evaluation	Findings	Drawback
1	Ahmed et al.	2020	Deep Learning YOLOv3	The model achieved 95% accuracy	Differentiates people who walks so closely and violates or breaches social distance	This study is limited to side and frontal view images of people
2	Hou et al.	2020	YOLOv3	--	Capable to predict the measures of social distancing between several people in a video	This study is Limited to only record the video of pedestrians walking on street
3	Rezaei and Azarmi	2020	YOLOv4 based DNN and Computer vision	The model achieved 99.8% detection accuracy	Track and detect dynamic and static people in public places to supervise the metrics of social distance in the era of COVID-19	This study is limited to MS-COCO and Google Open Image datasets
4	Soures et al.	2020	Hybrid Neural Network	--	Models the mobility role in handling the spread of virus	This study is limited to resource which is developing demand of pandemic rapidly compelling the choices of resource use
5	Ahmed et al.	2021	Faster RCNN	The Faster RCNN model achieved 96% accuracy	Monitors the social distancing between people effectively	This study is limited to top view dataset of human
6	Ansari and Singh	2021	Convolutiona l Neural	--	CNN based detectors of object denotes	This study is limited to the effect

			Network		promising results for supervising social distancing in public places	of Covid-19 with minimal damage to economic artifacts
7	Khamis and Samee	2021	Artificial Intelligence	--	Maintains distance among people to reduce virus exposure	This study is limited to artificial intelligence algorithm
8	Kumar et al.	2021	YOLOv3	--	Helps authorities to restructure the public places layout or take precautionary actions to resolve greater risk zones	This study is limited to people in real time
9	Mathurkar et al.	2021	YOLOv3 model	The model achieved 93.3% accuracy	Provides warning signals to handle social distance in this pandemic situation	This study focuses on regions where social distancing is not maintained and obtain SA for ROI in visual representation form through dashboard
10	Punn et al.	2021	Deep Learning and Deep sort method	The model achieved 78% detection accuracy	Monitors the social distance in real time	This study is limited to object detection models
11	Rahim et al.	2021	YOLOv4 model	The model achieved 97.84% detection accuracy	Provide an efficient social distancing monitoring solution in low light surroundings in COVID-19 situation	In this study the social distancing is supervised among people at fixed values of Cd
12	Shukla et al.	2021	Deep learning algorithm with YOLO model	--	Identify and estimate the distance between people in a frame	This study is limited to live images of CCTV cameras
13	Shalini et al.	2021	YOLOv3	--	Determine and find distance between people using pedestrian clusters by grabbing the video feed	This study is limited to deep learning and object detection model

The model developed by Hou et al. (2020) focused on examining the social distance between the pedestrians with YoloV3 model, where the model identified the distances fairly and needs further development for better accuracy. The study by Soures et al. (2020) developed a hybrid model named 'SIRNet' (epidemic + physical science + machine learning) to identify the social distances between people with Recurrent Neural Network (RNN) cells (Linear cells) + LSTM cells to identify the SEIR states (Suspected, Exposed, Infected and Recovered) of the individuals. Though the developed model is found effective, the model needs more sensitivity analysis towards refining the range-of-impact via various parameters. Ansari and Singh (2021) focused on convolutional neural networks based network with object detection algorithm to identify the human's social distancing during COVID-19. The results showed in public areas the model was efficient but the accuracy was not as expected and the model needs more training. The study concluded that using the Non-Maximum Suppression (NMS) algorithm in calculating the social distancing is feasible but however needs between people needs more training to overcome the overfitting problem.

