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AN EFFECTIVE REVIEW OF DEEP LEARNING-BASED DISEASE CLASSIFICATION AND SEGMENTATION METHODS USED FOR COVID-19 DETECTION

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Abstract : Due to the emergence of COVID-19 and the virus responsible for it, SARS-CoV-2, healthcare providers have had to create new technology and treatment options for patients. Deep Learning (DL) technology has been extensively used due to the COVID-19 outbreak, with many chambers seeking to espouse and personalize DL solutions to address pandemic-related issues. We reviewed studies on how deep learning is being used to combat COVID-19, with a focus on disease development, prognosis, intensity estimation, therapy and hospitalization assessment, innovative classification, and segmentation techniques. A systematic search was conducted on online research databases such as Google Scholar, PubMed, and Web of Science for relevant publication issues in the middle of 2020 and 2022. The search followed the regulations of the "Preferred Reporting Items for Systematic Reviews and Meta-Analysis". The term "deep learning" was combined with COVID-19-specific keywords to build the search syntax.

IndexTerms - Deep learning, Chest X-rays, Pretrained models, Feature extraction, Classification, Segmentation

I. INTRODUCTION

Coronavirus Illness 2019 (COVID-19) is an infection that began spreading in December 2019 from Wuhan, China [1]. This illness has devastated each region of the globe in a short period, and WHO declared a disease outbreak on March 11, 2020 [2]. Till December 2022, there were nearly 65.9 crores cases globally, and the death toll from this disease increased day by day [3], reaching 66.8 lakhs [WHO]. Based on the findings and attributes COVID-19 can spread through coughing and sneezing, making early identification and isolation crucial to prevent further transmission. The process of collecting tissue specimens from the nose or throat using RT-PCR is used to detect the presence of the coronavirus. This method extracts gene sequences and replicates them using a chemical and a PCR machine. If SARS-CoV-2 is present, a light beam is emitted, indicating a positive result.

RT-PCR has a false detection rate and is not widely available globally. Medical imaging, such as CT and X-rays, could be a useful alternative in detecting coronavirus when RT-PCR is unavailable. Furthermore, RT-PCR is costly and requires a significant length of time for spotting. Furthermore, felicitous instruction is necessary for healthcare practitioners to gather data for PCR, so while handling and producing X-rays and CT images.

Countless investigators even used Transfer Learning, adulation methodologies [4, 5], along with gradient-weighted class activation mapping (Grad-CAM) to improve the accuracy of their results. [6] & [7] addressed Artificial Intelligence (AI) -based models for COVID-19 diagnosis. Even though [8] evaluated several articles on COVID-19 prognosis, protection, regulation, rehabilitation, and management of diseases. Furthermore, [9] investigated various types of machine learning (ML) and DL- techniques for COVID-19 detection using X-ray image data [10] and also use a majority voting-based ensemble classifier strategy.

Even so, as the years progress, scholars are discovering sophisticated and enhanced frameworks for COVID-19 prognosis. We attempted to examine such innovative forms besides the groundwork of the prior COVID-19 classifiers in this paper. This research study will encompass journal articles that have been published or are in the process of being printed. Even though it might not be the most advantageous accession owing to the possibility of substandard studies we will gather all suggestions and data in one place for our COVID-19 research, with a focus on automatic detection using X-ray and CT chest images, without the use of peer appraisal. This study aims to demonstrate the techniques for automated diagnosis of COVID-19 using chest X-rays and CT scan images, which have been previously explored in research. The focus is on classification and segmentation methods. Our paper is organized in the following manner:

- First, "Classification approaches" describe the classification methods that researchers used to detect COVID-19.
- Second, "Segmentation methodologies" illustrate the segmentation methods used by researchers for COVID-19 detection.
- At last, in “Conclusion” - a discussion is held to assist the new researcher in discovering works in the detection of COVID-19.

