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Novel coronavirus (COVID-19) diagnosis using computer vision and artificial intelligence techniques: a review

Anuja Bhargava[1] · Atul Bansal[1]

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Abstract
The universal transmission of pandemic COVID-19 (Coronavirus) causes an immediate need to commit in the fight across the whole human population. The emergencies for human health care are limited for this abrupt outbreak and abandoned environment. In this situation, inventive automation like computer vision (machine learning, deep learning, artificial intelligence), medical imaging (computed tomography, X-Ray) has developed an encouraging solution against COVID-19. In recent months, different techniques using image processing are done by various researchers. In this paper, a major review on image acquisition, segmentation, diagnosis, avoidance, and management are presented. An analytical comparison of the various proposed algorithm by researchers for coronavirus has been carried out. Also, challenges and motivation for research in the future to deal with coronavirus are indicated. The clinical impact and use of computer vision and deep learning were discussed and we hope that dermatologists may have better understanding of these areas from the study.

Keywords Computer vision · Computed tomography · Machine learning · Coronavirus · COVID-19

1 Introduction

The Novel Coronavirus (Covid-19) named coronavirus because of the electronic microscope appearance to cosmic corona that is identical to the crown [15]. It is a widespread toxic disease epidemic in late 2019 and is originated from the serious syndrome of respiratory (SARS-COV-2) [73] as shown in Fig. 1. It is a member of the "Coronaviradae family" that is non-

✉ Anuja Bhargava
anuja1012@gmail.com

Atul Bansal
atul.bansal@gla.ac.in

[1] GLA University, Mathura, India

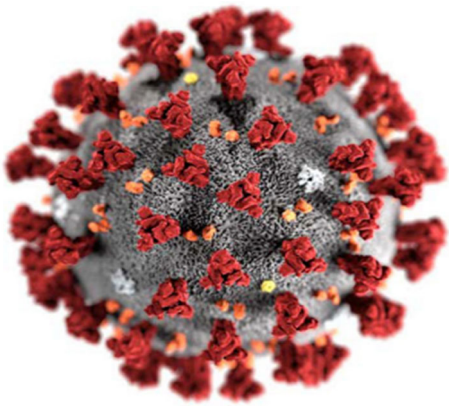


Fig. 1 Example of SARS-COV-2 [73]

segmented, enveloped, and the sense viruses. SARS-COV-2 constitutes 14 bonded residues which precisely connect with "human angiotensin-converting enzyme 2". The breezy respiratory infection in humans is identified as COVID-19 as far as SARS-COV-2 identification is done. A various field like industry, supply chain, production, insurance, transport, agriculture, and tourism affected by COVID-19 results in shock of the economy globally [60] and is at high risk around the world. According to OECD (Organization for Economic Cooperation and Development) due to COVID-19, the economy this year is the lowest [71].

The first infection is noted in Wuhan [China] on December 31, 2019, having symptoms like fever, dry cough, fatigue, nausea, shortness of breath, lung infiltrates, and dyspnoea. All the cases were associated with the seafood market, like fish and animal-like bats, snakes, poultry, and marmots [67]. The WHO (World Health Organization) claims the PHEIC (Public Health Emergency of International Concern) on January 30, 2020, and recognized it as pandemic on March 11, 2020 [109–111]. The virus infects 38, 86,230 cases of COVID-19 [up to May 8, 2019] out of which 2, 68,908 reports death and 13, 31,014 reports recovered. The geographical spread and various stats about recovery and deaths case of COVID-19 are shown in Figs. 2 and 3 till Oct 18, 2020.

The rise in several infections to people, results in curfew and lock-downs by governments all over the world and restricts people's movement, goods services and called for "work from home" to lower the virus spread rate. The governments are taking major steps to spread of virus globally. There is no vaccine claimed till now by any country for COVID-19.

