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Significant applications of Machine Learning for COVID-19 pandemic

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Abstract

Machine learning is an innovative approach that has extensive applications in prediction. This techniqueneeds to be applied for the COVID-19 pandemic to identify patients at high risk, their death rate, and other abnormalities. It can be used to understand the nature of this virus and further predict the upcoming issues. This literature-based review is done by searching the relevant papers on machine learning for COVID-19 from the databases of SCOPUS, Academia, Google Scholar, PubMed, and ResearchGate. This research attempts to discuss the significance of machine learning in resolving the COVID-19 pandemic crisis. Paper studied how machine learning algorithms and methods can be employed to fight the COVID-19 virus and the pandemic. Paper discusses the primary machine learning methods that are helpful during the COVID-19 pandemic. We further identified and discussed algorithms used in machine learning and their significant applications. Machine learning is a useful technique, and this can be witnessed in various areas to identify the existing drugs, which also seems advantageous for the treatment of COVID-19 patients. This learning algorithm creates interferences out of unlabeled input data-sets, which can be applied to analyse the unlabeled data as an input resource for COVID-19. It provides accurate and useful features rather than a traditional explicitly calculation-based method. Further, this technique is beneficial to predict the risk in healthcare during this COVID-19 crisis. Machine learning also analyses the risk factors as per age, social habits, location, and climate.

1. Introduction

Machine learning is a data analysing method, which is the main concern to make computers update or adapt their actions. That action can be forecasting about any event or controlling a machine, for instance, an intelligent robot. After applying these actions, the result will show the accuracy. The correct selection of the actions will be the measure of accuracy. To illustrate, assuming one is playing a chess game against the computer, one might win every time in the beginning; however, after several games, the computer will start beating the opponent until the opponent finally never wins (Randhawa et al., 2020; Samuel et al., 2020; Li Da Xu, 2014). Learning to beat one, it can go so on and might apply the same strategy against the other players playing with it. It takes the ideas from neuroscience, physics, mathematics, statistics, and biology to upgrade or make computers learn (Feng & Xu, 1999b; Gandhi & Singh, 2020; Li Xu, 2006). Biosensors present significant applications in fighting COVID-19 and future pandemics (Bahl, Javaid, et al., 2020). Modern technologies are helpful for COVID 19 pandemic to trace the infected patients and to fulfill other essential requirements (Sharma et al., 2020; Vaishya, Bahl, et al., 2020). Telemedicine technology is very helpful in avoiding the visits to the healthcare facilities during the hard times of lockdown due to Coronavirus pandemic and also it provides a suitable option for the treatment of patients (Bahl, Singh, et al., 2020).

In the current pandemic, machine learning helped us to understand and identify who is at the most risk (Imtyaz et al., 2020; Khan et al., 2020). Apart from that, machine learning played a significant role in developing the drug or vaccine, detecting the patients, studying the behaviour of existing drugs for similar virus diseases, mapping from where the virus came from, and forecasting the next pandemic. Since the drug for the disease is not yet developed, social distancing is used to merely break the chain of spreading the disease (Lu, 2019; Li Da Xu et al., 2018). This pandemic behaviour can only be tracked when some robust mathematical basis can be formed for decision making. In a nutshell, Machine learning will help determine where and when the disease is likely to grow and spread (L. Duan et al., 2009; Karunanithy & Velusamy, 2020; G. Shen & Ye, 2017). For instance, the travel history can be traced and tracked automatically of an infected patient, and the spread will also be detected (Tuli et al., 2020). Genome sequence and molecular docking, which include various machine learning techniques, can be used to develop the vaccine for this COVID-19 pandemic (Libbrecht & Noble, 2015).