Authors Khamis and Samee (2021) developed an artificial intelligence model with genetic neural network algorithm, to extract the features. The study concluded

that the use of machine learning models to identify and classify the diseases during the COVID-19 aided the medical practitioners to affirm the diseases and control the spread by providing medication, that are faster than normal medical practice. Though the study concluded that the usage of machine learning models reduced the morbidity rate, the developed Genetic Neural Network model needs more training towards feature extraction to identify the diseases in individuals to attain higher accuracy (>90%). Study by Shukla et al. (2021) used the YOLO model with deep learning algorithm to identify the social distancing with parameters of violation like 6 feet between two people. The study concluded that, though the model was effective in identifying the distances, the drawback was the proposed system needs to be installed physically in the monitoring areas and it covers only the certain limited distance. Authors Kumar et al. (2021) developed a YOLOv3 algorithm based model to identify the distance among people in crowded areas. The developed model uses computer vision and concluded that computer vision is more accurate and efficient in identifying and estimating the distance between people than face detection and body temperatures. However, the study by Shalini et al. (2021) found that though machine learning models are effective and significance in object detection and tracking algorithms, the study concluded that, machine learning models with convolutional neural networks is also preferably better in classification algorithms. The deep learning with computer vision is identified to be more effective in the study but the developed model lacked in accuracy when the identification and classification of distances was applied in real-time. Thus through the rigorous reviews of the above studies, it is understandable that machine learning models are effective in social distancing estimation.

Machine Learning Models for Monitoring Usage of Face Mask

According to Almghraby and Elnady (2021) research a detector for face mask is proposed which supports healthcare for public people. This research uses MobileNetV2 architecture model which can manage both low and high processing loads of work. The main purpose of Basha et al. (2021) study develops a detector for face mask with Deep Learning, PyTorch and OpenCV models that helps to predict whether or not an individual wears face mask in public places during this COVID-19 situation. This study used a NN model named ResNet which is trained on dataset. Contrary to that Boulos (2021) establishes a NN system which can be trained to recognize facial characteristics of people while most of their faces are enclosed by face masks. The convolutional neural networks model is used in this study which has accomplished outstanding accuracy even the actual dataset is restricted. Boulila et al. (2021) is to utilize deep learning which shows outstanding outcomes in real life applications to assure effective real time detection of face mask. This study proposes MobileNetV2 to predict face mask in real time. Harshita et al. (2021) study proposes a method that uses the techniques of deep learning to supervise individual's activity assuring individual's safety in public areas. The major purpose of the study is to decide if an individual is wearing a mask and maintain social distancing as per guidelines and suggestions which are

provided by governments and major scientists in this pandemic situation. The main purpose of Kulkarni and Suma (2021) study is to recognize whether an individual on video or image stream is to wear a face mask or not with the use of deep learning and computer vision. This study constructs a system for detection of face mask using many classifiers which is feasible on Convolutional Neural Network. Limbasiya and Raut (2021) proposed COVID-19 social distancing and face mask detector system which is a single stage detector comprising of ANN to combine greater level semantic data with numerous feature maps and a machine learning module to concentrate on finding social distancing and face mask simultaneously. The system can be used in any infrastructures which can be helpful to assure security and safety of people. According to the research of Mbunge et al. (2021) an extensive examination of AI models has been employed to predict face masks. This research showed that the models of deep learning accomplished 100 percent accuracy in predicting COVID-19 face masks. There is a requirement for sharing real-world face mask images of COVID-19 for modeling deep learning techniques. The study of Singh et al. (2021) proposed advanced detection methods for face masks using deep learning. Two state-of-art models of object detection namely FR-CNN and YOLOV3 is proposed to accomplish this model. This study compares both the model's performance with their inference time and rate of precision; however the study found that the usages of machine learning models vary according to the users where the impact of algorithms in computer vision impacts the model's performance and the efficiency. In the study of Taneja et al. (2021) a model is suggested and applied for detecting face that can find whether an individual is wearing mask or not accurately. MobileNetV2 is the architecture model used which is a lightweight convolutional neural networks that needs reduced power of computation and can be combined easily in mobile and computer vision systems. Similarly in the research of Tomas et al. (2021) an intelligent approach is proposed to detect when face masks are worn improperly in real time scenarios automatically. This study used Convolutional Neural Network with transfer learning to predict if the mask is used or not used but it also predicts mistakes that are not considered which may contribute to the spread of virus. The study of Teboulbi et al. (2021) presents an implementation of social distancing D and face mask detection framework as an embedded system for vision. This study offers a comparative research of varied face mask and face detection models of classification. The classification solution tracks people without or with masks in real time situation and assures social distancing by creating an alarm signal if there is damage in public places or scene.