Therefore, the researcher motivates to understand, explore, and treatments of COVID-19. The technologies such as computer vision and artificial intelligence could be best fitted in a crisis of COVID-19 [39, 69, 80]. The objective of this review paper is to give a comparative analysis of computer vision in COVID-19 and also to review various image acquisition, segmentation, and deep learning. This review is specified to US, Italy, Spain, Germany, Iran, France and India.

2 Classification of key area

This section presents different computer vision techniques used for COVID-19 briefly explained in subsequent sections, as depicted in Fig. 4. Also, the classification of positive and negative COVID-19 patients involves basic steps as shown in Fig. 5.

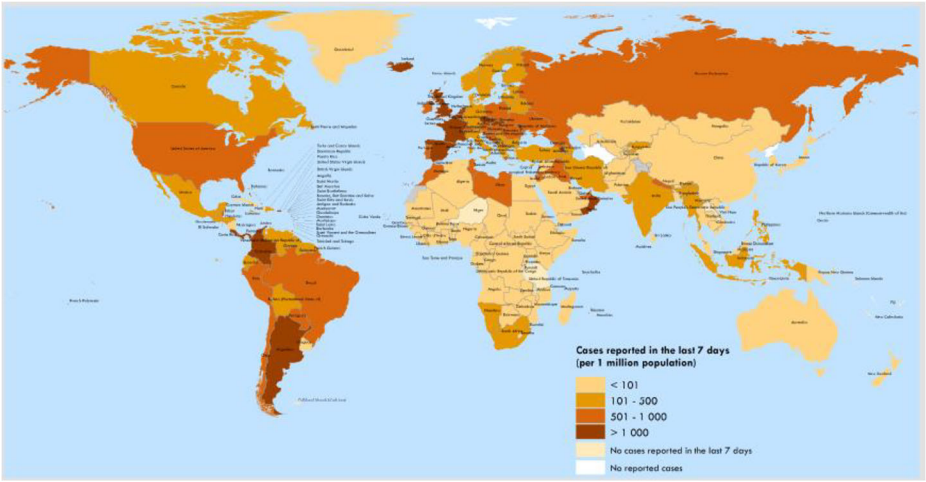


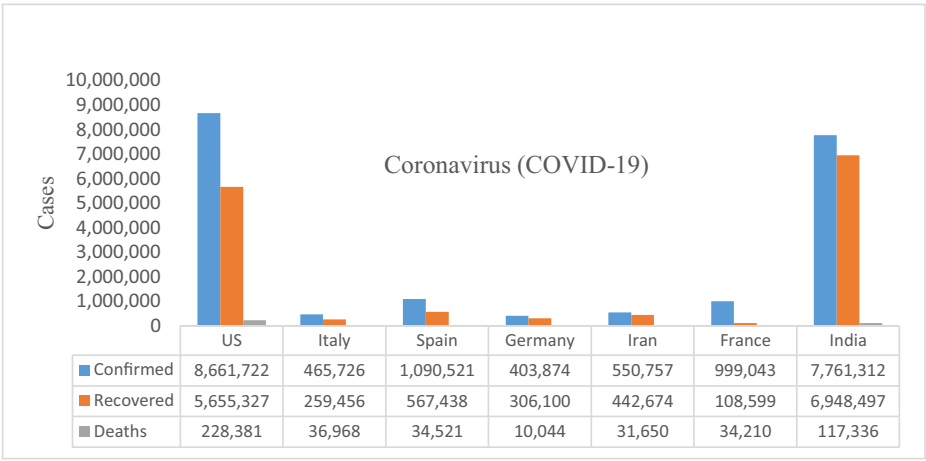
Fig. 2 Example of the geographical spread of confirmed COVID-19 till Oct 18 [109]

2.1 Image acquisition

"The judgment about the exact disease, especially after doctor examination is the diagnosis and expected development of the disease by a doctor is prognosis defined by Cambridge dictionary (https://dictionary.cambridge.org/). The COVID-19 currently diagnosis with RT-qPCR (Reverse Transcriptase Quantitative Polymerase Chain Reaction) [103]. Nonetheless, this manual test is time-consuming and shows some of the false reports [20].

