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Review on Diagnosis of COVID-19 from Chest CT and X-Ray Images Using Deep Learning Algorithms

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***Abstract*- As we all know , the world has been in a cocoon this whole year, and we have only now begun to step back into normalcy. COVID-19 outbreak was announced as a Global Pandemic by WHO on 11 March 2020 by which time the Global tally of infected people was at 114,243 and the deaths at around 4302. Due to the absence of specific therapeutic drugs or vaccines for the novel COVID-19, it is essential to detect the disease at its early stage and immediately isolate the infected person from the healthy population. Recent findings obtained using radiology imaging techniques suggest that such images contain salient information about the COVID-19 virus. Application of advanced artificial intelligence (AI) techniques coupled with radio-logical imaging can be helpful for the accurate detection of this disease. The objective of this paper is study the diagnostic value of CT and x-ray images and compare their efficiency against RT-PCR and also, to compare and analyse existing deep learning models for classification of Covid pneumonia from regular pneumonia and no pneumonia.**

***Keywords*- Deep learning; Computed Tomography(CT); Artificial Intelligence(AI).**

I. INTRODUCTION

Novel Coronavirus Disease 2019 (COVID-19) has become a global pandemic with an exponential growth rate and a still incompletely understood transmission process. The virus is harbored most commonly with very little or no symptoms or warning signs , but can also lead to a rapidly progressive and often fatal pneumonia in 2 to 8% of those who are infected. In severe cases, COVID-19 has been observed to result in acute respiratory distress, multiple organ failure, and eventually death[1].

New studies are suggesting that the novel coronavirus can undergo mutations that may make it more deadly & contagious than before.The rapid rate of spread puts a strain on the healthcare systems worldwide due to lack of sufficient key protective equipment and qualified provi ders, partially driven by variable access to point-of-care testing methodologies, including reverse transcription poly merase chain reaction (RT-PCR).

Testing COVID19involves analyzing samples that indicate the present or past presence of severe acute respiratory syndrome-associated coronavirus (SARS-CoV-2).

The test is done to detect either the presence of the virus or of antibodies produced in response to infection. RT-PCR tests are currently the recommended standard diagnostic tool for COVID-19.RT-PCR assays are performed by coll ecting nasopharyngeal and/or oropharyngeal swabs, sput um, blood samples, body fluids, stool samples and bronch oalveolar lavage fluid.RT-PCR is limited by its low sensit ivity,sometimes reported as low as60–70% and associated with a relatively high number of false negative results due to inadequate specimen collection, improper extraction of nucleic acid from the specimen, or collection at a too-early stage of infection[1], which implies that many patients with COVID-19 may not be identified and may not receive the appropriate medical attention. Such patients constitute a risk for infecting a larger healthy population given the highly contagious nature of the virus.

Chest CT has become a standard imaging tool in the diag nosis and assessment of a variety of respiratory conditions, such as interstitial lung disease,lung cancer and pneum onia. In addition, chest CT is noninvasive and relatively easy to perform in an equipped facility and can produce fast diagnosis.So,in this context,chest CT may provide benefits for diagnosis of COVID-19 as it has greater sensit ivity for detecting early pneumonic changes.Artificial intelligence(AI) has the potential to aid in rapid evaluation of CT scans for differentiation of COVID-19 findings from other clinical entities. In this era of worldwide crisis, it is crucial to accelerate the development of AI techniques to detect COVID-19 and to differentiate it from non–COVID-19 pneumonia and non-pneumonia diseases in CT images[1].

Application of machine learning methods for automatic diagnosis in the medical field have recently gained popu larity by becoming an adjunct tool for clinicians. Deep learning, which is a popular research area of artificial intel ligence (AI), enables the creation of end-to-end models to achieve promised results using input data, without the need for manual feature extraction.Deep learning techni

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ques have been successfully applied in many problems such as arrhythmia detection, skin cancer classification, breast cancer detection, brain disease classification, pneu monia detection from chest X-ray images, fundus image segmentation, and lung segmentation.

The COVID-19 epidemic's rapid rise has necessitated the need for expertise in this field. This has increased interest in developing the automated detection systems based on AI techniques. Additionally, AI approaches can be useful in eliminating disadvantages such as insufficient number of available RT-PCR test kits, test costs, and waiting time of test results. One of the most important disadvantages of chest radiography analyses is an inability to detect the early stages of COVID-19. However, well-trained deep lea rning models can focus on points that are not noticeable to the human eye, and may serve to reverse this perception.

This paper aims to establish that CT is superior to RT-PCR and then it will highlight the existing work done on developing deep learning algorithms for the classification of covid/no covid and covid/non covid pneumonia.