2. How machine learning is helpful to fight COVID-19

The trend and patterns of data-sets can be identified with the aid of machine learning methods and algorithms. The literature identifies that inhibitory synthetic antibodies have been predicted as a possible cure with the help of a machine learning device (Chi-Hsien & Nagasawa, 2019; Li-da Xu, 2014). The neutralisation response of the patient and 1933 virus-antibody samples have been collected. Graph featurisation integrated with machine learning method to screen the hypothetical antibody sequences, which were thousands in number. It has been found that eight out of them were stable antibodies that inhibit COVID-19 (Magar et al., 2020; Roy et al., 2020; L D Xu et al., 2014). After considering those data-sets, it can be concluded that it is potentially helpful to apply machine learning techniques to fight against COVID-19. Figure 1 shows the role of machine learning for COVID-19. Machine learning helps to quickly identify patterns and trends of the large volume of data, which might not be easy for humans to recognise. Thus, to illustrate, a causal relationship between two events can be easily identified with the help of a machine learning program. Apart from the identification, it can improve or adapt their actions over time. The efficiency and accuracy keep increasing as the number of data increases (Feng et al., 2003; Kullaya Swamy & Sarojamma, 2020; Vafeiadis et al., 2018; Li Xu, 2006). The algorithm which experiences from data results in making better decision and predictions. It has another significant advantage: this technique has instantaneous ability to adapt without human interference.
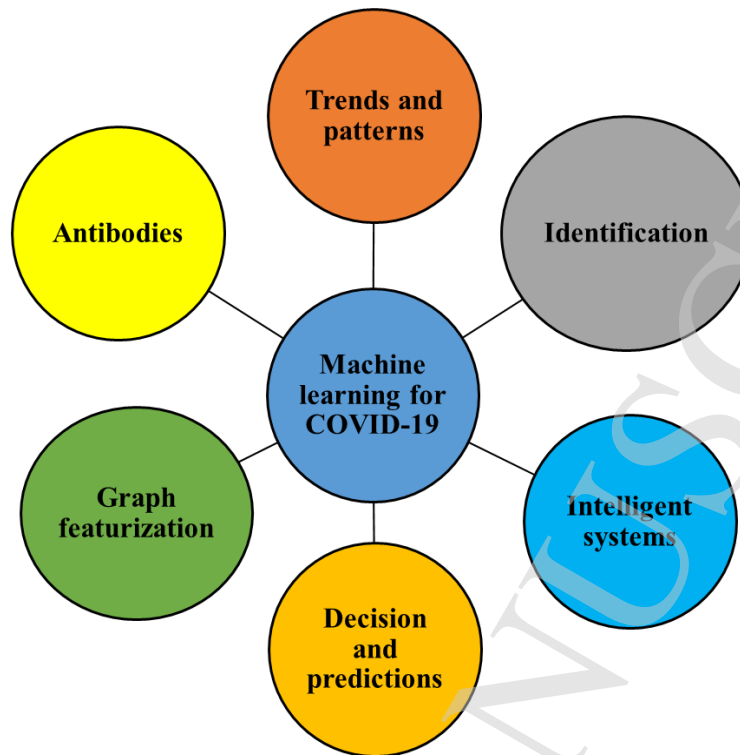
Figure 1: Different roles of machine learning for the COVID-19 pandemic.

3. Major machine learning methods

Machine learning methods can understand anti-virus software programs or security software programs. Table 1 provides the major machine learning methods as being deployed successfully.

Table 1: Major Machine Learning methods

S.No.	Machine Learning method	Description of the method
1.	Regression	The regression method of machine learning is a forecasting methodology to examine the relationship between a dependent and an independent variable. Individually, the parametric equations can be evaluated from any given data (such as the relationship between the rash driving and the number of road accidents by a driver). This method of machine learning was implemented to analyse the ordinary as well as infrequent genetic modifications. It has been found that the study for 200 replicates from simulated binary, quantitative traits, and also exome sequencing that was provided from Genetic Analysis Workshop 17 is evaluated by the regression method (Dasgupta

		et al., 2011; Tropea & Rango, 2020).
		Thus, to identify the problems while analysing the high-dimension, low sample size data, the regression method is being used (Dasgupta et al., 2011). This method is to predict cases of severe acute respiratory disease COVID-19.
		In one study, the confirmed cases have been predicted using the regression method with the aid of time-series data (Gupta et al., 2020). From this study, it is concluded that for COVID-19 cases, the recovery, and death cases, can be predicted.
2.	Clustering	Clustering is one of the methods of machine learning where a given set of patterns are grouped into disjoint clusters, also known as a partitioning process. The clusters that are alike are in the same pattern.
		This method of machine learning has its application in domains that includes neural network and statistics (Alsabti et al., 1997). Within the clusters, objects must be closer to each other for a clustering task to be performed.
		In contrast, the arbitrary selection of the sample's centre point leads to cluster aggregation formation but not convergence. Cluster analysis is mainly dependent on the alikeness in clustering data sets, that come under the learning, which does not need any supervision (Yuan & Yang, 2019).
		A study for COVID-19 has been done for clustering; it is found that in a day to day growth, there are some distinct clusters when considering deaths, recovered, and confirmed cases from coronavirus. Also, the countries that have fewer cases daily will have lesser deaths (Zoumpekas, 2020).
3.	Classification	Classification is a machine learning method in which the algorithm itself learns from the input data given to it; meanwhile, the learning further advent in categorising new observations. For updated boundary conditions, the training data set is being implemented. The database causes one to identify each target class, and once the boundary conditions are determined to further, one has to predict the target class (Leonel, 2019).
		Often ecologist has to work with clamorous and high-dimensional data. These data are non-linear, which is not compatible with the assumptions of conventional statistical procedures (L. Duan et al., 2007; J. Li et al., 2009). Thus, to deal with this problem, the classification method of machine learning has been implemented (Kampichler et al.,