2.1.1 Computed tomography (CT) scan

Alternatively, acquiring an image using a CT scan of the chest obtains a more detailed, enhanced form compared to a standard x-ray scan. The images formed incorporate fats, bones,



	US	Italy	Spain	Germany	Iran	France	India
Confirmed	8,661,722	465,726	1,090,521	403,874	550,757	999,043	7,761,312
Recovered	5,655,327	259,456	567,438	306,100	442,674	108,599	6,948,497
Deaths	228,381	36,968	34,521	10,044	31,650	34,210	117,336

Fig. 3 Stats of COVID 19 in some countries till Oct, 18 [109]

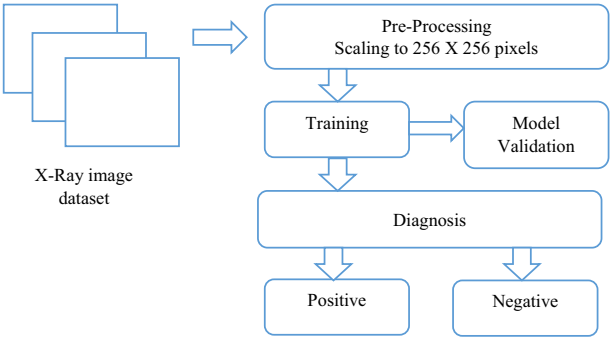


Fig. 4 Basic Steps to identify COVID-19 using image processing

organs, and muscles that result in accurate diagnose by physicians. The spiral chest CT and high-resolution scan are the two categories of CT scan [3]. Inspiral chest CT scan (https://www.radiologyinfo.org/en/info.cfm?pg=chestct), the spiral lane is followed by an X-Ray tube, produces a 3D image of lungs. In a high-resolution scan, it produces an image from a single rotation by the X-Ray tube.

Crucial aspects of CT scan covers consolidation, ground-glass opacity, lesion distribution, nodules, and recitation of interlobular septa [16, 61, 65]. The radiologist's experts identify the disease which is time-consuming, therefore, to imbrute the process computer vision is used. Various images acquired by distinct researchers using CT scans comprise of subsequent characteristics as shown in Table 1. Figure 6 shows some of the samples from the CT scan images.

2.1.2 X-ray image

The digital CXR (Chest X-Ray) radiography is preferred for imaging because it is easily available and cheaper. It is us for cancer [77], cardiac [4] and osteoporosis disease [94]. Due to low contrast, pre-processing is done by contrast enhancement [47] in X-Ray imagery. Various images acquired by distinct researchers using X-Ray comprise of subsequent characteristics as sown in Table 2. Figure 7 shows some of the samples from the X-Ray scan images.

Various images acquired by distinct researchers using different resources comprise of subsequent characteristic as shown in Table 3.

Fig. 5 Basic platform of coronavirus

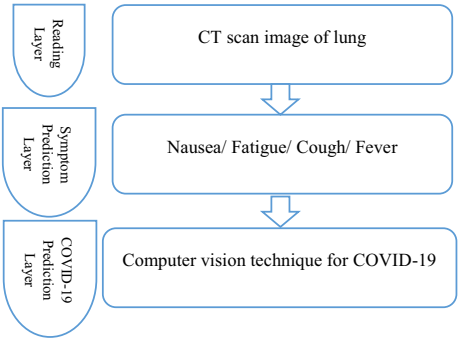


Table 1 Classical approaches for COVID-19 using CT-scan

Authors	Database (CT Images)	Segmentation	No. of patient	Accuracy (%)
Jun Chen et al. [17]	46,096	UNet++	106 with 51+ve	95.24%
Shuai Wang et al. [104]	453	–	99	82.90%
Xiaowei Xu et al. [115]	618	VNet	219 with 110+ve	86.70%
Ying Song et al. [93]	777		88	86.00%
Opir Gozes et al. [34]		U-Net	56	99.60%
Fei Shan [85]	249	VB-Net	249	91.60%
Cheng Jin et al. [43]	970	2D CNN	496	94.98%
Mucahid Barstuga et al. [9]	150	–	–	99.68%
Lin Li [62]	4356	U-Net	3322	–
Chuansh Zheng [90]	–	U-Net	540	95.90%
Shua Jin [44]	–	UNet++	1136 with 723+ve	–