II. LITERATURE SURVEY

1. Case study:
A case study was conducted byTongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Wuhan, Hubei, China[2]. From January 6 to February6,2020,a total of1049 patients(meanage6 standard deviation,51years 615;467men[46%]) who were suspected of having severe acute respiratory syndrome coronavirus 2 infection and who underwent both chest CT and laboratory virus nucleic acid testing (RT-PCR assay with throat swab samples) took part in this study. With use of RT-PCR as the reference standard, the performance of chest CT in the diagnosis of COVID-19 was assessed. The positive rates of reverse-transcription polymerase chain reaction (RT-PCR) assay and chest CT in our cohort were 59% (601 of 1014patients) and 88%(888 of1014 patients), respectively, for the diagnosis of patients suspected of having corona virus disease 2019 (COVID-19).

With RT-PCR as a reference standard, the sensitivity of chest CT for COVID-19 was 97% (580 of 601 patients); in 308 patients with negative RT-PCR results but positive chest CT scans, 147 of 308 (48%) were reconsidered as highly likely cases and 103 of 308 (33%) as probable cases with a comprehensive evaluation. n With analysis of serial RT-PCR assays and CT scans, 60% (34 of 57) to 93% (14 of 15) of patients had initial positive chest CT scans consistent with COVID-19 before the initial positive RT-PCR results; 42% of patients (24 of 57) showed improvement on follow-up chest CT scans before the RT-PCR results turned negative. To summarize the results of the case study, chest CT had higher sensitivity for diagnosis of COVID-19 as compared with initial reverse-transcription polymerase chain reaction from swab samples in the epidemic area of China thus Chest CT may be considered as a primary tool for the current COVID-19 detection in epidemic areas.

Table.1. Summary of Patient Characteristics.

Characteristic	Value
No. of patients	1014
Age (y)	
Mean ± standard deviation*	51 ± 15 (2–95)
<20	7 (1)
20–39	267 (26)
40–59	409 (40)
≥60	331 (33)
No. of men	467 (46)
Median time between chest CT and RT-PCR assay (d)*	1 (0–7)

Abbreviations for the results table:
FN = false negative,
FP = false positive,
NPV = negative predictive value,
PPV = positive predictive value,
RT-PCR= reverse-transcription polymerase chain reaction,
TN = true negative,
TP = true positive.

Table.2. Performance of Chest CT in the Diagnosis of COVID-19.

	Results*				Test Performance				
Parameter	TP	TN	FP	FN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Overall	580	105	308	21	97 (580/601) [95, 98]	25 (105/413) [22, 30]	65 (580/888) [62, 68]	83 (105/126) [76, 89]	68 (685/1014) [65, 70]
Age									
<60 y	362	81	225	15	96 (362/377) [94, 98]	27 (81/306) [22, 32]	62 (362/587) [58, 66]	84 (81/96) [76, 90]	65 (443/683) [61, 68]
≥60 y	218	24	83	6	97 (218/224) [94, 99]	22 (24/107) [16, 31]	72 (218/301) [67, 77]	80 (24/30) [63, 91]	73 (242/331) [68, 78]
Sex									
M	272	35	148	12	96 (272/284) [93, 98]	19 (35/183) [14, 25]	65 (272/420) [60, 69]	75 (35/47) [61, 85]	66 (307/467) [61, 70]
F	308	70	160	9	97 (308/317) [95, 99]	30 (70/230) [25, 37]	66 (308/468) [61, 70]	89 (70/79) [80, 94]	69 (378/547) [65, 73]

III. EXISTING WORK

Recently, many radiology images have been widely used for COVD-19 detection. Machine learning is used to make decisions on tasks that people have difficulty making

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decisions or problems that require more stable decisions using both numerical and image-based data. A deep convolutional neural network (CNN) is the most widely used among machine learning methods. It is one of the first preferred neural networks, especially in image-based problems, since it contains both feature extraction and classification stages and produces very effective results. In image-based COVID-19 researches, the CNN model or different models produced from CNN are widely encou ntered[15].

1. Covid/Non-Covid Pneumonia classification:

Xu et al. [3] proposed a method that consisted of preproce ssing, CT image segmentation using ResNet18, and the classification of CT scans performed by adding location-attention that provides the relative location information of the patch on the pulmonary image. The proposed method tested on the considered 618CT samples(219with COVID-19,224CT imageswith influenza-Aviral,and 175CT images for healthy people), and Xu etal. concluded that the overall accuracy rate of the proposed method was 86.7%.

Wang et al. [4] proposed another deep learning method to distinguish COVID-19 and other pneumonia types. The segmentation, suppression of irrelevant area, and COVID-19 analysis were the processes of the proposed method.

Dense Net121-FPN [5] was implemented for lung segmen tation, and COVID19 Net that had a DenseNet-like struc ture was proposed for classification purposes.Two validati on sets were considered, and the authors reported 0.87 and 0.88 ROC AUC scores for these validation sets.