		2010).
		In the study for COVID-19, 150 CT images were used. The four distinct databases were created for those 150 CT images before the classification process. Those were named as coronavirus/non-coronavirus. It is found that the machine learning classification method can be implemented to diagnose the COVID-19 as an assistant system (Barstugan et al., 2020; W. Shen et al., 2020).
4.	Transfer Learning	This method is developed for a particular job that is reused for the second problem as the starting point. It has been implemented in another task to develop the process of a new problem (Curry, 2018). Presently, this method has been implemented so often in real-world applications.
		In machine learning, it is assumed that the future and training data must be in the identical feature space; however, in a real application, the assumption does not hold or valid (L. Duan & Binbasioglu, 2017; N. Duan et al., 2019; Lakshmi et al., 2018). In such cases, if the transfer learning method implemented successfully, it may enhance the performance without expending many data-labelling efforts (Pan & Yang, 2010).
		Transfer learning techniques helped to improve the diagnostic performance in the case of COVID-19. For automatic diagnosis of COVID-19, quantitative evaluation has shown high precision. The learning method could be used for the early screening of coronavirus (Hernández-Orallo et al., 2020; Razzak et al., 2020).
5.	Ensemble Methods	To reduce the variance and improve the predictions, this ensemblemethod of machine learning united with various machine learning methods for the objective of building one predictive prototype.
		This method ameliorates machine learning outcomes by combining several models. However, this method is preferred over other existing methods due to the effectiveness of its usage (Smolyakov, 2017).
		In the literature, the ensemble method has been employed for cancerous gene expression data. In terms of precision, response, and accurate prediction, this method justified its performance overall the data-sets (H.-X. Li & Da, 2000; Zhou & Xu, 1999).
		It has concluded that the job of categorising gene expression data should be taken into consideration for cancerous samples (Tan & Gilbert, 2003). Presently, the ensemble method has been used to screen a large (nearly a million entries) database in the case of COVID-19 (D. Mishra et al., 2020; Rab et al., 2020).

		This method imparts an efficient method to provide computational drug screening also enhances the knowledge about small-molecule treatment against COVID-19 (Batra et al., 2020; Zhong et al., 2020).
6.	Neural Nets and Deep Learning	Neural nets are biologically-inspired programming language. It is a way of machine learning where the computer learns to perform some jobs by evaluating the training itself. To illustrate an object identification system loaded with thousands of images of distinct objects such as cups, cars, trees, etc. With the aid of neural nets, it would be able to minimize the visual patterns in the images that continuously relate with particular labels (Hardesty, 2017). Meanwhile, deep learning mainly focused on algorithms stimulated by the design and function of the brain known as artificial neural networks (Nielsen, 2015). To give an idea of deep learning, speech recognisers on smartphones, and Google's newly invented automatic translators come under this category (Hardesty, 2017). In the literature, for intrusion detection, a deep learning approach has been implemented with the aid of recurrent neural networks (RNN-IDC). This model causes improvement in the efficiency and accuracy of intrusion identification (C. Yin et al., 2017). The study for COVID-19 with the help of a deep learning model results in understanding its rapid growth in the day to day manner and predicting the future reachability of this pandemic. It uses real-time information from the John Hopkins dashboard (Punn et al., 2020).
7.	Dimensionality Reduction	In this method of machine learning, the number of random variables taken into account gets reduced. The principal variables obtain it. In the literature, an anomaly detection system used by the machine learning algorithm, for example, principal component analysis and support vector machine has been studied (S. Kumar & Tripathi, 2018; A. Mishra & Majhi, 2019). To come up with the more informative attributes from the data, dimensionality reduction and PCA help to minimise high dimensional network data. To do so, it accordingly reduces the execution time and simultaneously increases the accuracy of classification (Alguliyev et al., 2019; Feng & Xu, 1999a, 1999b). They observed that the dimensionality reduction method comes up with more accurate results, even with a new subspace that enhances the classification. The new subspace has combined features corresponding to maximum variance (George, 2012). For COVID-19, this high