2.2 Image segmentation

After acquiring an image, the segmentation of the image is a crucial fundamental step in the analysis and processing of the estimation of COVID-19. It depicts the ROI (Region of Interest) like infected lesions, lobes, lung in the image. The segmented ROI is used to extract features for analysis and diagnosis purposes. The immense quality 3-dimensional image is provided by a CT scan for disclosing COVID-19. The most prominent method for ROI in CT scan incorporates U-Net, U-Net++, VB-Net. Presently, none of the methods is refined for X-Ray image segmentation. Despite bounded segmentation methods, several researchers consider segmentation as a fundamental process to investigate COVID-19. Table 4 illustrates the segmentation technique involved in COVID-19.

The convolutional neural network (CNN) to used to extract features from COVID-19 X-Ray images. In this process, a special type of CNN called a pre-trained model where the network is previously trained on the dataset, which contains millions of variety of images. So, transfer learning is applied by transferring weights that were already learned and reserved into the structure of the pre-trained model, such as Inception. The different types of features such as edges, texture, colors, and high-lighted patterns are extracted from the images.

2.3 Diagnosis for COVID-19

Artificial intelligence (AI) A dynamic tool for COVID-19 prediction and analysis is an Artificial Intelligence technique [108]. Presently, various researchers and their studies show AI has been widely utilized for COVID-19 issues using ML (Machine Learning) and DL

Fig. 6 After symptom of COVID19 **a** Day 5 **b** Day 15 **c** Day 20

Table 2 Classical approaches for COVID-19 using X-Ray

Authors	Database (X-Ray Images)	Segmentation	Accuracy (%)
Guszt et al. [31]	662	U-Net+	97.50%
Asmaa et al. [1]	80	CNN	95.12%
Ali Narin et al. [70]	–	ResNet50	97.00%
Linda Wang et al. [100]	16,756	–	92.40%
Ezz El et al. [38]	–	DCNN	89.00%
Khalid et al. [8]	5856	ResNet50	96.00%
Prabira et al. [84]	–	ResNet50	95.38%
Ioannis D et al. [6]	1427	VGG19	95.57%
Biraja Ghoshal et al. [33]	68	BCNN	88.39%
Mohd F., Abul Hafeez [28]	–	ResNet50	96.23%

(Deep Learning). Generally, ML is used for précising the structure of the data which is handled by people [10]. ML methods train the input data and analyze the output data statistically. The application of ML includes the detection of infected persons and the temperature of the person [5, 12, 27].

DL has been designed for better performance of neural networks and a type of artificial neural network and has multilayers. The more layers are increased, the greater accuracy is achieved. In machine learning, Deep Belief Networks (DBN) is a productive graphical model or, alternatively, a class of deep neural networks consisting of multiple layers in hidden nodes. When trained on a series of unsupervised examples, the DBN can learn to reconfigure its entries as probabilistic. The layers then act as feature detectors. After this learning phase, a DBN can be trained with more control to make the classification. DBNs can be seen as a 4 combination of simple, unsupervised networks, such as restricted Boltzmann machines (RBMs) or auto encoder, which serve as the hidden layer of each subnet, the visible layer of the next layer.

DL algorithms are used to detect solutions for COVID-19. The manifold neural network layers are used by connected weight vector [78, 92]. Various application of DL includes computer vision, object detection, speech recognition [42, 64, 68]. Several DL based solution for COVID-19 are established by AI methods [30]. Table 5 utilizes the literature related to the AI diagnosis of COVID-19.

The different companies utilized AI for adequate detection and disease diagnosis caused by a coronavirus. Table 6 shows some of the cases used by AI. The literature presents various AI-based solutions for COVID-19 detection using temperature detection of face [82, 98] and data analysis [83, 88].