Table 2 shows the reviews of machine learning models for monitoring usage of face mask.

Table 2. *Reviews of Machine Learning Models for Monitoring Usage of Face Mask*

S.No.	Author	Year	Model	Performance Evaluation	Findings	Drawback
1	Almghraby and Elnady	2021	Deep learning (MobileNet V2)	This study achieved 98% accuracy in validation	This model is efficient with resource when it comes to deployment which can be used for safety	This study has hardware barriers where the GPU takes huge amount of time and consumes huge amount of energy to train the model
2	Basha et al.	2021	ResNet	This study achieved 97% validation accuracy	Detects whether or not individuals wear face masks in public places which leads to their health and their contacts in this pandemic situation	This study is limited to CC camera footage at public areas
3	Boulos	2021	CNN	The model achieved 97.1% accuracy	Provides rapid and accurate results for face identification security systems	The actual dataset is limited in this study
4	Boulila et al.	2021	Deep learning	The proposed approach received 99% accuracy	Provides accurate face mask wearing detection and whether it is worn in real time or in a proper way	This study is limited to surveillance cameras in real world to verify if people are wearing masks and following norms properly
5	Harshita et al.	2021	Deep Learning CNN	This face mask wear condition achieved a healthy accuracy of 99.22%	Monitors individuals activity assuring individuals safety in public areas	This study is limited to public regions which is typical of supervision by closed circuit TV cameras
6	Kulkarni and Suma	2021	CNN	This study achieved 90% accuracy for training and 10% accuracy for testing the model	This model is successful in categorizing an individual in wearing a face mask or not and is capable to predict several people in a video frame	This study is carried out with limited set of data
7	Limbasiya and Raut	2021	Yolov3	The model used in this study achieved was between 85 % and 95%	The model is used to manage a secure surroundings and assures security of people by supervising public places automatically to avoid the spread of virus	This study uses only IP cameras and CCTV cameras to predict people without mask and violence of social distancing
8	Mbunge et al.	2021	Deep learning models	The study achieved 99.9% accuracy in finding COVID-19 face masks using Inceptionv3 CNN	This study detects face masks to assure adherence and compliance to covid-19 face masks	The datasets that are used to detect face masks are made artificial which do not indicate real world surroundings that influence the models precision accuracy when it is used in real world

9	Singh et al.	2021	R-CNN and YOLOV3	62% and 55% precision rates for YOLOv3 and FR-CNN, respectively	This study is used to supervise people wearing face masks in public places	This study comprises of people images of two types i.e., without and with face masks
10	Taneja et al.	2021	CNN	The model of face detector achieved greater accuracy of 99.8%	This study helps to recognize whether an individual is wearing a face mask or not properly and perform as a surveillance system as it performs for both real time videos and images	This study is limited to real time videos and images
11	Tomas et al.	2021	CNN	This study achieved 100% accuracy	This study have proposed an approach to predict when face masks are damaged in real time scenarios	The data sets on the status of wearing mask is usually small and it recognize only the existence of masks
12	Teboulbi et al.	2021	CNN	The system achieved an accuracy of 100%	Tracks people without or with masks in real time situation and assure social distancing by generating an alarm signal	This study is limited to CNN models