		dimensional feature is used to observe the pattern of data for effective forecasting cases (Jaiswal, 2020).
8.	Reinforcement Learning	This method of machine learning mainly focused on how software systems should react or revert in any given environment. It helps to 8minimise some part of the cumulative rewards and let one take the decision substantially, such as the game of chess (Kang et al., 2020; Li D Xu, 2000).
		In the literature, the residual algorithm with a function approximation system has been applied for reinforcement learning. The developed reinforcement learning algorithms ensure to narrow down to an efficient and optimal solution while implementing lookup tables (Baird, 1995).
		This work results in the implementation of a better method to analyse distributed control issues, complex systems, and help examination of prior applied knowledge (Bradtke & Duff, 1994).
9.	Word Embeddings	This method of machine learning uses the ability of networks to learn from text data that has been upgraded or improved. This technique is used to 8minimise the dimensionality of text data. The application of word embedding is being applied in many fields and is beneficial. Sentimental analysis is of great value to examine when it comes to obtaining subjective information from text documents (H. X. Li et al., 2003; H. X. Li & Xu, 2001). These tasks show their fruitfulness when applied to the market or any clinical research. In literature, this method has been adopted for sentiment detection out of available text data.
		The method employed requires minimal computational resources and is impacted significantly while dealing with any real-world scenario (Giatsoglou et al., 2017).
		Word embedding tries to build a relationship by relying on an elementary concept. The words used interchangeably show some kind of relationship and are useful while examining the case of COVID-19 (Tirtha, 2020).
10.	Natural Language Processing	Natural Language Processing (NLP) is a field of machine learning that helps computers understand, manipulate, analyse the data given to it, and potentially produce human language. For instance, auto-correct, detection of spam emails, etc. (Haleem et al., 2020; Shetty, 2018).
		In the literature, from the idea of speech recognition, the most recent learning research in NPL implements statistical techniques. It also introduces new methods of learning (Cardie & Mooney, 1999).
		NLP is helping to identify the COVID-19 cases in the early stage by

		powering the chat programs. Moreover, to reduce the spread of this pandemic, NLP is driving monitoring efforts. The method is helpful in text analysis of the medical record and examining the cases of COVID-19 (Srivastava, 2020).

In a nutshell, machine learning methods are significantly valuable when it comes to forecast or predict the nature of any given data-sets. Coronavirus can sustain on various surfaces (Suman, Javaid, Haleem, et al., 2020). Also, there is an acute shortage of ventilators worldwide, which are essential for patients suffering from COVID-19 (K. Iyengar et al., 2020). The coronavirus outbreak has greatly impacted the supply chian in healthcare industry (K. P. Iyengar et al., 2020). As witnessed from the above study, for COVID-19, the machine learning methods are informative and worth working with.

4. Algorithms used in machine learning

This section discusses the different algorithms of machine learning, such as semi-supervised learning, reinforcement learning, robot learning, and so on. Table 2 represents the algorithms that are used in machine learning. Meanwhile, the co-relation between these algorithms and the severe acute respiratory disease COVID-19 has been studied.

Table 2: Algorithms used in machine learning.

S. No.	Name of Algorithm	Description of Algorithm
1.	Semi-supervised learning	In semi-supervised learning, an algorithm learns from the data-set, which contains both the labelled and the unlabeled data; often, the more numbers are of unlabeled data-sets. The application of this method can be seen when one does not have enough data or resources to produce it. To illustrate, assuming one is developing a model to identify the fraud for a bank. Some of the frauds can slip by without one's knowledge. One can label the data because of its awareness. However, the rest of the data will remain unlabeled (Gandhi & Singh, 2020; Tung, 2019; Li D Xu, 1994, 1999). In the literature, researchers have examined semi-supervised learning for predicting breast cancer. The system is studied taking two known databases, namely Wisconsin diagnostic breast cancer database and breast cancer Wisconsin database. It is found that the results were satisfactory, as the predictions were accurate (Peng et al., 2016). In a study, the semi-supervised learning-based methodology is applied for predicting diabetes disease (J. Wu et al., 2009). In the case of COVID-19, the information is unlabeled data, so this method can be implemented to get an accurate

		prediction.
2.	Supervised learning	It is a learning model for unanticipated input data. It is applied to make predictions. In this learning algorithm, one has the prior information of all the input data-sets. The algorithm then teaches a model to forecast for the response of new data. Thus, to develop predictive models, this learning uses classification algorithms and regression methods (Shobha & Rangaswamy, 2018).
		In the literature, the aim is to diagnose lung cancer disease initially. Supervised learning has been used in the analysis to train the model. A multi-layer perceptron network has been applied to develop the model. This model is further employed to test data. The test data is then compared with the medical diagnosed report for accurate prediction (Balachandran & Anitha, 2010).
3.	Unsupervised learning	It is a machine learning algorithm applied to build interferences from the data-sets consisting of unlabeled input data responses. Cluster analysis comes under unsupervised learning, which is used for analysing exploratory data. While assembling the data or exploring the hidden patterns, this method has been found very useful. This method is used for medical imaging for the segmentation of the images under analysis.
		In the literature, the self-organising map approach is generally used, which is based on unsupervised learning. To activate or fire, the output neurons compete among themselves. This application has been used for the classification of MRI brain images. The available literature analyses the process of minimising the dimensionality of the image its application to the MRI image of the brain, which is being processed at an early stage (Goswami & Bhaiya, 2013).
4.	Self-learning	It is a machine learning algorithm, which moderately learns itself by observing the data in some domains. The more the data, the more the accuracy for the algorithm to update itself. It is the learning where no eternal rewards can be seen (Shams et al., 2020). For both the action and its consequence, this algorithm works, with computes in a crossbar manner (Bishop, 2006).
		In the literature, the CT image of the lung has been examined for pulmonary nodules. This pulmonary nodules system cannot be practised since radiologists have to assign the boundary condition while creating the database feature. These nodules are then segmented with the help of a self-learning technique. This algorithm has helped in reducing the involvement of radiologists (Dhara et al., 2017).