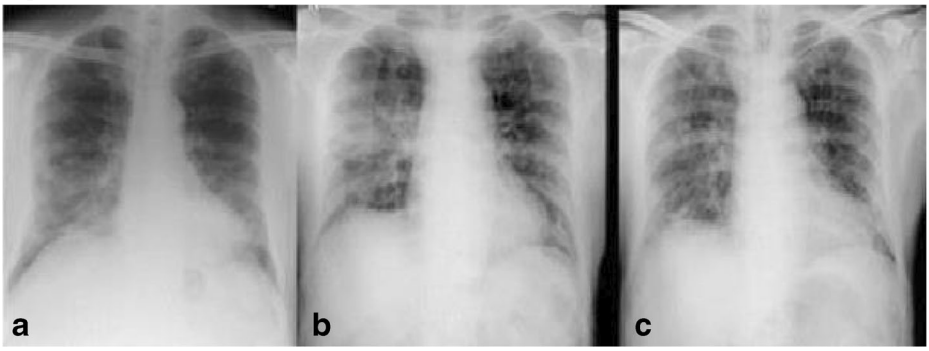


Fig. 7 Chest radiography **a** Day 0 **b** Day 4 **c** Day 7

Table 3 Summary of the dataset available

Dataset	No. of Images	Link
COVID CT DATASET [123]	349	https://github.com/UCSD-AI4H/COVID-CT
RADIOGRAPHY [22]	2905	https://github.com/tawsifur/COVID-19-Chest-X-ray-Detection
IMAGE DATA [23]		https://github.com/ieee8023/covid-chestxray-dataset.
COVIDx Dataset [100]	16,756	https://github.com/ieee8023/covid-chestxray-dataset:
ChestX-ray8 [101]		https://nihcc.app.box.com/v/ChestXray-NIHCC).
Masked Face Recognition [105]	90,000	https://github.com/X-zhangyang/Real-World-Masked-Face-Dataset.
Thermal Image [58]		–

2.4 Avoidance and management

Various guidelines [112] are granted by WHO for the prevention and control of COVID-19. Extensive strategies to restrain incorporates source control, early recognition, precautions, engineering, and control. To reduce the infection in the early stages, the utilization of vigilant equipment or mask is necessary. All over the world, some of the countries like India implement it as a jurisdiction strategy and was promoted by machine learning systems. The table utilizes the work related to the prevention and control of the disease (Table 7).

2.5 Learning lessons COVID-19

The coronavirus has been efficient and transparent, still, various points must be learned for the outbreak in the future utilized in Table 8.

2.6 Infection syndrome and medication

To date, there is no specific cure for infection originated by COVID-19. Yet, bountiful manifestation can be evaluated depending upon the condition of the patient. Currently, various researchers and teams are working on devise vaccination for the infection. Computer vision is

Table 4 Utilization of image segmentation techniques for COVID-19

Authors	Segmentation Tech.	ROI	Utilization
Zheng et al. [124]	U Net	Lung	Examination
Cao et al. [13]	U Net	Lesion/ Lung	Evaluation
Huang et al. [40]	U Net	Lung lobes/ Lesion/ Lung	Evaluation
Qi et al. [79]	U Net	Lung lobes/ Lesion	Evaluation
Gozes et al. [35]	U Net	Lesion/ Lung	Examination
Li et al. [63]	U Net	Lesion	Examination
Chen et al. [18]	UNet++	Lesion	Examination
Jin et al. [45]	UNet++	Lesion /Lung	Examination
Shan et al. [86]	VB-Net	Lung lobes/ Lesion/ Lung	Evaluation
Tang et al. [96]	Commercial Software	Lesion /Lung	Evaluation
Shen et al. [89]	Threshold-based region growing	Lesion	Evaluation

