

THE PRACTICES OF ARTIFICIAL INTELLIGENCE TECHNIQUES AND THEIR WORTH IN THE CONFRONTATION OF COVID-19 PANDEMIC: A LITERATURE REVIEW

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Abstract

Today, the medical society is living in the era of artificial intelligence, which is developed and becomes more famous thanks to the coronavirus disease of 2019 (COVID-19) pandemic, which has given the space for artificial intelligence to appear more influential in analyzing medical data and providing very accurate results. This science has deservedly been able to achieve an excellent and vital position among healthcare workers, and it has become a necessary element of their work because of its a great potential for practical decision-making. The prospects of using intelligent systems in the medical field are deemed essential in the health division due to their ability to analyze big data and give exact results, aiming to improve the health of citizens and save their lives. In this article, a set of important information about the vital role of artificial intelligence in the medical field is highlighted. In addition, how this science does manage to confront SARS-CoV-2 by highlighting a set of investigations and analyses in predicting the spread of the virus, tracking infections, and diagnosis of cases through chest x-ray images of COVID-19 patients. The database of this article covered more than 40 studies between 2020 and 2021 and investigated the effects of utilizing artificial intelligence techniques in analyzing SARS-CoV-2 data. These studies are gathered from PubMed, NCBI, google scholar, Medrxiv and other sites. This article includes a plethora of information about artificial intelligence and SARS-CoV-2. The findings confirm that artificial intelligence has a significant role in the healthcare domain, and it is advised to utilize its applications in the decision-making method.

Keywords: Artificial Intelligence, COVID-19, SARS-CoV-2, Vaccines, Machine Learning, Deep Learning.

INTRODUCTION

For decades, the world has started to think about machinery devices and the ways of their construction, as Alan Turing firstly proposed this concept in 1950 with their article on machines and their growth, entitled “Computing Machinery and Intelligence” [1]. The concept of artificial intelligence is presented to the public in 1956 by the American scientist John McCarthy [2]. From this time, this concept was not clearly visible until the arrival of the SARS-CoV-2 pandemic [3], which has a great credit for the spread of this concept and its practice in the medical fields in a significant and noticeable way. In China, machines are used to serve healthcare workers in transporting medicine and food to the rooms of the injured people and using them in sprays disinfectant and monitoring citizens [4] [5]. Artificial intelligence is a set of models that have the ability to predict the unknown by creating complex algorithms that can make judgments from the input data that they encounter in solving problems and making decisions [6] [7]. Also, there is an active part in artificial intelligence, which is machine learning [8], it is a general term for artificial intelligence algorithms that work with statistical logic based on predictions by designing models that can develop analytical equations to solve problems according to the data of those problems

in order to make the appropriate decisions [9]. Although these algorithms are not explicitly programmed to perform a particular task, they are based on existing data.

The sudden progress in the effectiveness of computer media in recent years is a high indication of the level of integration, usefulness, and the unique role that computers could play in the modern contemporary world and in particular in the medical domain [10-12]. Most nations of the world seek to grow their health organisations through the use of modern technology and the introducing of a culture of information and communication technologies in hospitals [13]. Despite the tremendous development in artificial intelligence, there is now a set of obstacles that stand in the development of its effectiveness capabilities, as this science collides with a terrifying triad represented by the expensive medical imaging techniques, such as fluorescence imaging [14], computerised tomography (CT) scans [15] and magnetic resonance imaging (MRI) [16], doctors who have the knowledge and skill necessary to deal with these techniques; and improving software that can analyse thousands of patients data. Many disciplines have become more familiar with computer science in the last decade. The latter allows the simulation of human intelligence through artificial intelligence, which is the respiratory system of computer science [17]. In other words, the growth of artificial intelligence allows the physicians to help diagnose the disease and make the right decision in improving patient health conditions. Diagnosing diseases is a complex and confusing matter and requires experience in determining a person's health condition [18][19]. Some specialists find it challenging to determine the type of disease.

In addition, the accurate disease diagnosis takes a long time and, thus, assessment and management of patient could be delayed; thanks to artificial intelligence, the process of diagnosing the disease has become straightforward, uncomplicated, quickly, and easily accomplished [20]. There are many published studies showing high statistics in the use of artificial intelligence applications in the medical field [21][22]. The growth of artificial intelligence techniques utilised in medicine represents a new perspective that can be used to reduce the time in diagnosing the patient's condition, costs and most importantly is medical errors, contributing to enhancing human resources in medical branches with more significant requirements.