5.	Reinforcement learning	This algorithm is mainly concern with how should a software agent have to decide any given environment. It focuses on empowering one's ability to take action and analyse the feedback with the aid of interacting experience with the world (Singh et al., 2020; Vaishya et al., 2020; Yu et al., 2019). In the literature, the potential of reinforcement learning has been applied for the detection of lung cancer. It is found that early diagnosis of such diseases remarkably improves the result of the treatment, and simultaneously, the survival rate (Z. Liu et al., 2019). A reinforcement learning-based method has been implemented for a diabetes diagnosis. The result showed that the algorithm could be considered a more efficient alternative for diabetes diagnosis (Mansourypoor & Asadi, 2017). Optimise the action path for fighting against any pandemic can be achieved with this algorithm. Thus, with the aid of this significant analysis, the optimal and accurate sequence of actions to stop the COVID-19 spread.
6.	Sparse dictionary learning	This machine learning method focuses on obtaining a frame known as a dictionary. Some of the training data show a sparse representation and to have a better dictionary; the representation must be sparser. In the literature, the sparse dictionary learning technique has been employed to diagnose breast cancer in mammograms (Singh et al., 2020; Vaishya et al., 2020). Thus, aiming that, a supervised discriminative dictionary learning method is used on dense invariant feature transform. It has been found that the sparse vectors are more discriminative as compared to classical vectors (Singh et al., 2020; Tavakoli et al., 2017). A sparse representation-based radionics system has been proposed for the detection of brain tumours. The sparse dictionary learning method applied to extract the statistical characteristics of the tumour area that has to examine (G. Wu et al., 2018). This feature of the machine learning method can be applied to detect the cases of COVID-19 disease.
7.	Feature learning	This is a group of techniques that let a system find the representations required for the quality/feature detection automatically from the data available. Manual feature engineering has been replaced by this method. It helps machines to learn the features and apply them to complete any given specific task. A common eye disorder Age-related Macular Degeneration (AMD) that mainly affects the central part of retina often detected in older people. This disease ultimately leads to permanent vision loss. In the literature, the feature learning method has been used, and it

		automatically distinguishes the AMD from suffering patients from normal healthy people with accuracy. Without even the retina's pre-segmentation, this method accurately processes the image (Venhuizen et al., 2015).
		In a study, a multi-modal stacked DPN feature learning algorithm has been used to diagnose Alzheimer's disease at an early stage. The algorithm used to detect this disease, showing better results by diagnosing the disease with higher accuracy and at its initial days (Shi et al., 2018).
8.	Robot learning	It is combining machine learning and intelligent robotics results in a new research field known as robot learning. This learning method allows a robot to adapt to its surroundings and skills to learn the algorithm. In the literature, to get information on remote environments, the robot learning method has been implemented employing the interaction of humans through a physiological interface. The method reduces the human workload as well as maximises the efficiency and accuracy of the teleoperation system. For such tasks, a non-linear build-up model has been developed as the name of robot learning (Luo et al., 2019).
		Thus, to understand andanalyse the fatigue behaviour of the emerging muscles, the robot learning method has been used. This has been done by examining the human's surface electromyography recording simultaneously with the understanding of robot learning (N. Wang et al., 2018).
		The intelligent robots are designed in such a way that they are capable of delivering food, medicine, etc. to the patients that are suffered from a pandemic disease like COVID-19.
9.	Anomaly detection	Identification of infrequent or rare objects, events, or experiments that causes a rise seems suspicious. This can observe when the majority of the data differs significantly from the existing ones (Zimek & Schubert, 2017). Generally, anomalous objects are seen as some sort of problems such as medical problems, bank fraud, and structural defects (Hodge & Austin, 2004).
		Usually, the case of diabetic retinography screening has been done with manual grading of the images available. However, this literature applied anomaly detection methods for screening. The advantage of this algorithm is that one can benefit from the numerous healthy cases available (Sutradhar, 2019).
		In the literature, with the aid of mammography, the detection of breast cancer has been examined. While diagnosis, whenever, any abnormality has been identified, that region has been highlighted. It implies that

| | | anomaly detectors have benefits over traditional methods (Quellec et al., 2016). |
| | | As this detection method suspects infrequent or rare events or medical cases, it will help identify the new cases of COVID-19. |

We observed from the above table that there is a relationship between these algorithms of machine learning with the COVID-19 pandemic. The above machine learning algorithms may be constructive to identify the number of effective cases that are suffered from novel coronavirus.