Table 5 Study related to AI diagnosis

Author	Dataset	Technique	Accuracy
Ghoshal et al. [33]	70	CNN	92.90%
Narin et al. [70]	50+ve, 50 -ve	ResNet50	98.00%
Zhang et al. [122]	70+ve, 1008 other	ResNet	95.20%
Wang et al. [100]	45+ve, 1203 -ve	CNN	83.50%
Chen et al. [18]	51+ve, 51 -ve	UNet++	95.20%
Zheng et al. [124]	313+ve, 229 other	UNet, CNN	95.90%
Jin et al. [46]	496+ve, 1385 other	CNN	–
Jin et al. [45]	723+ve, 413 other	UNet++, CNN	–
Wang et al. [106]	44+ve, 55 -ve	CNN	82.90%
Ying et al. [117]	88+ve, 86 -ve	ResNet50	86.00%
Xu et al. [116]	219+ve, 175 -ve	CNN	86.70%
Li et al. [63]	468+ve, 1445 -ve	ResNet 50	–
Shi et al. [91]	1658+ve, 1027 -ve	RF	87.90%
Tang et al. [97]	176+ve	RF	87.50%

the source of how helping to develop and support clinical management. The identification of crucial patients and their medical treatment is a major step in clinical management. A corona score (disease progression score) is suggested to adjust and classify the patient as shown in Fig. 8. "Corona score measures the progression of the patient over time. The corona score is computed by a volumetric summation of the network activation maps" [34]. Table 9 utilizes the work related to infected disease management and control.

2.7 Provocation and future work

In this paper, the challenges in research are highlighted first and then future directions are explored one by one.

2.7.1 Provocation

(i) Managerial Consideration- The use of computer vision (machine learning, deep learning) in the clinical sector like COVID-19 must be examined delicately.

Table 6 Cases used by AI

Use case	Developed/Used by	Aim
Bluedot	Toronto-based Start-up	- Detects epidemics [11] - Build a prediction model for virus detection - Collect information by NLP and ML from social media Government documents Healthcare data
Infravision	Tongji Hospital Wuhan	- Detect disease precisely [41] - Early detection of patient
Alphafold		- SARS-COV-2 prediction [24] - Entrusted by DL and ML - Not verified yet
NVIDIA	Zhongnan Hospital, Wuhan	- Primarily used for detecting cancer - identifies signs of COVID-19 [2] - Used for fast treatment

Table 7 Summary of avoidance and management for COVID-19

Authors	Database	Method	Accuracy
Zhongyuan Wang et al. [105]		Deep learning (recognition of masked face)	95.00%
Joshua M. Pearce [74]	–	-open-source microcontrollers - 3 printers -Ventilator manufacturer	–
W. Chiu et al. [21]	72327patient	- infrared thermography	–
Edouard A. Hay [37]	–	-CNN	90.00%

(ii) Person Privacy Security- The tracking application of COVID-19, individual privacy security is very necessary. The government benefits from tracking the person location using the data location of mobile but this explication depends on user privacy. The security and privacy issues must be taken care of by governments [25].

(iii) Lack of dataset- A crucial challenge in a dataset like infection, medical supply, and affected areas. Currently, the dataset is from the patient collection [23, 66], social media [19], not ample for computer vision.

2.7.2 Future work

Several attempts have been made for COVID-19 using computer vision (machine learning, deep learning, artificial intelligence), but these are not sufficient for the diagnosis of coronavirus.

(i) Image acquisition using artificial intelligence proves to be effective and efficient in scanning. For applications in clinics, the number of the dataset must be further improved.

