Review of Deep Learning Algorithms for Diagnosis of Covid-19

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Abstract

Covid-19 has changed the way we live. It has impacted almost everyone on the globe. Even if the vaccines are effective, it will still take considerable amount of time for the world to be normal again. Until then, there is a need for efficient diagnosis to reduce both false positives and false negatives which are often encountered when manually done by physician. Deep learning has been used successfully to tackle this and other similar problems in radiology and in general medical imaging. Due to inherent nature of complexity in the problem, neural networks mimics the human brain and works quite well in this domain. In this work, we review the existing literature and present the various algorithms using both transfer learning and custom networks. We present the different datasets that have been used until now which are comprised of Chest X-Ray images and Chest CT-Scans. Hopefully this work, will be a nice read for someone looking for benchmarks in regards to Covid-19 diagnosis using neural networks.

1 Introduction

The coronavirus pandemic caused by Severe Acute Respiratory Syndrome (SARS-CoV-2) is one of the greatest challenges faced by humanity in decades. As of May 2021, it is still creating havoc with lockdown on and off across the globe. Although global vaccine campaigns are in full run, it will still take months or even years to immunize each and every people. A lot of questions still remain open like:

1) How effective the vaccines would be?

2) What are the potential complications from the mutation of the virus?

3) Will coronavirus eventually be eradicated or it will linger around us like the flu virus?

To test whether a person is affected by coronavirus, Reverse Transcription-Polymerase Chain Reaction (RT-PCR) test is used. However, these tests are quite expensive especially in places with short supply of doctors and medical equipment. Another problem with these tests is that it produces false negatives and false positives, thus reducing the efficiency of it. Diagnosis using Chest X-rays, thoracic CT and MRI produces better results.

The procedure of using CT scan can be summarized using three steps:

1) pre-scan preparation

2) image acquisition

3) disease diagnosis

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The chance of getting both false positives and false negatives is minimized using CT scan diagnosis. However, the radiations from it can be dangerous. The total number of CT scans in one's lifetime should not exceed 25, else there is a chance of developing malignant cancer. Also, CT scans are quite expensive. Hence chest X-Rays are the main diagnostic technique used by physicians.

Deep learning has been successfully used to tackle a lot of medical imaging problems like tumour classification, tumour detection, organ segmentation, drug discovery etc. Covid-19 diagnosis using neural networks is a good idea as it reduces the time and money while increasing the efficiency. This is especially important in places where doctors are in short supply thus reducing the burden on healthcare system.

2 Related Work

A similar review of previous works in this domain was made by (Islam et al., 2021). Efficient diagnosis using Chest CT scans was done by (Song et al., 2021). It was tough to get large datasets for training neural network algorithms. To tackle this, (Oh et al., 2020) used stack of custom neural networks in block. (Panwar et al., 2020) obtained state of the art results with low neural network memory footprint. Sample efficient neural network was used by (He et al., 2020) using chest CT scans.

(Jamshidi et al., 2020) wrote an extensive review on artificial intelligence algorithms for diagnosis of covid from chest X-ray scans. (Hemdan et al., 2020) proposed a framework for classifying covid from normal using chest X-ray scans. A comparison of 10 convolutional neural network architectures was demonstrated by (Ardakani et al., 2020). Some of the datsets were not labelled properly. (Zheng et al., 2020) tackled this using a neural network designed for efficient labelling.

(Jain et al., 2021) proposed a novel algorithm for detecting covid markers in chest X-ray scans. Chest CT scans were used to train deep learning algorithms by (Wang et al., 2021). A custom Residual Neural Network inspired by famous ResNet series of algorithms was used by (Farooq and Hafeez, 2020). (Nayak et al., 2021) did a comprehensive study for various applications of deep learning in regards to coronavirus diagnosis.

A new datset comprised of chest CT scans was proposed by (Afshar et al., 2021). Deep learning algorithm for quantifying the amount of infection in lungs was proposed by (Shan et al., 2020). (Zhou et al., 2021) used ensemble of neural networks and obtained very high accuracy. A suvery of various deep learning approaches for coronavirus diagnosis from chest X-ray was studied by (Ismael and Şengür, 2021).

(Ni et al., 2020) used a neural network as a classifier for classifying pneumonia from coronavirus. (Basu et al., 2020) also used a custom neural network for diagnosis of covid from chest X-ray scans while (Shah et al., 2021) used chest CT scans. Uncertainty and interpretability while diagnosis was tackled by (Ghoshal and Tucker, 2020).

(Sedik et al., 2020) showed a pipeline for deploying deep learning model in the form of REST-API for the users to consume thus removing the load from doctors. Both classification and segmentation problem was tackled by (Amyar et al., 2020) using coronavirus and pneumonia as the target disease.

(Maghdid et al., 2021) proposed transfer learning algorithm for classifying apart covid fro pneumonia. Multi task deep learning algorithm was used by (Alom et al., 2020) for coronavirus diagnosis. A very large chest CT scan dataset was proposed by (Zhao et al., 2020). (Hu et al., 2020) proposed weakly supervised neural network for lung infection detection and classification.

3 Background

The key contributions of this review are as follows:

1. To compare the performance of various deep learning algorithms using chest X-ray and chest CT scan image data.

2. To compare the details of experiments used like training set size, test set size, neural network architecture used, loss functions, evaluation metrics, hyperparameter configuration used etc.