5. Significant applications of Machine learning for COVID-19 pandemic

In this section, the noteworthy applications of machine learning have been discussed. Table 3 presents the implementation of these applications on the COVID-19 pandemic. The application of machine learning, such as predicting the nature of any data, can be utilised to understand patients' behaviour suffering from the COVID-19 pandemic.

Table 3: Significant applications of Machine learning for the COVID-19 pandemic.

S.No.	Application	Description
1.	Medical imaging of Infected patient	The novel coronavirus 2019 is spreading globally. It results in ill effects on human health and the global economy. This novel virus is spreading globally among humans and an urgent need to detect the positive cases as soon as possible so that the spreading chain can be braked. Few studies have encountered changes in chest X-ray and CT images before the beginning of COVID-19 symptoms (Chan et al., 2020). Chest radiological imaging such as computed tomography (CT) and X-ray has played an important role in early diagnosis and treatment of the COVID-19 pandemic (S. Yin et al., 2020; Zu et al., 2020). It is also found that by using radiology imaging techniques, the COVID-19 virus can be detected in the human body.
		The application of machine learning-artificial intelligence (AI) techniques coupled with radiological imaging is very helpful in detecting these disease symptoms in the subjects. A new automatic model to detect COVID-19 symptoms in the patients is presented using a chest X-ray image. They used the developed automatic model to accurately diagnostics for binary and multi-class classification. It is found that as advised by the developed automatic models can be used to diagnose other chest-related diseases, including tuberculosis and pneumonia (Ozturk et al., 2020). However, there is a limitation of the developed model that it is not robust and took fewer COVID-19 X-ray images.

Page **13** of **28**

2.	Provide an intelligent platform for healthcare	Machine learning-artificial intelligence (AI) is found as an emerging tool which shows their potential to fight against novel coronavirus disease. The existing technology with NLP, computer visions, etc. enables the computers to leverage big data-enabled models for pattern recognition, interpretation, and prediction. It is observed that the current pandemic disease COVID-19 is spreading worldwide quickly, so there is a strong need to explore and unzip the AI to cure or diagnose the infected patients by COVID-19.
		It is found that China has developed AI-driven sensors that can quickly recognise individuals with a fever, even in crowds. The sensing of COVID-19 patients can be detected by using AI-based technology in Florida through facial thermal scans (V. Kumar, 2020).
		AI-based an app, 'COVID voice detector' used to detect the infection in the human voice. Augmented reality and virtual reality technology provided the virtual environment to the patients to engage with medical professionals.
3.	Precise and personalised treatment of the patient	The advanced machine learning algorithms can be used to understand the COVID-19 pandemic disease spread pattern better. The primary aim is to improve the diagnostic speed and accuracy of the novel coronavirus (Kesharwani et al., 2020; Suman, Nandan, Haleem, et al., 2020a, 2020b; Suman, Javaid, Nandan, et al., 2020).
		The secondary aim is to identify the most susceptible people based on personalised genetic and physiological characteristics (Alimadadi et al., 2020). Personalised treatment strategies can mostly take benefit from precise classifications of the population based on categorised COVID-19 susceptibility.
		The hospitals also required advanced machine learning methods to analysepersonalised therapeutic effects to evaluate new COVID-19 patients. This enhancement in the hospitals will increase the better care of each patient and also improve the local hospital arrangement.
		It is found that with the precise treatment monitoring based on the new "liquid" detection technologies, patients can be identified quickly with increasing affordability (Faulkner et al., 2020; IJzerman et al., 2018).
4.	Identify fever, cough and cold symptoms.	Fever, cough, and cold are the primary symptoms of any flu. It is very important to detect the symptoms according to the affected disease so that the diagnosis can be made accordingly. Misdiagnose can create problems for human health care as the ongoing pandemic disease COVID-19 has the same symptoms as the common flu. It is essential to