Table 8 Summary of lessons to be learned from COVID-19

Current Response	Development	Issue	Learning Marks
Shortfall of clarity	Initially identified by clinics	Information delay of cases	Build betrayer for the global necessity
Travel Control	Initially scramming for the outbreak at international borders	Traveling without screening through international airports	Earlier traveling from high-risk countries must be restricted.
Quarantine Control	Firstly, reported on Dec 31, 2019in Wuhan	Spread of coronavirus nationally and internationally	The high-risk area must be quarantine
Misreported Public	Falsehood opinion, falsity spread among the public	False precautions, Segregation	To escape falsity, transparency must be maintained.
Emergency Notice delay	Delay of a month announcing for public emergency	Acerbity was not properly broadcasted	Development of framework timely.
Exploration and Evolution	Lack of funds for treatment and vaccine of coronavirus	Around 3, 00,000 patients died worldwide.	The requirement of more investment for efficient treatment

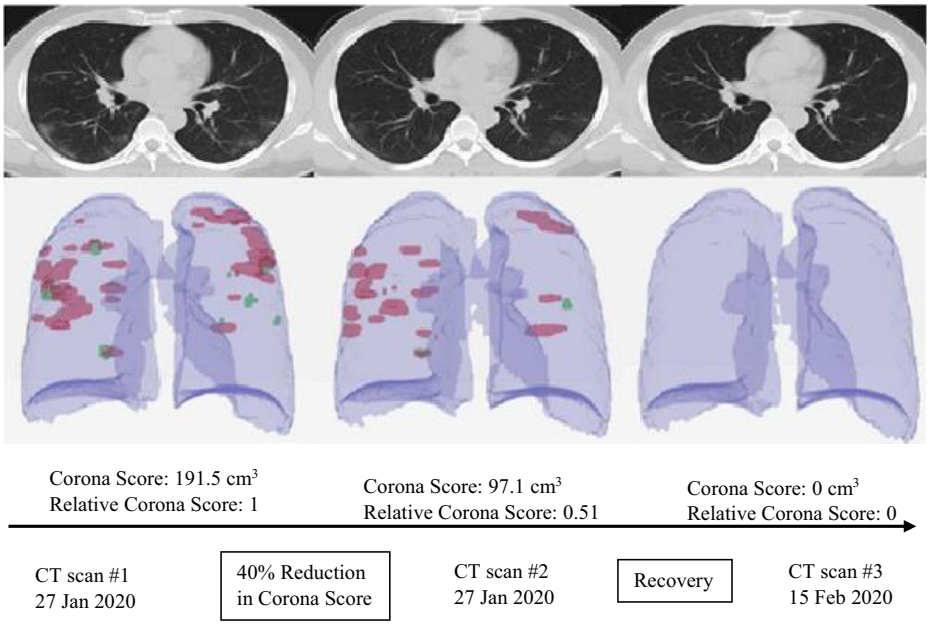


Fig. 8 Summary of Corona Score

(ii) XAI (Explainable Artificial Intelligence) [7, 29], CAM (Conventional Class Activation Mapping) are also prompted for practice in clinics.
(iii) Supervised Deep Learning [26, 72], deep learning transfer methods [95] are also incorporated for the investigation of COVID-19.

Despite limited solutions, a methodology based on machine learning [36, 57, 59, 114], medical imaging [102], fusion and oncology, Natural language processing [118], and different learning algorithms [14, 32, 48–56, 75, 76, 81, 87, 119–121, 125] could be used for measuring the coronavirus COVID-19 disease.

3 Conclusion

This paper presents comprehensive reviews of machine learning methods to encounter the COVID-19 (Coronavirus) epidemic. The methods are described in four categories. A

Table 9 Summary of Infection syndrome and medication

Authors	Method	Connotation
Daniel Wrapp et al. [113]	- Biophysical assays	- Trimeric Spike glycoprotein is used to bind virus
Ophir Gozes et al. [34]	-Corona Score	- Based on CT scan images - 191.5 com3 is measured
Yumlu Wang et al. [107]	- Deep learning - Bidirectional Neural network	- Classification of abnormal respiratory
Yoshihiro Uesawa et al. [99]	- Deep learning	- Drug discovery

comprehensive summary of classical approaches that includes resources for development and research is presented. The article survey on various image processing methods with wide bibliography for coronavirus results in new research encouragement. Yet, this survey was favored as an early review for testing and controlling the COVID-19 pandemic. These attempts impact the outbreak and post coronavirus environment.

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Conflict of interest Authors do not have any conflicts.

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