Hu et al. [6] In addition to classify COVID-19 and normal cases,performed another experiment to differentiate COVID-19 cases from other cases as bacterial pneumonia and SARS. The average sensitivity, specificity, and the AUC score were obtained as 0.8571, 84.88%, and 92.22%, respectively.

Bai et al. [7] implemented the deep learning architecture EfficientNet B4[55] to classify COVID-19 and pneumonia slices of CT scans. The diagnosis of the six radiologists on the corresponding patients were used to evaluate the effici ency of the results obtained by an AI model. The AI model achieved 96% of accuracy, while the average accuracy of the diagnosis of radiologists was obtained at 85%.

Li et al. [8] proposed a COVNet that used ResNet50 as a backbone to differentiate COVID-19, nonpneumonia, and community-acquired pneumonia. In their study,4352 chest CT scans from 3322 patients were considered. A max-pooling operation was applied to the features obtained from COVNet using the slices of the CT series, and the resultant feature map was fed to a fully connected layer. This led to generate a probability score for each consider ed class.It was concluded that the proposed model achi ev ed a sensitivity, specificity, and ROC AUC scores of 90%, 96%, and 0.96, respectively, for the COVID-19 class.

Wang et al. [9] conducted another study on differentiating COVID-19 from non-COVID-19 CT scans. In their propo sed network, UNet was first trained for lung region segme ntation, and then, they used a pretrained UNet to test CT volumes to obtain all lung masks. They concatenated CT volumes with corresponding lung masks and sent them to the proposed DeCoVNet for the training. Wang et al. concluded that the proposed network achieved a 0.959 ROC AUC score.

Table 3.Covid/non covid pneumonia classification results.

Class.	Subjects	Method	Sens. (%) or recall	Spec. (%)	Prec. (%)	Acc. (%)	AUC (%)	F1-score
COVID-19/influ-A/normal	219 COVID-19 224 influ-A 175 normal	CNN ResNet	86.7	N/A	81.3	N/A	N/A	83.9
COVID-19/CT-EGFR	1266 COVID-19 4106 CT-EGFR	COVID19Net (DenseNet-like str.)	79.35	71.43	N/A	85.00	86.00	90.11
COVID-19/other pneu.	521 COVID-19 397 normal 76 bac. pneu. 48 SARS	DL ShuffleNet V2	85.71	84.88	N/A	85.40	92.22	N/A
COVID-19/other pneu.	521 COVID-19 665 non-COVID-19 pneu.	DNN EfficientNet B4	95	96	N/A	96	95	N/A

2. Covid/No-Covid classification:

Liu etal.[10]proposed another deep neural network model, namely, lesion-attention deep neural networks, where the backbone of the model used the weights of pretrained networks such as VGG16, ResNet18, and ResNet50. The proposed model was capable of classifying COVID-19 images, which was the main aim of the study, with 0.94 of the AUC score using VGG16 as the backbone model. Besides this, the model was able to make a multilabel prediction on the five lesions.

Singh et al. [11] proposed a multiobjective differential evolution- (MODE-) based convolutional neural networks to detect COVID-19 in chest CT images. It was concluded that the proposed method outperformed the CNN, ANFIS, and ANN models in all considered metrics between 1.6827% and 2.0928%.

Amyar et al.[12] developed another model architecture that included image segmentation, reconstruction, and classification tasks, which was based on the encoder and convolutional layer. The experiments were performed on three datasets that included 1044 CT images, and the obtained results showed that the proposed architecture achieved the highest results in their experiment, with 0.93% of the AUC score.

Ahuja et al. [13] used data augmentation and pretrained networks to classifyCOVID-19 images.Data augmentation was performed using stationary wavelets, and the random rotation, translation, and shear operations were applied to the CT scan images. ResNet18, ResNet50, ResNet101, and SqueezeNet were implemented for the classification task, and Ahuja et al. concluded that ResNet18 outperformed other models by obtaining a 0.9965 AUC score.

Han et al. [14] proposed a patient-level attention-based deep3Dmultiple instance learning (AD3D-MIL) that learns Bernoulli distributions of the labels obtained by a pooling approach. They used a total of 460 chest CT examples,230 CT examples from 79 COVID-19 confirmed patients, 100 CT examples from 100 patients with pneumonia, and 130 CT examples from 130 people without pneumonia.Their proposed model achieved an accuracy,AUC,and the Cohen kappa score of 97.9%, 99.0%, and 95.7%, respectively, in the classification of COVID-19 and non-COVID-19.

Table 4. Covid/no-covid classification.