Machine Learning Models for Monitoring Hand Hygiene

The study of Yeung et al. (2016) developed a system which regularly checks on compliance of hand hygiene in hospital surroundings. This study proposes computer vision and an algorithm of machine learning using convolutional neural networks. This study handles with perception of depth and predicts if an individual is washing hands properly according to guidelines. The research of Ivanovs et al. (2020) et al proposed neural network which can be employed to build an application of mobile phone for real time feedback and automatic quality control for medical staffs. This research train the neural network on real world set of data with various movements of hand washing. Kim et al. (2020) proposed a wholly automated monitoring hand hygiene tool of hand rubbing action based on alcohol or video using spatio-temporal characteristics with three-dimensional convolutional neural networks. The convolutional neural network has increased the detection and identification of human actions. The main aim of Deshmukh et al. (2021) is to create a product which can be installed in different private and public places which predicts whether any people is following appropriate instructions of hand hygiene as mentioned by the World Health Organization. This study uses different models of convolutional neural networks to realize the appropriate method to acquire the best accuracy. The study of Lulla et al. (2021) presents a huge real world set of data with videos recording hand washing of medical staff as a part of their usual duties. This study explains how the information is used to train a machine learning classifier that accomplishes 75% accuracy of classification on test set of data.

Table 3 shows the reviews of machine learning models for monitoring hand hygiene.

Table 3. *Reviews of Machine Learning Models for monitoring hand hygiene*

S.No.	Author	Year	Model	Performance Evaluation	Findings	Drawback
1	Yeung et al.	2016	Convolutional Neural Networks	80.7% precision in identifying pose-based approaches in hand hygiene	It is essential to find the compliance of hand hygiene which is an essential factor of reducing the cost related with infections in hospital	It is not able to predict how the steps of hand hygiene is accurate or how long the individual is carrying out the task
2	Ivanovs et al.	2020	Neural Network	This study achieved greater than 64% accuracy in identifying varied movements of hand wash	Mobile phone application is constructed to enhance real time feedback and automatic quality control for medical staffs	This study train the neural network using 2000+ real world dataset
3	Kim et al.	2020	Convolutional Neural Network	This study achieved 76% accuracy	Monitors hand hygiene by reducing the infection outbreak in hospitals	This study experimented that from kinetics-400 transfer learning is advantageous whereas the stream of optical flow was not useful in dataset
4	Deshmukh et al.	2021	Convolutional Neural Network	This study achieved an accuracy of 77.24%	Proper hand wash is undertaken and people are motivated to manage hand hygiene accurately	This study is tested using 32471 annotated videos dataset for the need of categorizing the steps carried out by a user during washing hands
5	Lulla et al.	2021	MobileNetV2	This study achieved 75% classification accuracy	Enhances real world washing quality carried out by medical staff	This study is limited to 3185 episodes of hand washing which is annotated up-to 7 varied individuals

Challenges and Future Directions

Most of machine learning approaches depend on large-scale data for training like medical imaging, image sources and other medical applications. Due to the rapid increase of corona-virus, appropriate and valid datasets are not sufficient for accessing machine learning approaches (Mondal et al. 2021). Publicly accessible datasets adopted in various machine learning approaches are collected from sources of medical image like medical institutions and hospitals where it is difficult to pursue exclusion and inclusion criteria of COVID-19 like asymptomatic vs. symptomatic COVID-19 cases at which such images were considered. Due to large amounts of misleading reports and audio materials related to COVID-19 are recorded on different online sites. Processing of machine learning based algorithms will be slow when filtering erroneous information and audio (Pi 2021). It is complicated to work with incorrect and unclear data in descriptions of text.

Huge amount of data from different sources might be false (Onyema et al. 2022). Therefore, extra information makes it difficult in exacting meaningful data.