II. CLASSIFICATION APPROACHES

The majority of the COVID-19 prognosis frameworks employ a convolutional neural network (CNN) [11] as a feature separator and Softmax or sigmoid for prediction. In [12] and [13] the SVM classifier is used along with the combination of CNN and the Softmax layer. The CNN is used with a Softmax layer merged with a Decision Tree, random forest (RF), XGboost [14], Adaboost [15], bagging classifier [16], and light GBM [17]. In [18] CNN is merged with KNN, SVM, and support estimator network.

In general two ways are used for relegating COVID-19 images: (i) Binary & (ii) multi-class classifications. The chest X-rays and CT images of COVID and non-COVID patients were used for the binary classification but this approach is led very inaccurately because of the availability of different types of lung diseases. To overcome this problem Multiclass classification approach is used with COVID, pneumonia, and normal patient datasets for the classification using Softmax classifier. Comparing both the multiclass classification performs better than the binary classification.

In [19] a cascaded learning strategy is used to improve the sensitivity matrices of the DNN classification model. In [20] adapting the usual pneumonia domain knowledge to COVID-19 was proposed by the author. Dailin Lv et al., [21] proposed Cascade-SEMEnet which is a combination of SEME-ResNet50 and SEME-DenseNet169 with 97.1% accuracy.

In [22] the author proposed a quick detection with a potent way of Covid-affected persons with the help of simultaneous-tasking DL methods which gives 84.67% on chest X-rays and 98.78% on CT scans. The author suggested assessing the infected regions through chest X-rays and CT scans to detect COVID-19. The results would be qualitative and quantitative, revealing the percentage of infected regions and their location.

In [23] the author recommended the Infection Size Aware Random Forest (iSARF) method for classification with the help of grouped infected lesion sizes with 87% accuracy. In [24] five pre-trained models were suggested for the detection of COVID-19 pneumonia patients using chest x-rays. The author used three types of Datasets which give 96.1%, 99.5%, and 99.7% accuracies respectively.

The DenseNet121-Covid-19 hybrid DL - CNN was proposed by [25] using the Gravitational Search Optimization algorithm (GSA). [26] Proposed a technique that detects COVID-19 pneumonia using pre-trained DL algorithms for high accuracy. Transfer learning technique has been taken for the separation and the proposed work provides 99.7% for binary & 97.9% accuracy for multiclass classification.

Matteo Polsinelli et.al. [27] Proposed a light CNN for the potent discrimination of COVID from the CT images based on the SqueezeNet model with 83.00% accuracy. In [28] the author used seven pre-trained models for the automatic diagnosis of COVID named COVIDX-Net. Anas Tahir et al., [29] proposed a model to distinguish COVID-19, SARS, and MERS chest X-ray images using deep CNNs with sensitivities of 99.5%, 93.1%, and 97% respectively. Intra-model variability was proposed by [30] for the identification of COVID using chest X-rays.

In [31] author suggested a novel metaheuristic approach by combining dipper-throated and particle swarm optimizers by augmenting and segmenting the lung regions from the original chest X-rays. Later on the pre-trained model VGG19 was used for feature extraction and also a feature selection method was proposed to select the important features to boost the classification accuracy. The model attains 99.88% accuracy using the suggested optimizer.

Author [32] proposed a Siamese CNN model for the automatic detection of COVID–19 using chest X-rays with 96.70% accuracy. In [33] author proposed a DNN for the classification of COVID-19 with 98.33% accuracy. An Adaptive CNN was proposed by [34] by optimizing the deer hunting optimization algorithm for the segmentation and classification of COVID-19 disease. An automatic COVID-19 diagnostic and severity prediction system named COVIDX was proposed by [35] to recognize COVID-19 and the prognosis rigidity by using classical machine learning algorithms. TABLE 1 summarizes the presented methods of classification approaches and the techniques utilized.