		develop the testing kits is such a way that they guide or help the health care providers to detect the suffering patient.
		Machine learning-based artificial intelligence model is used (Imran et al., 2020) to develop an app named 'AI4COVID-19' to preliminary diagnosis the COVID-19 patients, by taking their two seconds cough recordings. Thus, to avoid the misdiagnosis, a novel multi-pronged mediator centred risk-averse AI architecture is developed.
		Various mechanisms can be used to detect the COVID-19 in human beings, such as CT and X-ray scan images, blood samples of the subjects, etc. The primary symptoms in the COVID-19 patients are severe fever, cold and dry cough, and tiredness. Artificial Intelligence (AI) based smartphone sensors have been used by (Maghdid et al., 2020) to detect the above virus symptoms.
		The designed AI-enabled smartphones found the severity of pneumonia and could also predict the result of the disease. Machine learning-based, an urgent end-to-end data-driven modelling approach was proposed to gather the health care data input to a Supervised Machine learning model to ascertain an individual's health status (Anthony, 2020). The proposed approach used an online survey questionnaire application to collect health care data.
5.	Proper health monitoring	To monitor the health of the patients, suffering from pandemic disease, is very important. Machine learning- artificial intelligence has been rolled out to monitor hospitalised patients affected by COVID-19 (McCall, 2020).
		AI has been used to monitor symptoms in the COVID-19 patients; it also provides decision support for CT and X-ray scans, and also help to automate hospital operations. China Hospital established a smart field hospital by using robots. Connected thermometers and bracelet-like device are used to monitor patients.
		The intelligent robots are designed in such a way that they are capable of delivering food, medicine, etc. to the patients. South Korea government developed an app allowing people to self-report symptoms of pandemic disease COVID-19 (Wittbold et al., 2020). The importance of lung imaging in tracking and treating coronavirus patients is studied by (Hunter, 2020).
6.	Clinical trials	The machine-learning-based risk predictive analytical approach is used (Schaaf et al., 2020) to enable pharmaceutical companies to make better predictions and perform new clinical trials. This developed approach is

used in current pandemic diseases such as COVID-19 and can be used as a platform for the next-generation transformation of clinical operations management.

The key challenges in clinical trials are: the patients and the health care staff may come to the exposure of the infectious or pandemic disease during the trial operations, clinics refuse to take part in the trials, and the patients may falling out of trials, etc. During clinical trials, it is very important to regularly review the COVID-19 status, trends, and predictions (Jaly et al., 2020). However, it is very important to take the advice from the epidemiologists from time to time, so that the risk can be avoided.

7.	Disease and patient behavioural analysis	The patient's behaviour and the analysis of the current and future pandemic disease behaviour are very important. Machine learning-based artificial intelligence focuses on developing mathematical models to analyse the COVID-19 pandemic disease using national data (Punn et al., 2020).

Machine learning and deep learning models are used to understand the daily exponential behaviour by using real-time information from the Johns Hopkins dashboard. A comparative analysis of machine learning and soft computing models to predict the COVID-19 outbreak is proposed (Ardabili et al., 2020).

It is found that the two machine learning models, such as multi-layered perceptron, and adaptive network-based fuzzy inference system, showed promising results towards the model of the behaviour of the COVID-19 outbreak from nation-to-nation.

In this view, it is imperative to predict the behaviour of the spreading the virus so that the early actions may be planned to stop the spread of the COVID-19 disease. Machine learning algorithms play an important role in epidemic analysis and forecasting in the availability of massive epidemic data.

8.	Virtual treatment	Various machines and deep learning methods can be used for virtual treatment or virtual reality therapy (Bălan et al., 2020; Opriş et al., 2012). It has significantly emerged in the present decades and allows the design of immersive virtual worlds that provide advancements in a safe and controlled manner (Yuan & Yang, 2019). Virtual reality technology was used for drug addiction treatments. Machine learning assisted virtual screening was used by the researchers along with scoring led found the best results in the scores of H7N9. Machine learning-guided virtual

		reality simulators can guide the neurosurgeons before they step into the operating room (Anderton, 2019). In the present situation, like the widespread COVID-19 pandemic, in which virus is spreading rapidly, getting more accurate scores quickly informing the problems to accelerating the development of drugs or vaccines (Schmit, 2020). However, using machine learning methods and virtual reality or screening methods may solve this issue.

It is observed that the novel coronavirus is spreading through human to human by developing their hosts. The spread connectivity between the doctors and the patients is very large. In this regard, there is a need to diagnosis effective or expected patients virtually. Globally, physicians and health systems are racing to adopt virtualised treatment approaches that eliminate the need for physical interactions between the patients and health care providers. To prevent the people from the COVID-19 and track the effective patients' Indian government using instant messaging platforms, to provide virtual health care services (Webster, 2020). Arogya Setu-the app is the step forward in this area. Virtual robots are used to deliver medicine and food to COVID-19 patients so that the physical contact between the doctors and the patients can be avoided (V. Kumar, 2020). |
| 9. | Prediction of future disease symptoms | It is very important to predict the symptoms of present and future diseases that may hit the humanity with the impact of deaths globally. Machine learning methods such as deep neural network and long-short term memory learning methods are used to predict the symptoms and spread of infectious diseases such as chickenpox, scarlet fever, and malaria (Chae et al., 2018). Industry 4.0 technologies are very useful in fighting against Coronavirus (Javaid et al., 2020).