The outbreak of COVID-19 virus has influenced the security and safety of people all around the globe. This virus has become a threat which spread all over the globe influencing millions of people's lives. The outbreak has a profound influence on people's wellbeing globally and the number of diseases associated deaths continues to develop worldwide. This pandemic situation requires immediate precautions and measures to avoid its worldwide impacts. Along with clinical treatment and methods the latest technology has assisted to manage deadly diseases earlier. From several years ago researchers, scientist, healthcare experts and doctors are using the latest computer techniques to resolve the criticality of disease (Sarker 2021). Technology is developing continuously with huge success particularly in the sector of deep learning and machine learning. Though the technology has been dwelling into daily lives of people with huge success particularly in deep learning and machine learning, a new paradigm Artificial Intelligence has become essential in healthcare sector (Silahtaroğlu and Yılmaztürk 2021). Artificial intelligence has assisted people in the critical battle against COVID-19 virus. Machine learning is one such way to offer essential solutions driven by data to support humanity to manage with COVID-19 virus. Machine learning has been used in assisting people to combat against COVID-19 virus. To manage COVID-19 the data driven solutions are promised to support humanity (Fink et al. 2020). A brief overview of Machine learning algorithms was discussed in this review for predicting social distancing, monitoring face mask and hand hygiene. Different unsupervised and supervised machine learning algorithms were discussed briefly and their uses in combating COVID-19 virus was also discussed with different datasets. The machine learning solutions performs well while finding the COVID-19 disease cases (Ibrahim and Abdulazeez 2021). The worldwide pandemic of COVID-19 virus has become the major security problem for several nations. The growth of accurate machine learning solutions for the outbreak of COVID-19 disease is important to offer insights into the consequences and spread of this deadly disease. Humans are facing the most difficult times presently. People are made to stay at home, cities are closed, the stock market is declining whereas nurses and doctors are busy in assisting patients affected with COVID-19 virus and police and soldiers are busy in guarding people to lock down at their homes safely to prevent them from this COVID-19 virus (Kalkman 2021). This review estimated the applicability of machine learning models for finding the outbreak of COVID-19 virus. World Health Organization and medical experts are providing essential guidelines to people to secure themselves from this deadly virus. A centralized set of global COVID-19 patient information will be advantageous for future machine learning and AI research to evolve diagnostic, therapeutic and predictive solutions against COVID-19 virus and relevant pandemic situation in future. This study could be further extended by collecting real time data and developing an advanced machine learning model using deep neural networks. The developed model could be trained using real time dataset and the performance of the model could be tested appropriate parameters in the future.

Machine learning approaches could be improvised for future for combating COVID-19 in these ways machine learning based approaches could be adopted for discovering viral components and protein composition using exact analysis of biomedical expertise like genetic sequences, viral trajectories and main protein structures. They are adopted for discovering vaccines and medications as well as simulating vaccine-receptor and drug-protein interactions, forecasting future vaccine and drug reactions for individuals with different symptoms related to COVID-19. By expanding knowledge graphs and social networks, machine learning approaches could identify and track the people characteristics near COVID-19 patients, efficiently predicts and tracks the likely spread of disease.

According to World Health Organization's report, post vaccinations and COVID-19 preventions in many countries, the death rates have been rapidly decreasing, which is fortunately a positive sign. However, in countries like Peru, China, Bulgaria, Georgia, Hungary, UK, Italy, and more the death rates of COVID-19 is still growing despite the measures and prevention techniques. Contrarily in countries like North Korea, Nigeria, Tanzania, Bhutan, Tajikistan, Macao, and more the death rates have packed down. This shows that, the countries that followed the preventive measures flattened the spreading of disease and decreased the morbidity rate and thus bought down their country's mortality rate. Usage of machine learning models to identify the preventive measures to classify the individuals is thus found to be efficient and effective than human intervention, when the target population is huge/unknown.

Conclusion

The current paper has reviewed in detail about several research works done by recent researchers on how machine learning as a technique could be applied for monitoring adherence of COVID-19 guidelines by the people. Different types of applications like social distance prediction, hand hygiene detection; mask prediction has been illustrated by the researchers of the past through machine learning techniques. Thus, it can be concluded that machine learning is suggested as an efficient tool to resolve the present pandemic situation and win against the battle of COVID-19 virus. If this opportunity is taken to gather data, integrate skills and pool knowledge several lives of people can be saved now and in future. From findings, it is concluded that for identifying the social distancing between people the machine learning L model with genetic neural network algorithm and AI algorithm is effective with higher accuracy of 99%. Similarly, the identification and classification of inputs (images/videos) to categorize with and without face masks the machine learning models convolutional neural network model with deep learning is found to be feasible, efficient, and reliable than other neural network models with minimum of 98% accuracy. Lastly, among the hand hygiene identification and classification machine learning models, the deep learning model was found effective with 100% accuracy. Thus, it is established through the analyses that deep learning and artificial intelligence models are far effective and

accurate in identifying and classifying inputs, when combined with computer vision algorithms.