Unfortunately, the application of artificial intelligence faces challenges in the realm of health. It is not easy to comprehend the human mind on a synthetic scale. In fact, there are many countries that are very optimistic and encourage their hospitals and universities to employ these technologies and also how to link the relationship between the physicians and artificial intelligence [23]. There are many published and popular pieces of literature that provides the importance and benefits of artificial intelligence in medical sciences, as well as high indicators that expect the emergence of artificial intelligence technology among physicians and specialists and the use of machines to perform or assist in surgical operations or the production of drugs and other essential things [24-30].

At the end of 2019, the whole world has witnessed the spread of a deadly and ruthless pandemic termed the COVID-19 pandemic caused by a coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [31][32], where the first infected case is announced in the most famous city on the globe is Wuhan city, China, on 31st December 31 of 2019, then this virus spread to everywhere like wildfire, and no one can obstruct it [33]. The COVID-19 pandemic is significantly different from the rest of the previous epidemics [34], as it has appeared at a time of significant and robust development in application technologies and machines [35][36]. Many websites have appeared to track the number of SARS-CoV-2 infected cases and deaths due to this virus, which are published and updated on a daily basis, and distributed by countries and cities. For instance, the Bing website tracks the spread of SARS-CoV-2 infection (<https://www.bing.com/covid/>) in all nations, as this site shows the numbers infected patients, recovered cases, and the deaths, whether in total or in each nation. In addition, this website includes tracking the number of people who have received COVID-19 vaccinations. In Turkey, the Turkish Ministry of Health creates a page on its website that tracks the spread of the SARS-CoV-2 virus, and it is updated daily, as well as gives the number of citizens who received a full dose and one dose of the COVID-19 vaccine. There are many other examples of these sites in

tracking the spread of SARS-CoV-2 infection; if linked with the movement of human data in other nations, it constitutes an extensive database that could be developed through effective medical policies to combat this fatal virus. Moreover, the data can be used to train artificial intelligence algorithms and techniques to obtain more effective solutions in predicting the spread of the COVID-19 pandemic, diagnosing infections, and determining the appropriate treatment [37].

The prominent enrichment of this article is to highlight a set of literature and articles published in the fight against the COVID-19 pandemic utilising artificial intelligence techniques in predicting spread, tracking infections, and diagnosing cases of the disease. This article can become as one of the references that can be used in the future.

In the following parts, the COVID-19 pandemic in a set of lines is explained in part 2. The contributions of some of the published literatures about fighting this pandemic are exhibited in part 3. Eventually, a conclusion is drawn up in part 4.

COVID-19 PANDEMIC

In the past centuries, many severe pandemics have appeared that have profoundly affected the lives of millions of souls, and the most popular of one is the Spanish flu (Great Influenza-1918) [38]. This pandemic has pressed the people and countries to follow strict precautionary measures at the home, workplace, and public to confront it and limit its infectivity, including wearing masks, enforcing social distancing between citizens, practicing hand hygiene on an ongoing basis, taking off clothes before entering the residential place, isolating the infected and suspected cases, prohibiting public gatherings, enclosing educational institutions, applying curfews from time to time, sealing-off borders, and closing cities [39- 42]. Thus, this pandemic and its associated health measures have caused significant impacts on the physical and psychological health, and financial, cultural, social, and other aspects of people's lives of different diverse levels, including the general population, COVID-19 patients, and students [43- 48]. The SARS-CoV-2 disease is not only severe [49][50], but it is one of the most famous among the diseases, as its symptoms and methods of protection from it have become known to all, unlike other diseases that require a healthcare worker to confirm them, thanks to social networking sites, which in turn have contributed to the transmission of progress in the spread of the virus in every nation and also ways to prevent it [51][52]. Figure 1 exhibits the possible transmission routes of coronaviruses into humans and their primary origins and intermediate reservoirs [53]. Most human emerging infectious diseases originate from animals as they act as reservoirs for pathogens and transmit them frequently to humans [54] [55]. Table 1 summarises the latest statistics of total SARS-CoV-2 infected case, the number of deaths due to this virus, and the number of people who received vaccinations from the Google website. These statistics are from the beginning of the pandemic until November 2021 for the first ten nations with Iraq and Jordan. In the situation of SARS-CoV-2 infection, the incubation period from virus entry into the body until symptoms arise is on average 4-7 days [56-58]. The signs or symptoms can be very faint or quite vague. The most common symptoms/signs are fatigue, dry cough, nasal congestion, sore throat, fever, muscle pain, and shortness of breath may be recognised, while the runny nose, headache, vomiting, diarrhoea, and loss of sense of smell decrease [59-61]. The average time from the first onset of symptoms until the onset of acute respiratory distress syndrome is estimated to be about eight days [62]. It is strongly advised to monitor the oxygen saturation (SpO_2) level with pulse oximetry to detect hypoxia as early as possible in the COVID-19 patients (Figure 2). Oxygen treatment is widely used and highly suggested worldwide as it is significant and has the potential to reduce the spread of SARS-CoV-2 in the lungs [63] [64]. Shen et al.; reported that oxygen treatment could disrupt virus replication, improve antiviral immune response, and reduce angiotensin-converting enzyme (ACE2) expression, indicating that oxygen night treatment could delay the construction of the virus [65]. Hypoxia is the dysfunction that happens due to a lack of oxygen in the blood, cells and tissues, and it indicates the weakness of a patient's respiratory system to oxygenate arterial blood [66] [67]. The dyspnoea (shortness of breath) describes uncomfortable, difficult and fatigue breathing; while tachypnoea (normal range is 12-20 breaths per minute) describes an increased respiratory