Table 1 Summary of classification approaches

Author	Year	Techniques Used
[19]	2020	Cascaded learning strategy (DNN)
[20]	2020	CNN
[21]	2020	DNN
[22]	2020	Deep Learning methods
[23]	2020	iSARF classification
[24]	2020	Pre-trained DNN models
[25]	2020	CNN with GSA
[26]	2020	Pre-trained DL algorithms
[27]	2020	Light CNN
[28]	2020	7 Pretrained models
[29]	2020	Deep CNN
[30]	2020	DNN

[31]	2022	DNN
[32]	2022	CNN
[33]	2022	DNN
[34]	2022	Adaptive CNN

III. SEGMENTATION METHODOLOGIES

Constructing a model requires using only consequential features to avoid degrading precision. Therefore, determining the Region of Interest (ROI) is crucial before training. Segmentation can help with this because it can separate an image's insignificant regions. Image segmentation splits digital images based on pre-defined factors in digital image processing and computer vision where a fragment signifies a set of pixels. Medical image processing improves COVID-19 detection by locating the ROI, which includes the lung region. Excessive and unrelated image areas can interface with prediction accuracy. Using fragmentation methods, only ROI areas are preserved, reducing the negative reaction of considering features outside the boundary. Ophthalmologists, usually do segmentation, but it's time-consuming. Numerous transparent automatic segmentation methods can be used, such as region-based, edge-based, clustering, and so forth. The U-Net model relies on CNN and has been reconfigured to deliver optimal segmentation in the sector of medical imaging [36].

In [37] the author proposed swiftly developed AI-based CT image analysis tools that can achieve high accuracy in detecting COVID cases and quantifying disease burden. Artificial intelligence (AI) was proposed by [38] for fast detection of COVID-19 detection by using more than ten thousand CT scans of COVID-infected persons. The proposed CNN-based system achieves 90.19% of sensitivity and 95.76% of specificity. In [39] the author developed a DL-based algorithm that can be able to, enumerate the depth of COVID-19 infection from CT scans. The proposed algorithm is zipped with image processing algorithms, especially for lung segmentations and 2D classification.

In [40] the author suggested a new DL algorithm for segmenting multiple COVID-19 infection portions in CT scans, offering a promising tool for quantitative diagnosis of COVID-19 lung infection. In [41] the author proposed a U-Net-based segmentation model which can be able to deal with small lesion segmentations on CT- scans. The outcomes show that the model achieves 86.7% of sensitivity and 99.3% of specificity.

The [42] proposed sixteen segmentation-based classifying DL systems for the automatic and precise spotting of COVID-19 disease by utilizing 8 pre-trained models for the classification. The model outperforms with 97.45% accuracy and an AUC of 0.998. An automated DL-based model CHS-Net was proposed [43] which uses 2-cascaded residual U-Nets as a contextual centralized segmenter to locate COVID-19-infected zones from the lungs curve in CT scans with 0.965% accuracy. A deep learning segmentation and classification pipeline were proposed by [44] using chest X-rays for the COVID-19 infection. The model successfully achieves 91% of accuracy and 92% of sensitivity.

The author proposed an automated deep learning-directed 3-dimensional fragmentation of the entire lung and parasitized zones [45] in COVID-19-infected persons to give speed and accurate user intervention impervious approach for locating and evaluating lung and pneumonia melanomas named COLI-Net. An innovative encoder and decoder based on a density atrous spatial pyramid pooling panel were suggested by [46] that is employed at the model's bottom to obtain microstructures using a multistage jump mechanism linearization tactic.

In [47], the author utilized DL strategies to evaluate optimistic COVID-19 scenarios in CT images. The ultimate focus is to provide quick and accurate diagnostic medical advice for prevention strategies of COVID-19 lesion effectiveness, which was investigated using semantic segmentation and object detection methods.

Adaptive Unet-based chest fragmentation and clustering algorithms utilizing deep attributes were recommended in [48] for the identification of COVID-19 diagnostics. In [49] used a conditional generative adversarial network (C-GAN) for chest fragmentation to generate an accurate recognition of the COVID-19 approach using chest X-rays with a classification accuracy of 96.6%.