References

Ahmed I, Ahmad M, Rodrigues JJPC, Jeon G, Din S (2020) A deep learning based social distance monitoring framework for COVID-19. *Sustainable Cities and Society* 65(Feb):102571.

Ahmed I, Ahmad M, Jeon G (2021) Social distance monitoring framework using deep learning architecture to control infection transmission of COVID-19 pandemic. *Sustainable Cities and Society* 69(Jun): 102777.

Alafif T, Tehame A M, Bajaba S, Barnawi A (2020) Machine and deep learning towards COVID-19 diagnosis and treatment: survey, challenges and future directions. *International Journal of Environmental Research and Public Health* 18: 1117.

Almghraby M, Elnady AO (2021) Face mask detection in real time using MobileNetV2. *International Journal of Engineering and Advanced Technology* 10(6): 104–108.

Ansari MA, Singh DK (2021) Monitoring social distancing through human detection for preventing/reducing COVID-19 spread. *International Journal of Information Technology* 13: 1255–1264.

Basha CMAKZ, Pravallika BNL, Shankar EB (2021) An efficient face mask detector with PyTorch and deep learning. *EAI Endorsed Transactions on Pervasive Health and Technology* 7(25).

Bhattacharya S, Maddikunta PKR, Pham Q-V, Gadekallou TR, Krishnan SR, Chowdhary CL, et al. (2020) Deep learning and medical image processing for corona virus (COVID-19) pandemic: a survey. *Sustainable Cities and Society* 65(Feb): 102589.

Boulila W, Alzahem A, Almoudi A, Afifi M, Alturki I, Driss M (2021) *A deep learning based approach for real time face mask detection*. Available at: https://arxiv.org/ftp/arxiv/papers/2110/2110.08732.pdf.

Boulos MM (2021) *Facial recognition and face mask detection using machine learning techniques*. Thesis Dissertation and Culminating Projects, 728.

Cohen J, Normile D (2020) New SARS: like virus in China triggers alarm. *National Library of Science* 36(6475): 234–235.

Deshmukh R, Agarwal R, Murtuza SM, Evangeline P (2021) Computer vision and deep learning based hand hygiene guidance. *Journal of Xian University of Architecture and Technology* 13(5): 534–544.

Dutta S, Bandhopadhyay S K (2020) Machine learning approach for confirmation of COVId-19 cases: positive, negative, death and release. *IberoAmerican Journal of Medicine* 3: 172–177.

Fink O, Wang Q, Svensen M, Dersin P, Lee W-J, Ducoffe (2020) Potential, challenges and future directions for deep learning in prognostics and health management applications. *Engineering and Applications in Artificial Intelligence* 92: 103678.

Harshita S, Deep N, Gautham MG, Deepthi K (2021) Social distancing and face mask detection using deep learning. *International Journal of Innovative Science and Research Technology* 6(6): 114–120.

Hou YC, Baharuddin MZ, Yussof S, Dzulkifly S (2020) Social distancing detection with deep learning model. In International *Conference on Information Technology and Multimedia*.

Ibrahim I, Abdulazeez A (2021) The role of machine learning algorithms for diagnosing diseases. *Journal of Applied Science and Technology Trends* 2(1): 10–19.

Ivanovs M, Kadikis R, Lulla M, Rutkovskis A, Elsts A (2020) *Automated quality assessment of hand washing using deep learning*. Available at https://arxiv.org/abs/2011.11383.

Kalkman JP (2021) Military crisis responses to COVID-19. *Journal of Contingencies and Crisis Management* 29(1): 99–103.

Kamalov F, Cherukuri A, Sulieman H, Thabtah F, Hossain A (2021) *Machine learning applications for COVID-19: a state of the art review*. Available at: https://arxiv.org/pdf/2101.07824.pdf.