rate, and hyperpnea means an increased inhaled tidal volume [68][69]. 2% of oxygen in the blood is dissolved, and 98% is bound to haemoglobin (Hb) [70][71]. Oxygen bound to Hb is measured with a pulse oximeter. The average value of SpO₂ is between 90-100% [72]. Oxygen dissolved in blood is measured by the partial pressure of oxygen (PaO₂) in arterial blood gas [73]. The PaO₂ is approximately 160 mmHg at normal atmospheric pressure at sea level [74], while it is 140 mmHg in the trachea [75], 100 mmHg in arterial blood [74], and 40 mmHg in venous blood [74]. The alveolar-arterial oxygen difference does not exceed 10-15 mmHg. Ordinarily, some severe cases suffer from shortness of breath or lack of oxygen in the blood after a period of one week from its appearance in the affected body, followed by septic shock, then acute respiratory distress syndrome (ARDS) [76][77]. The effects of these cases are very inconsistent and may lead the patient to death or survival from this virus. Some reports and investigations have appeared that confirms that people have a pandemic and the most obvious symptoms that have appeared them. For illustration, [78] in China, the Chinese centre for disease control and prevention announces that more than 44,500 people are confirmed to have contracted SARS-CoV-2, as 81% of them are mild cases (with or without pneumonia), while 14% have 50% of lung injury and their condition is very severe (hypoxia, anorexia, shortness of breath), in addition, 52% had a very critical condition (shock, body dysfunction, failure respiratory) and the death rate is 2.3%. In the States [79], a report from the US centres for disease control and prevention explains that 14% of the 1.3 million people approved with SARS-CoV-2 are admitted to hospitals, more than 2% are followed up in the intensive care unit (ICU), and more than 5% of them died. A set of investigations has confirmed that severe lung injuries are associated with diabetes mellitus, malignant tumours, primary immunosuppression and obesity, which do not lead to high mortality. In contrast, high mortality is associated with the elderly, having high blood pressure and being a male [80].

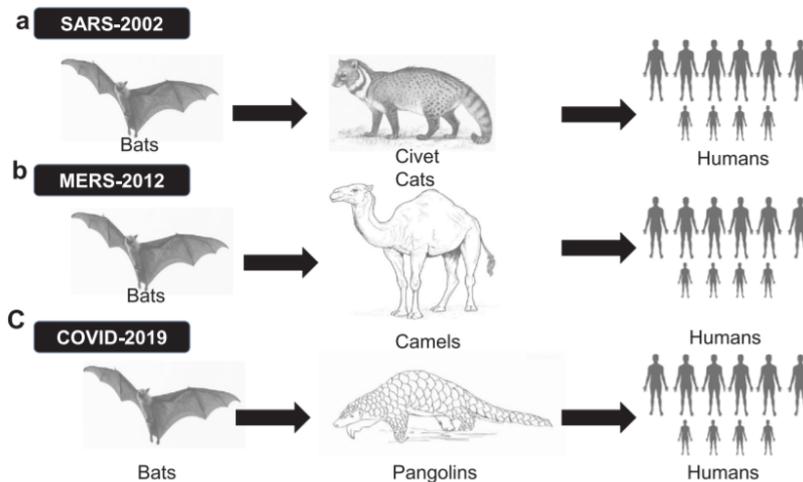


Fig. 1. Origin of coronaviruses and transmission into humans. (a) SARS: the source is bats, and intermediate reservoirs are civet cats. (b) MERS: the source is bats, and intermediate reservoirs are camels. (c) SARS-CoV-2 (COVID-19): the source is bats, and intermediate reservoirs are pangolins.