An encoder-decoder-based method was proposed by [50] to segment the regions of the infected areas on COVID-infected CT scan images in terms of both quality and volume when compared to the certainty. A fully automated framework was proposed by the author [51] for the four-region segmentation of the whole chest in chest X-rays by combining two DL-based segmentation and detection models. An effective weakly supervised COVID disease segmentation method was proposed by [52] with scribble supervision.

A unique quartet DL model is created by combining the bagging DL approach proposed by [53] for enhancing segmentation performance and reducing the prediction uncertainly using chest X-rays. A transfer learning-based DL model was proposed by [54] using the Otsu thresholding algorithm to segment the COVID-infected CT scans to diagnose COVID-19.

An efficient CNN-based hybrid classification and fragmentation framework was proposed by [55] with 100% of classification accuracy. A semi-automated threshold-based fragmentation model to produce chest ROI fragmentations from a COVID-infected person's chest CT scans was proposed by [56] by calculating precise PLA to decide the infection severity. A novel SAUNet++ model, proposed by [57] by using an improved loss function to deal with small region segmentation of COVID-infected lesions.

An attention decoder CNN fuses shape, proposed by [58] by extracting boundary information from CT contours to enhance the penetration of COVID-19 disease with 85.43% of dice score. A dual multiscale dilated network was proposed by [59] for the segmentation of chest X-ray images by using the core principle of post-region of equity fusion by achieving a dice score of 75.7%.

In [60] operational segmentation network was suggested for the identification of COVID-19 by segmenting the reliable diagnosis of the disease with 99.65% accuracy. In [61] the author suggested a deep adversarial network that can able to predict the lung-infected region

by segmenting offering patient care COVID-19 recognition. TABLE 2 summarizes the presented methods of Segmentation Methodologies, data type and the techniques utilized.

Table 2 Summary of segmentation methodologies

Author	Data Type	Year	Techniques Used
[38]	CT Scans	2020	CNN based segmentation
[39]	CT Scans	2020	DL based algorithm
[40]	CT Scans	2020	DL based segmentation
[41]	CT Scans	2020	U-Net based segmentation
[42]	CT Scans	2022	DL based segmentation
[43]	CT Scans	2022	DL based segmentation
[44]	Chest X-rays	2022	DL based segmentation
[45]	CT Scans	2022	DL based segmentation
[47]	Chest X-rays	2022	Semantic segmentation
[48]	Chest X-rays	2022	Adaptive U-Net-based segmentation
[49]	Chest X-rays	2022	C-GAN for lung segmentation
[50]	CT Scans	2022	Encoder-decoder-based segmentation
[51]	Chest X-rays	2022	DL based segmentation
[53]	CT Scans	2022	DL based segmentation
[54]	CT Scans	2022	DL based segmentation
[55]	CT Scans	2022	CNN based segmentation
[56]	CT Scans	2022	Semi-automatic threshold based segmentation
[57]	CT Scans	2022	U-Net based segmentation
[58]	CT Scans	2022	CNN based segmentation
[59]	Chest X-rays	2022	DNN(multiscale dilated network) based segmentation
[61]	CT Scans	2022	DNN based segmentation

IV. Conclusion

In this paper, we aim to provide a concise summary of AI-based strategies for fighting the COVID-19 disease outbreak using clinical data. The aim is to provide up-to-date information to researchers for faster and cost-effective disease detection model creation. We inspected a total of 51 COVID-19 prognosis frameworks, 25 of which include classification techniques and 26 of which are segmentation methodologies. Amid mounting research, it hasn't been demonstrated that any of the available models can completely replace RT-PCR tests for COVID-19 diagnosis. Due to the expense and duration of a CT scan, it is evident from our survey that X-ray images are much more easily accessible than CT images. Because of this, the majority of researchers have used chest X-rays to prognosis against COVID-19. We also discovered a dearth of annotated medical images of COVID-19 patients, which would significantly increase the efficiency of statistical models. Additionally, we pointed out that transfer learning with domain adaptation is a common and successful method and that using segmentation as a pre-processing step has a significant impact on model performance.

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