Khamis S, Samee BEA (2021*)* Social distancing model using machine learning techniques, advances in data science and intelligent data communication technologies for COVID-19. In *Advances in Data Science and Intelligent Data Communication Technologies for COVID-19*, 41–53. Springer.

Khan FA, Asif MA, Ahmad A, Alharbi M (2020) Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development. *Sustainable Cities and Society* 55(2): 102018.

Kim M, Choi J, Kim N (2020) *Fully automated hand hygiene monitoring\\in operating room using 3D convolutional neural network*. Available at: https://arxiv.org/abs/2003.09087.

Kulkarni B, Suma V (2021) Face mask recognition using tensor flow a deep learning framework. IJESC 11(5): 28007–28009.

Kumar A, Patle B, Hirwani S (2021) Social distance detector using deep learning. *International Journal of Innovations in Engineering Research and Technology* 8(6): 39–42.

Kushwaha S, Bahl S, Bagha AK, Parmar KS, Javaid M, Haleem A, et al. (2020) Significant applications of machine learning for COVID-19 pandemic. *Journal of Industrial Integration and Management* 5(4): 453–479.

Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. (2020) Early transmission dynamics in Wuhan, China, of novel corona virus- infected pneumonia. *The New England Journal of Medicine* 382(Jan): 1199–1207.

Limbasiya B, Raut C (2021) COVID-19 face mask and social distancing detector using machine learning. *International Research Journal of Engineering and Technology* 8(5): 2056–2061.

Liu Y, Gayle A, Wilder-Smith A, Rocklov J (2020) The reproductive number of COVID-19 is higher compared to SARS corona virus. *Journal of Travel Medicine* 27(2).

Lulla M, Rutkovskis A, Slavinska A (2021) Hand washing video dataset annotated according to the World Health Organization's hand washing guidelines. *Data* 6(4): 38.

Majumder AB, Gupta S, Singh D, Majumder S (2021) An intelligent system for prediction of COVID-19 case using machine learning framework-logistic regression. *Journal of Physics: Conference Series*, 1797.

Mathurkar G, Parkhi C, Utekar M, Chitte PH (2021) Ensuring social distancing using machine learning. In *ITM Web of Conference* 40: 03049.

Mbunge E, Simelane S, Fashoto SG, Akinnuwesi B, Metfula AS (2021) Application of deep learning and machine learning models to detect COVID-19 face masks - A review. *Sustainable Operations and Computers* 2: 235–245.

Mondal MRH, Bharati S, Podder P (2021) Diagnosis of COVID-19 using machine learning and deep learning: a review. *Curr Med Imaging* 17(12): 1403–1418.

OECD (2020) *Using artificial intelligence to help combat COVID-19*. Available at: https://www.oecd.org/coronavirus/policy-responses/using-artificial-intelligence-to-help-combat-covid-19-ae4c5c21/.

Onyema EM, Almuzaini KK, Onu FU, Verma D, Gregory US, Puttaramaiah M, et al. (2022) Prospects and challenges of using machine learning for academic forecasting. *Computational Intelligence and Neuroscience* 2022: 5624475.

Pathak Y, Shukla PK, Tiwari A, et al. (2020) *Deep transfer learning based classification model for COVID-19 disease*. IRBM.

Pi Y (2021) Machine learning in governments: benefits, challenges and future directions. *JeDEM - EJournal of EDemocracy and Open Government* 13(1): 203–219.

Punn NS, Sonbhadra SK, Agarwal S, Rai G (2021) *Monitoring COVID-19 social distancing with person detection and tracking via fine-tuned YOLOv3 and deepsort techniques*. Available at: https://arxiv.org/pdf/2005.01385.pdf.

Rahim A, Maqbool A, Rana T (2021) Monitoring social distancing under various low light conditions with deep learning and a single motionless time of flight camera. *PLoS ONE* 16(2): e0247440.

Rahman MM, Khatun F, Uzzaman A, Sami SI, Bhulyan MA, Kiong TS (2021) A comprehensive study of artificial intelligence and machine learning approaches in confronting the coronavirus (COVID-19) pandemic. *International Journal of Health Services* 51(4): 446–461.