Table 1. SARS-CoV-2's statistics from the beginning of the outbreak until 25th November 2021

Nations	Total cases	Deaths	Total doses given	Fully vaccinated
Worldwide	259,465,151	5,174,661	7,776,456,951	3,320,133,143
USA	48,064,155	776,197	452,704,982	194,481,416
India	34,544,882	466,980	1,193,769,229	418,692,797
Brazil	22,043,112	613,339	297,960,460	128,481,994
UK	9,974,843	144,286	113,041,002	46,208,819
Russia	9,270,885	262,733	122,045,399	54,621,506
Turkey	8,654,142	75,618	119,726,075	50,192,722
France	7,296,757	116,289	103,333,752	46,777,499

Iran	6,092,822	129,280	102,145,229	44,726,047
Germany	5,595,674	100,123	119,524,302	56,717,761
Argentina	5,319,867	116,458	66,426,671	28,645,100
Iraq	2,076,922	23,725	11,380,981	4,325,757
Jordan	1,031,549	12,151	8,110,107	3,849,114



Fig. 2. Pulse oximeter from Microtek [This image downloaded from Google]

Despite the spread of vaccines and the decrease in the number of infections from time to time, the adopted precautionary measures to prevent the transmission of the virus between citizens such as (wearing masks, a social distancing between citizens, practising hand hygiene on an ongoing basis, isolating the infected, curfew from time to time, closing cities, etc.) do not control significantly to stop the pandemic and do not achieve a return to traditional life. Also, some nations such as the United Kingdom and other European countries, allowed many practices to return to their normal state while adhering to health measures such as institutions, sports, events such as football and other practices, where the European championships allowed the public to return to the stadiums and encourage their teams naturally, but with the condition of commitment to wearing masks and taking COVID-19 vaccines (see Figure 3). Furthermore, while the virus is still evolving in its infectious strains, which are more robust than its predecessor, and many citizens continue to take vaccinations, and specialists continue to develop these vaccines until they are compatible with the development in the genes of the virus.



Fig. 3. People are receiving the COVID-19 vaccine in the United Kingdom. [These images are downloaded from Google]

SARS-CoV-2 infection develops by binding to the angiotensin-converting enzyme 2 (ACE-2) receptors of the host cell via protein spike and entering the cell [81]. The virus then leaves the cell by antigen-presenting cells (APC) and is presented to helper T cells [82]. In this regard, all investigations of the SARS-CoV-2 vaccine aim to use spike proteins and produce antibodies in order to achieve a more useful vaccine [83]. In addition, inactivated virus vaccines, nucleic acid-based vaccines (mRNA and DNA vaccines), vector vaccines, protein-based vaccines, virus-like particles, and live virus-attenuated vaccines are being tried to achieve extraordinary outcomes and are applied to citizens for the prevention of this virus. Table 2 presents the most popular types of vaccines and the companies producing them. So far, with the lack of definitive treatment for

SARS-CoV-2 and the COVID-19-related socio-economic burden, the vaccine against COVID-19 is, perhaps, the best hope and the most cost-efficient intervention for ending this pandemic. However, COVID-19 vaccine hesitancy and low acceptance rates are critical threats to achieving herd immunity and ending this pandemic [84]. On this basis, countries determine treatment protocols for outpatients and inpatients according to their health policies and opportunities available to them considering scientific data. In Iraq, arrivals or departures are prevented from travelling or entering Iraq unless they present the vaccination card or swab report, and the result is negative.

Table 2. Coronavirus disease of 2019 (COVID-19) vaccines

Vaccine Types	Names and Chemical Companies
mRNA Vaccines [85]	mRNA-based vaccines Pfizer/BioNTech (BNT162b2), Moderna (mRNA-1273)
DNA Vaccines [86]	DNA-based vaccines Osaka University, Ege University, and Entos Pharmaceuticals. ZyCoV-D is developed by Zydus Cadila. DNA plasmid vaccine S, S1, S2, RBD & N by National Research Centre
Vector Vaccines [87]	AstraZeneca/Oxford, Sputnik V is developed by Gamelaya Institute Centre, CanSino, and Johnson & Johnson.
Protein Subunit Vaccines [88], Virus-Like Particle Vaccines [89]	Novavax, VBI Vaccines, Medicago, SpyBiotech
Live Attenuated Vaccines [90]	Codagenix
Inactivated Vaccine [91]	Sinovac (CoronaVac.), Sinopharm, Bharat/BioNTech (COVAXIN)

THE ROLE OF ARTIFICIAL INTELLIGENCE IN FACING THE COVID-19

Today, it is not easy to gain a universal definition that describes the capabilities of artificial intelligence and what it contributes to human assistance. It often refers to the field of computer science that attempts to simulate the cognitive processes of the human mind through the ability to learn, build information, save knowledge, solve problems and make decisions. The logical aim of artificial intelligence is to create intelligent entities, in other words, computer programs, where artificial intelligence can be considered systems capable of accomplishing tasks, for instance, translation of a document, self-driving, and identifying a person through the features of a face, etc. Artificial intelligence is not limited to accomplishing human tasks, but, in some cases, it has the ability to surpass the best expert in a particular field by making decisions with lower error rates or by identifying patterns and practices that are unnoticeable to the human eye. Consequently, artificial intelligence allows data and information to be analysed by implementing completely different methods and approaches to traditional methods as well as genetic algorithms that are widely operated to execute large sets of big data [92] [93]. This science allows answering other mysteries: What "occur"? (for diagnosis), what will occur? (to predict), What do they (experts) do? (prescription). Artificial intelligence is the knower, as it has many merits in the field of health care, such as automatic speech recognition and natural language processing, prediction, diagnosis, image analysis, use of robots in hospitals, and expert systems.