Class.	Subjects	Method	Sens. (%) or recall	Spec. (%)	Prec. (%)	Acc. (%)	AUC (%)	F1-score
COVID-19/ non-COVID-19	496 COVID-19 1385 others	CNN	94.06	95.47	N/A	94.98	97.91	NA
COVID-19/ non-COVID-19	N/A	CNN	~90	~90	N/A	~90	Not clear	~90
COVID-19/ non-COVID-19	449 COVID-19 100 normal 98 lung cancer 397 other	DL multitask	94	79	N/A	86	93	N/A
COVID-19/ non-COVID-19	349 COVID-19 397 non-COVID-19	ResNet18	100.0	98.6	N/A	99.4	99.65	99.5

IV. CONCLUSION

COVID-19 continues to spread around the globe. New classification and prediction models using AI, together with more publicly available datasets, have been arising increasingly. However, the majority of the studies are from the preprint literature and have not peer-reviewed. Furthermore, many of them have different classification tasks. This study has been conducted with very limited data. The data used in this study has come from different institutions and different publications. This study aimed to review existing deep learning models for covid / no covid classificationandcovid/non covid pneumonia classification and compare their performances.

REFERENCES

[1] Ko H,Chung H, Kang Ws, Kim Kw, Shin Y, Kang Sj, Lee Jh, Kim Yj, Kim Ny, Jung H, Lee J, “covid-19 pneumonia diagnosis using a simple 2d deep learning framework with a single chest ct image: model develo pment and validation”,j med internet res 2020; 22 (6):e19569.

[2] Tao Ai, Zhenlu Yang, Hongyan Hou, Chenao Zhan, Chong Chen, Wenzhi Lv, Qian Tao, Ziyong Sun, Lim ing Xia,”correlation of chest ct and rt-pcr testing for coronavirus disease 2019 (covid-19) in china”, radio logy 2020; 296:e32–e40.

[3] X.Xu, X.Jiang, C.Ma et al.,“a deep learning system to screen novel coronavirus disease2019 pneumonia,” en gieering, 2020.

[4] S.Wang,Y.Zha,W.Li etal.,“a fully automatic deep lea rning system for covid-19 diagnostic and prognostic analysis,” european respiratory journal, vol. 56, no. 2, article 2000775, 2020.

[5] G.Huang,Z.Liu,L.VanDerMaaten,And K. Weinberger, “densely connected convolutional networks,” in proce edings of the ieee conference on computer vision and pattern recognition, pp. 4700–4708, honolulu, hi, usa, 2017.

[6] R.Hu, G.Ruan, S.Xiang, M.Huang, Q.Liang, And J. Li ,“auto mated diagnosis of covid-19 using deep lear ning and data augmentation on chest ct,” medrxiv ,2020,https://medrxiv .org/abs/2020.04.24.20078 998.

[7] H.X. Bai, R.Wang, Z.Xiong et al., “ai augmentation of radi ologist performance in distinguishing covid-19 from pneu monia of other etiology on chest ct,” radio logy, vol. 296,No. 3, pp. E156–e165, 2020.

[8] L.Li, L.Qin, Z.Xu etal., “using artificial intelligence to detect covid-19 and community-acquired pneumonia based on pulmonary ct: evaluation of the diagnostic accuracy,”radiology,vol.296, no.2, pp.E65–e71, 2020.

[9] X.Wang,X.Deng,Q.Fuetal.,aweakly-supervised frame work forcovid-19 classification and lesion localization from chest ct,”ieee transactions on med ical imaging, vol. 39, no. 8, pp. 2615–2625, 2020.

[10] B.Liu, X.Gao, M.He, L.Liu, And G.Yin, “a fast online covid-19 diagnostic system with chest ct scans,” in pro ceedings of kdd 2020, new york, ny, usa, 2020.

[11] D.Singh, V.Kumar, M.K. Vaishali, And M.Kaur, “cla ssification of covid-19 patients from chest ct images using multi objective differential evolution–based con volutional neural networks,” european journal of clini cal microbiology & infec tious diseases, vol. 39, no.7, pp.1379–1389, 2020.

[12] A. Amyar, R. Modzelewski, And S. Ruan, “multi-task deep learning based ct imaging analysis for covid-19: classifification and segmentation,”medrxiv,2020, htt ps://medrxiv.org/abs/2020.04.16.20064709.

[13] S. Ahuja, B. K. Panigrahi, N. Dey, T. Gandhi, Andv.

[14] Rajinikanth, “deep transfer learning-based automated detection of covid-19 from lung ct scan slices,” applied intelligence, 2020.

[15] Z.Han, B.Wei, Y.Hong et al.,“accurate screening of covid-19 using attention based deep 3d multiple insta nce learning,” ieee transactions on medical imaging, vol.39, No.8, pp.2584–2594, 2020

[16] Hindawi, "review on diagnosis of covid-19 from chest ct images using artificial intelligence" computational and mathematical methods in medicine volume 2020, article id 9756518,