3. To highlight the challenges faced while training deep learning algorithms for efficient diagnosis.

4. To present future research directions for efficient diagnosis of coronavirus from medical images.

For comparing various datasets that have been used for evaluating neural network, we present number of images and number of class in every dataset. The image size in every dataset is variable.

The datasets comprised of Chest X-ray and Chest CT-scan used so far in literature is shown in Table 1:

Table 1: Summary of the COVID-19 diagnosis datasets used

Author	No of images	No of class
(Cohen et al., 2020)	589	2
(Islam et al., 2021)	79	1
(Kermany et al., 2018)	109312	4
(Irvin et al., 2019)	224316	14
(Wang et al., 2017)	108948	14
(Wang et al., 2020)	13975	3
(Zhao et al., 2020)	812	2

For the comparison, we presented number of images used, number of classes, backbone or custom architecture used and the performance of the network which is comprised of Accuracy and AUC value for each of the individual networks.

Other evaluation metrics like sensitivity and specificity, F1 score, kappa, NCV, precision and recall were also used in some of the work. To be consistent and make a fair comparison, we did not present these.

A comparison of deep learning algorithms in Chest-CT images using pre-trained networks is shown in Table 2:

Table 2: Summary of deep learning based COVID-19 diagnosis in CT images using pre-trained networks

Author	No of images	No of class	Backbone	Performance
(Wu et al., 2020)	495	2	ResNet50	Accuracy=76, AUC=81.9
(Li et al., 2020a)	4536	3	ResNet50	AUC=92
(Yousefzadeh et al., 2021)	2124	2	DenseNet	Accuracy=96.4, AUC=98.9
(Xu et al., 2020)	618	3	ResNet50	Accuracy=86.7
(Jin et al., 2020)	1391	2	Inception V3	AUC=99.1
(Javaheri et al., 2020)	89145	3	BCDU-Net	Accuracy=91.66, AUC=95
(Ardakani et al., 2020)	1020	2	VGG16	Accuracy=99.51, AUC=99.4
(Chen et al., 2020)	35255	2	Unet++	Accuracy=98.85, AUC=99.4
(Cifci, 2020)	5800	2	Inception V4	Accuracy=99.74

A comparison of deep learning algorithms in X-Ray images using pre-trained networks is shown in Table 3:

Table 3: Summary of deep learning based COVID-19 diagnosis in X-ray images using pre-trained networks

Author	No of images	No of class	Backbone	Performance
(Apostolopoulos and Mpesiana, 2020)	1442	3	VGG19	Accuracy=96.78
(Loey et al., 2020)	307	6	GoogleNet	Accuracy=100
(Minaee et al., 2020)	5071	2	ResNet50	AUC=99.6
(Punn and Agarwal, 2021)	1076	3	ResNet50	Accuracy=98, AUC=99
(Narin et al., 2021)	100	2	ResNet50	Accuracy=98,AUC=100
(Moutounet-Cartan, 2020)	327	3	VGG16	Accuracy=84.1, AUC=97.4
(Luz et al., 2020)	30663	3	EffecientNet	Accuracy=93.9, AUC=99.4
(Hemdan et al., 2020)	50	2	DenseNet121	Accuracy=90, AUC=90

A comparison of deep learning algorithms in Chest-CT images using custom neural networks is shown in Table 4:

Table 4: Summary of deep learning based COVID-19 diagnosis in CT images using custom neural network

Author	No of images	No of class	Backbone	Performance
(He et al., 2020)	746	2	CRNet	Accuracy=86
(Wang et al., 2021)	1065	2	Modified Inception	Accuracy=79.3, AUC=81
(Liu et al., 2021)	193	2	Modified DenseNet 264	Accuracy=94.3,AUC=98.6
(Zheng et al., 2020)	630	2	DeCovNet	Accuracy=90.1, AUC=95.9
(Amyar et al., 2020)	1044	2	Modified MLP	Accuracy=86, AUC=93
(Singh et al., 2020)	150	2	ModeCNN	Accuracy=93.25

A comparison of deep learning algorithms in X-Ray images using custom neural networks is shown in Table 5:

Table 5: Summary of deep learning based COVID-19 diagnosis in X-Ray images using custom neural network

Author	No of images	No of class	Backbone	Performance
(Wang et al., 2020)	13800	3	CovidNet	Accuracy=92.4
(Ucar and Korkmaz, 2020)	2839	3	Bayes SqueezeNet	Accuracy=98.26
(Khan et al., 2020)	1251	4	Coro-Net	Accuracy=89.5
(Rahimzadeh and Attar, 2020)	15085	3	Concatenated CNN	Accuracy=99.5
(Li et al., 2020b)	2239	3	DCSL	Accuracy=97.01
(Khobahi et al., 2020)	18529	3	CoroNet	Accuracy=93.5
(Afshar et al., 2020)	13800	3	Capsule Network	Accuracy=95.7, AUC=97

4 Conclusions

Covid-19 is a global emergency as of May 2021. There is a lot of uncertainty at the moment about the future. Hopefully the vaccines would be effective and life would come back to normal as early as possible. But until then, efficient diagnosis of patients is a requirement. Deep learning powered by neural networks is a great alternative to the conventional diagnosis by physicians which are error prone. Not only would artificial intelligent algorithms reduce error but would also speed up the process and decrease the cost associated. This diagnosis could be used in other radiology and medical imaging problems in general.

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