In this part, the merits that could be achieved by artificial intelligence the face of SARS-CoV-2 in terms of prediction, tracking, patient diagnosis and virus detection will be identified through a set of published pieces of literature between 2020 and 2021.

Predicting the spread of the virus

Artificial intelligence techniques define the processes that aim to get them using algorithms that are the basis for the prediction process [94-96]. Predictions or decisions are created based on data

collected from current practices that are difficult for humans to develop by manual methods of complex data processing [97]. For this analysis, the computer is given a complete chance to discover its model. Data is presented for the task assigned to the model. The learning is done from the data provided first. The performance and operation of the generated algorithms are tested by learning using different data. In other words, the model that creates a performance measure with the outputs cannot accurately predict the required level, and its performance is increased by optimising to get more dependable results. Predicting the number of suspected serious cases or the appearance of confirmed cases is very necessary to prevent and control SARS-CoV-2 infection. A study by Yang et al. [98] employed citizen migration data to populate the infection model used, combined with artificial intelligence algorithms trained on SARS, to predict the SARS-CoV-2 curve. The effects of this investigation prove that delaying the implementation of public health measures imposed by the Ministry of Health of the People's Republic of China for a period of five days would have led to an increase in the spread of the pandemic at a high rate. Moreover, reducing or cancelling social distancing measures would have caused the number of infections to rise significantly. Another article published by Qin et al. [99], they employ five methods to predict SARS-CoV-2. The database of the study is obtained from social media search indexes, dry cough, fever, chest tightness, coronavirus, and pneumonia for the period from December 31, 2019, to February 9, 2020. The number of suspected cases from January 20, 2020, to February 9, 2020. This research confirms that social media search indexes are an essential, early, and practical indicator of predicting the number of SARS-CoV-2 infections, which government public health departments (in any nation) can get the advantage of in terms of identifying potential and high-risk areas in which the virus is spreading. In another study [100], a deep learning model is utilised is Long short-term memory (LSTM), which is a model used to predict the short-term trend of the spread of the virus and predict the number of infected people before four weeks. This study is applied in South Korea. The results of this work prove that the number of infected people in Korea would reach a peak in prediction after only one week and begin to decline gradually. In a study conveyed by Li et al. [101] to predict the use of machine learning techniques on a group of samples and analysis of Weibo posts from more than 17,800 active people via the Internet, it is advised to know the psychological conditions after the outbreak of the SARS-CoV-2 virus among citizens and provide them with appropriate support and treatment to get rid of feeling negative. In a study conducted by Irvin et al. [102] to predict COVID-19 using convolutional neural network architectures (Inception-v4, ResNet152, DenseNet121, and SEResNeXt101), they apply the Chest eXpert task (a comprehensive dataset for chest radiograph interpretation) to predict the probability of fourteen different observations from multi-view chest radiographs. Besides, they apply the Grad-CAMs technique to filter the output class to the final convolutional layer to produce a low-resolution map that highlights parts of the image important in discovering the output class. Figure 4 is an example of using the Grad-CAMs technique with sample images from Chest eXpert.