Similarly, machine learning methods, such as artificial intelligence or artificial neural network, can be used to predict the symptoms of future diseases such as genetic disorders etc. This prediction is made by observing the facial expressions or features, predict the risk of heart attack by observing the patterns of blood vessels on the retina at the back of the eye, used to monitor a patient's posture, breathing and even sleep for early signs of illness, etc. (Kaminsky, 2019). The future health care condition of patients can be predicted using various machine learning tools by collecting data from the clinical reports, doctor's notes, and various wearable body sensors (S. Wang et al., 2016).

The machine learning models are helpful to predict the spread of the |

		COVID-19 pandemic in real-time. However, the methods are very effective to forecast the spread of novel coronavirus in the future. Also, machine learning methods may be used to predict the trends in infectious pandemic diseases such as COVID-19.
10.	Patient screening	Diagnosing a person, whenever any pandemic disease hits globally, is challenging, cumbersome, and difficult. It is very difficult for any country to develop testing kits on a large scale to go through each individual's test. It is also observed that whenever any pandemic disease happens, the symptoms indicate other potentially milder diseases. In this view, it is essential to gather accurate test data using cheaper test methods, which helps screen patients suffering from the existing pandemic (Schmit, 2020).
		Machine learning can help to screen COVID-19 pandemic patients by using artificial neural networks (L. Li et al., 2020).
		Machine learning is also used to identify the tell-tale patterns in a patient's resting heart rate, predict drug-target interactions between the virus's proteins and existing drugs, and generate or build biomedical knowledge graphs. A deep learning algorithm using chest CT or X-ray images to screen COVID-19 patients is used (Butt et al., 2020; Ozturk et al., 2020).
		A deep learning and transfer learning-based model COVID-Net is used for COVID-19 detection in patients (Apostolopoulos & Mpesiana, 2020; L. Wang & Wong, 2020).
		A deep learning model called DarkCovidNet was proposed to detect COVID-19 (Ozturk et al., 2020).
		All the above features of the machine learning methods suggest that they are very effective in screening the COVID-19 patients initially.

It is concluded from the above table, that the application of machine learning methods to predict the behaviour and nature of this severe acute respiratory COVID-19 disease. New cases can be easily identified, and the death rate can be reduced when using the benefits of machine learning methods. However, the wide application of machine learning is to develop an artificial network to make the computers intelligent in such a way the doctor's physical interaction with the patients can be reduced. Also, to enhance the current information technology in such a way that the detection, prediction, identification etc. of the effective patients can be made at home. To update our healthcare & other technological systems so that the effect of COVID-19 pandemic can be reduced worldwide, machine learning methods are very useful.

6. Discussion

The present study on machine learning methods for COVID-19 mainly focuses on how machine learning methods and algorithms can be applied to the COVID-19 pandemic to predict and analyse the recovery and death cases. A study for COVID-19 has been done for clustering, which is a machine learning method, and it is found that in day to day growth there are some distinguishable clusters when considering deaths, recovered, and confirmed cases from coronavirus disease. In brief, machine learning methods and algorithms can help the COVID-19 understand the behaviour of the patient and analyse the present and future scenarios considering this pandemic. This can result in a fewer number of effective cases and a lesser number of deaths caused by the COVID-19.

7. Conclusion

Machine learning can be used for the COVID-19 pandemic to update the database by learning the data itself. This technology is convenient and fruitful for screening the patients and performing a thermal scan of the human face and the whole body. This initial and quick scanning detects the fever of the person. The initial data is recorded, and machine learning models help to triage them effectively. The main objective of machine learning models is to accurately design the infectious disease prediction models that are desirable than the existing models, like auto-regressive integrated moving average method and ordinary least squares method to predict the symptoms of infectious pandemic diseases. The major applications of machine learning are for medical imaging of the infected patient, precise and personalised treatment of the patient, identify fever, cough and cold symptom, proper health monitoring, clinical trials, analysis of patient behaviour, virtual treatment, patient screening, prediction of future disease symptoms and provide an intelligent platform for healthcare. In the near future, machine learning will be competent to understand the COVID-19 circumstance, which requires immediate action. Its use will result in useful and accurate predictions when examining the cases of COVID-19 pandemic.

Acknowledgments

Declaration of Interests

The authors declare that they have no known competing interests regarding this article.

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