Rezaei M, Azarmi M (2020) DeepSOCIAL: social distancing monitoring and infection risk assessment in COVID-19 pandemic. *Applied Sciences* 10: 1–29.

Sarker IH (2021) Machine learning: algorithms, real-world applications and research directions. *SN Computer Science* 2(160): 1–21.

Shalini GV, Margret MK, Niraimathi MJS, Subashree S (2021) Social distancing analyzer using computer vision and deep learning. *Journal of Physics: Conference Series* 1916: 012039.

Shukla P, Kundu R, Arivarasi A, Alagiri G, Shiney J (2021) A social distance monitoring system to ensure social distancing in public areas. In *International Conference on Computational Intelligence and Knowledge Economy*.

Silahtaroğlu G, Yılmaztürk N (2021) Data analysis in health and big data: a machine learning medical diagnosis model based on patients' complaints. *Communication in Statistics - Theory and Methods* 50(7): 1547-1556.

Singh S, Ahuja U, Kumar M, Kumar K, Sachdeva M (2021) Face mask detection using YOLOV3 and faster R-CNN models: COVID-19 environment. *Multimedia Tools and Applications* 80: 19753–19768.

Soures N, Chambers D, Carmichael Z, Daram A, Shah DP, Clark K, et al. (2020) *SIRNeT: understanding social distancing measures with hybrid neural network model for COVID-19 infectious spread*. Available at: https://arxiv.org/pdf/2004.10376.pdf.

Stokes EK, Zambrano LD, Anderson KN, Marder EP, Raz KM, El Burai Felix S, et al. (2020) *Coronavirus disease 2019 case surveillance — United States, January 22–May 30, 2020*. Morbility and Mortality Weekly Report 69(24): 759–765. CDC.

Subhalakshmi RT, Balamurugan SA, Sasikala S (2021) Deep learning based fusion model for COVID-19 diagnosis and classification using computed tomography images. *Concurrent Engineering, Research, and Applications* 30(1): 116–127.

Syeda HB, Syed M, Sexton KW, Syed S (2020) *The role of machine learning techniques to tackle COVID-19 crisis: a systematic review*. Available at https://www.researchgate.net/publication/343870606_The_Role_of_Machine_Learning_Techniques_to_Tackle_COVID-19_Crisis_A_Systematic_Review.

Taneja S, Nayyar A, Vividha, Nagrath P (2021) *Face mask detection using deep learning during COVID-19*. Springer.

Teboulbi S, Messaoud S, Hajjaji MA, Mtibaa A (2021) Real time implementation of AI based face mask detection and social distancing measuring system for COVID-19 prevention. *Hindawi Journal* 2021: 8340779.

Togacar M, Ergen B, Comert Z, Ozyurt F (2020) A deep feature learning model for pneumonia detection applying a combination of m rmr feature selection and machine learning models. IRBM 41(4): 212–222.

Tomas J, Rego A, Viciano-Tudela S, Lloret J (2021) Incorrect facemask wearing detection using convolutional neural networks with transfer learning. *Healthcare* 9(8): 1050.

Uddin MI, Shah SAA, Al-Khasawneh MA (2020) *A novel deep convolutional neural network model to monitor people following guidelines to avoid COVID-19*. Available at: https://www.hindawi.com/journals/js/2020/8856801/.

Wang C, Horby PW, Hayden FG, Gao GF (2020) *A novel corona virus outbreak of global health concern*. Available at: https://pubmed.ncbi.nlm.nih.gov/31986257/.

World Health Organization – WHO (2020) *Novel coronavirus (2019-nCoV): situation report, 12*. WHO.

Yeung S, Alahi A, Luo Z, Peng B, Haque A, Singh A, et al. (2016) *Vision based hand hygiene monitoring in hospitals*. Available at: https://ai.stanford.edu/~syyeung/resources/vision_hand_hh_nipsmlhc.pdf.

Zhang Q, Yang LT, Chen Z, Li P (2020) A survey on deep learning for big data. *Information Fusion* 42(Jul): 146–157.