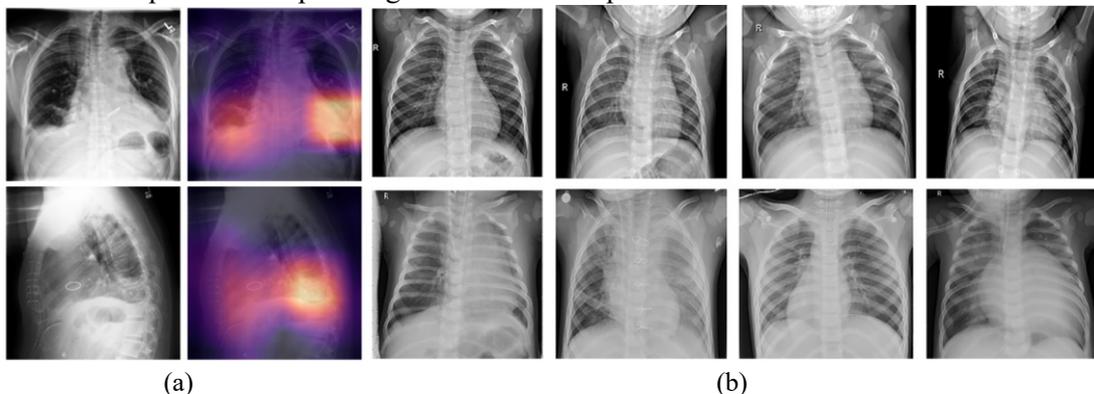


Fig. 4. a. Frontal and lateral radiographs of the chest in a patient using Grad-CAMs with predicted probabilities $p = 0.936$ & $p = 0.939$ on the frontal and lateral views, respectively. **b.** Eight sample images of chesteXpert [103].

Moreover, many other studies discussed machine learning techniques utilised in predicting the COVID-19 outbreak, some of which will be reviewed in Table 3. The articles in Table 3 are reports of samples cases for prediction includes rapid exclusion, prediction of diagnosis at first admission, critical patients' prediction, mortality prediction, prognosis, prediction of disease in children, and prediction of the need for intensive care in patients.

Table 3. A sample of articles between 2020 and 2021 that utilise machine learning techniques for prediction

Studies	No. of Samples	Methods	Effects
Meng et al. [104]	620	LR	Positive predictive is 86% Negative predictive is 84%
Gong et al. [105]	189	LR, RF, DT, and SVM	Accuracy is 95%
Sun et al. [106]	220	SVM	AUROC is 0.975
Yan et al. [107]	485	XGBoost	Accuracy is 90%
Brinati et al. [108]	279	DT, ET, KNN, LR, NB, and RF	Accuracy is 82% →86%
Yu et al. [109]	105 children aged 1-16yr.	Supervised DT	The male infection rate (60.95%) is higher than that of females (39.05%).
Yadaw et al. [110]	3841	XGBoost, LR, SVM, and RF	AUC is 91%
Berenguer et al. [111]	4035	LR	AUC is 0.845
Ikemura et al. [112]	4313	Stacked Ensemble Model + SHAP	AUC is 0.903
Statsenko et al. [113]	560	AdaBoost, GB, RF and ET	AUC value is 0.86 and aPTT, CRP and Fibrinogen results

Tracking the spread of the virus

In a study conducted by Zhao et al. [114] from China to follow more than 854,400 people who left from the Wuhan Tianhe Airport -Wuhan to 49 Chinese cities from December 30, 2019, to January 20, 2020, multiple linear models are presented to analyse data from the Baidu map (see Figure 5.a), where data are obtained from local citizens and airline passengers as predicted variables. This is valuable for estimating the size of the variation in infection with the Coronavirus from one city to another. In this study, the authors applied the Spearman correlation to analyse daily movement data departing from Wuhan. The results of this paper displayed a high degree of correlation between confirmed positive cases and the size of the city's population. In a study by Githinji et al. [115] to monitor the genomes of people entering Kenya by the coastline. The data for this study consists of more than 300 genomes collected between March 17 and July 31, 2020. The authors estimated that many of the confirmed findings are primarily of European origin, even though they come from countries neighbouring Kenya, which account for 74.1% of cases sequential. A group of strains is discovered in individuals (departures and returnees) examined at the Kenya-Tanzania border (See Figure 5.b). The results did not show significant and expansive development in the spread of the virus in Kenya, except undetected introductions through entry points that led to the effect of the pandemic on the Kenyan coast. In a study conducted by a group

of Algerian scholars [116], they advised designing an internet of things (IoT) investigation system. This system has been specifically designed to detect both sick persons not registered in the database and infectious regions. The strategy aims to assist the authorities in tracking people, fogging areas, and taking the necessary measures. In addition, the system is characterized by identifying all people who have been in close contact with patients or suspects. Thus, they are isolated at high speed and reduce and control the spread of the virus.

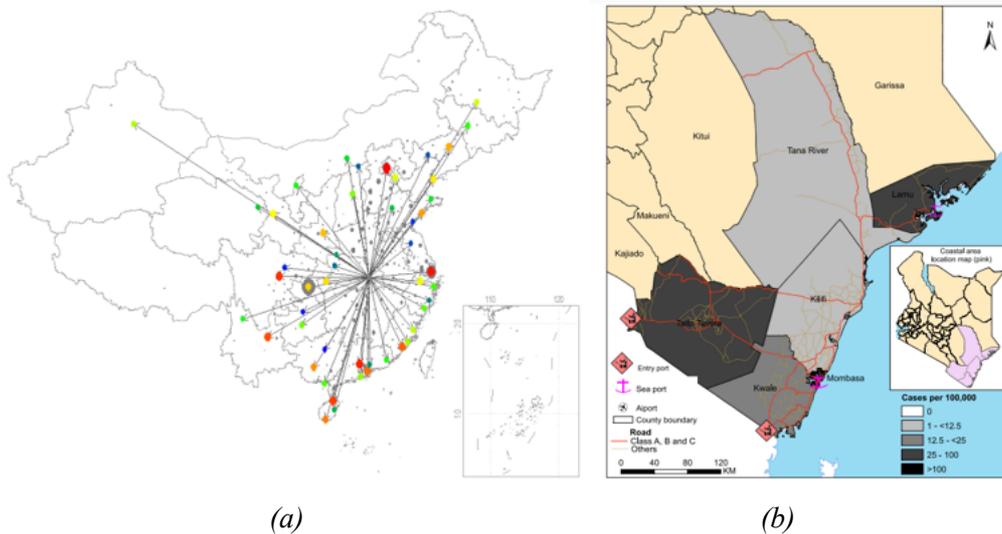


Fig. 5. a. The distribution of 854,424 air passengers from Wuhan Tianhe Airport to 49 cities in China from 30th December 2019 to 20th January 2020. The sizes of the marks indicate the number of passengers, which are also designed in colour series: blue, green, yellow, brown, and red. b. The map shows the spread of SARS-CoV-2 at the Kenya coast

The diagnosis of COVID-19

In 1959, the concept of machine learning was used by computer scientist A. L. Samuel in a computer game [117]. Then, it was first mentioned in the field of medicine in the article "Medicine and the computer. The promise and problems of change" by William Benjamin Schwartz 1970 where he explained that algorithms would be the physician's mindset that would improve their ability and sometimes replace the physician in analysing diseases [118]. Imaging and radiology technologies are one of the domains in which artificial intelligence is improving more durability thanks to machine learning and deep learning techniques [119-123]. These technologies have developed and recorded tremendous success in a lot of utilisations such as computed tomography and chest X-rays, efficiently and quickly [124]. The main reason is that these technologies statically save images that are then judged and categorised by health specialists where they can recognise, identify, and diagnose disease more accurately than the human eye can detect. Table 4 illustrates a set of machine learning techniques for classification and regression, from the most generally used linear techniques such as logistic regression to advanced techniques such as XGBoost. Today there are many studies conducted in the diagnosis of SARS-CoV-2 disease through chest X-ray images.

This part reviews a set of scientific literature carried out by a group of scholars in analysing chest X-ray images to detect SARS-CoV-2 in the human lung by applying machine learning and deep learning techniques. Figure 6 exhibits chest X-rays of victims with pneumonia and SARS-CoV-2; both diseases make the patient in challenge to breathe [125]. Table 5 exhibits a collection of 20 of literature in analysing X-ray images utilising artificial intelligence techniques.

Table 4. The most generally utilised machine learning techniques

Techniques	Type	Illustration
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RF	Classification and Regression	Series of uncorrelated predictor trees
GB	Classification and Regression	Series of staggered predictor trees
LR	Regression	Regression analysis is applied to predict the outcome of a class variable
SVM	Supervised classifier (linear model)	Classifier through the construction of dissociating hyperplanes
KNN	Supervised classifier (non-parametric method)	Judgment of the density function of the predictor variables as a function of the classes
LDA	Linear discriminant	The generalisation of Fisher's Linear Discriminant
NB	Probabilistic supervised classifier (linear classification method)	A probabilistic classifier based on Bayes' hypothesis

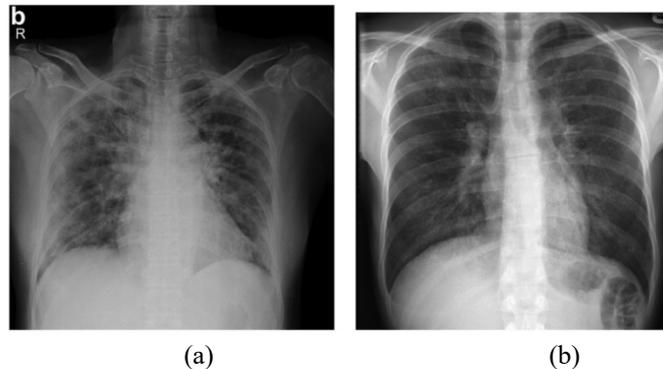


Fig. 6. Example of Chest X-ray for Patients with SARS-CoV-2 and pneumonia: (a) Chest X-ray of SARS-CoV-2 patient, (b) Chest X-ray of pneumonia patient

Table 5. Performance of some studies collected in the analysis of chest X-ray images

Studies	No. of Datasets	Methods	Accuracy%
Rahimzadeh and Attar [126]	15085	Xception and ResNet50V2	91.4
Narin et al. [127]	341	InceptionV3, ResNet50, ResNet101	96.1
Apostolopoulos et al. [128]	3095	MobileNet-v2	99.18
Mahmud et al. [129]	610	Transfer learning with CNN	97.4
Sathitratanacheewin et al. [130]	112,120	DCNN	-
Duran-Lopez et al. [131]	6926	CNN	94.43
Sekeroglu and Ozsahin [132]	6080	SVM, LR, DT, NB, KNN, VGG16, VGG19, InceptionV3, MobileNet-V2, ResNet50, and DenseNet121	98.50
Abbas et al. [133]	196	DeTraCResNet18	93.1
Maguolo and Nanni [134]	144	AlexNet	-

Minaee et al. [103]	300	ResNet18, ResNet50, SqueezeNet, and DenseNet-121	-
Wang et al. [135]	16,756	COVID-Net	92.4
Khan et al.[136]	1251	CoroNet	95
Ibrahim et al. [137]	3252	AlexNet	99.16
Alam et al.[138]	5090	(CNN+HOG) + VGG19 pre-trained model	99.49
Polat et al.[139]	1821	ResNet, DenseNet, and VGG	97.1
Shelke et al.[140]	2271	VGG-16, DenseNet-161, and ResNet-18	98.9
Cortés and Sánchez [141]	11,312	AlexNet	96.5
Mijwil [142]	1445	RF, LR, NB, and SVM	91.8
Khasawneh et.al [143]	1080	2D CNN, VGG16, MobileNets	98.7
Badawi and Elgazzar [144]	15000	DenseNet201, VGG-16, and VGG-19	99.62

CONCLUSIONS

When reviewing works related to the utilisation of artificial intelligence techniques in analysing SARS-CoV-2 data, such as (prediction, tracking, and diagnosis), it is remarked that big data and artificial intelligence have an influential and significant role in combating the spread of the pandemic. Although the science of artificial intelligence is often identified as a far-reaching and futuristic concept, the reality is that it is already used today in all varieties of fields, including pulmonology or pneumology. By digitising a plethora of data, growing machine learning techniques, and improving the computing power of computers in recent decades, artificial intelligence can open up great opportunities for automation. The more data increases, the more technologies are able to make the right decision. However, most of the literature has not been widely adopted, but it has provided worthy information exciting for the medical staff. Moreover, artificial intelligence techniques have greatly benefited in tracking cases of infection and transmission from one region to another, identifying the development of the virus's genes, and helping to assess the risks from the spread of the pandemic. Fortunately, the behaviour of artificial intelligence saved the lives of many medical staff and infected people, and the presence of big data and social networking sites helped monitor and track the spread of the epidemic. Some people think that the use of artificial intelligence techniques in making decisions that affect human life is unfair and biased decisions for a particular group, and this is not exact because the conclusions of these technologies depend heavily on big data; the more they increase, the more training these technologies are, they are essentially programmed for specific tasks and self-development of data analysis. In the end, certain mechanisms must be developed to test artificial intelligence techniques and preserve the privacy of patients or suspects in frequently improved applications to monitor and follow up on the spread of the pandemic. In the future, there will be a set of studies on the use of artificial intelligence in the service of medicine and medical staff and knowledge of the acceptance of vaccines by the population of the Earth.

Nomenclatures

Acronym	Description
2D CNN	2D Convolutional Neural Network
AUC	Area Under the ROC Curve
CNN	Convolutional Neural Network
COVID-19	Coronavirus 2019
DCNN	Deep Convolutional Neural Networks

DenseNet	Dense Convolutional Network
DeTraCResNet18	Decompose, Transfer, and Compose Residual Neural Network
DNA	Deoxyribonucleic acid
DT	Decision Tree
GB	Gradient Boosting
InceptionV3	It is a CNN architecture for object detection and image analysis
KNN	K-Nearest Neighbours
LDA	Linear Discriminant Analysis
LR	Logistic Regression
MERS	Middle East Respiratory Syndrome
MobileNets	It is Deep Convolutional Neural Networks
mRNA	Messenger RNA
NB	Naïve Bayes
ResNet50	It is a CNN that is 50 layers deep
RF	Random Forest
RNA	Ribonucleic acid
ROC	Receiver Operating Characteristics
SARS	Severe acute respiratory syndrome
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2 is the coronavirus that causes COVID-19
SHAP	Shapley Additive Explanation
SVM	Support Vector Machines
VGG-16	It is a CNN architecture that is 16 layers deep
VGG-19	It is a CNN architecture that is 19 layers deep
VLPs	Virus-Like Particle Vaccines

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