

Systematic Review and Metadata-Analysis of Covid-19 Detection and Classification Using Convolutional Neural Network and Chest x-ray images- recent advances

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ABSTRACT

Several works were published in regards to the and early detection of COVID-19 via mathematical modelling and Convolutional neural network. The aim of this work is to provide the research community with systematic overview of the methods used in these studies as well as a collection of available open-source datasets in regards to COVID-19. In all, 51 journal articles, reports, fact sheets, and websites dealing with COVID-19 were studied and reviewed. It was found that most mathematical modelling done were based on the Susceptible-Exposed-Infected-Removed (SEIR) and Susceptible-infected-recovered (SIR) models while the implementations were done via Convolutional Neural Network (CNN) on X-ray and CT images. In terms of available datasets, they include aggregated case reports, medical images, management strategies, healthcare workforce, demography, and mobility during the outbreak. Both Mathematical modelling and CNN have both shown to be reliable tools in the fight against this pandemic. Several datasets concerning the COVID-19 have also been collected with their respective sources. However, much work is needed to be done in the diversification of the datasets. Other CNN and modelling applications in healthcare should be explored in regards to this COVID-19.

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INTRODUCTION

The World Health Organization declared that new coronavirus disease 2019 (COVID-19) was a Public Health Emergency of International Concern on January 30th 2020 (Sohrabi C, et al. 2020). By then there were a total number of 7818 confirmed cases of COVID-19 globally with more than 1370 severe cases and 170 deaths. The bulk of which was found in China (WHO, 2020). Over the course of a few weeks the disease has propagated across the boundaries of China infecting nearly every country. In recent years, various CNN techniques were deployed in detection of COVID-19 using Chest X-ray image and CT image. (Fangoh & Selim, 2020) presented a CNN-XGBoost model use for Covid-19 detection in chest X-ray images. The proposed model integrates the feature extraction technique of

CNNs with XGBoost prediction capabilities and a machine learning technique called tree boosting. (Srinivasan, Singh, Biradar, & Revathi, 2021) proposed an enhanced model for detection of person, covid-19 social distance defilement detection, facial detection and face masks detection through object detector, CNN and clustering based binary classifier. (Rahman et al., 2021) proposed the application of diverse image development method, namely, histogram equalisation (HE), CLAHE, balance contrast enhancements technique (BCET), gamma corrections, and image complements on detection of covid-19.

The U-Net algorithm was newly developed which was compared with the standards U-Net algorithm for lungs segmentations. (Chaudhary et al., 2021) proposed

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deep learning technique, called the Efficient-COVIDNet CNN used in COVID-19 detection with Chest-X-ray images. The proposed model exceeds prior algorithm and achieved accuracy of +2% with advanced sensitivity and positive predictive outcomes. The EfficientNet CNN was executed on public COVIDx dataset, which consist of 14000 X-ray images with highest number of positive cases of COVID-19. (Mishra, Singh, Joshi, & Engineering, 2021) proposed a deep learning and CNN technique for Covid-19 detection using the Chest X-ray dataset, created from the mixture of public X-ray images from infected patients. Different CNN classifiers were applied, such as NASNetLarge, Inception-V3, DenseNet-201, ResNet-152-V2, Xception, VGG-16, VGG-19, InceptionResNet-V2 and MobileNet-V2.

Tang et al. (2021) proposed a deep CNN model used for COVID-19 detection through th application of Chest X-Ray images. The proposed model was aim at examining the best achievement of CNN models (ResNet-V101, SqueezeNet, DarkNet-V19, VGG16, and VGG19.) appropriate for detecting COVID-19 using chest X-ray dataset obtained from private and public domain. Madaan et al. (2021) proposed CNN model with image classification named XCOVNET used for detection of COVID-19 using X-ray images. The proposed model detects covid-19 by dividing the 392 datasets into positive and negative X-ray infected images during the first part, while the second part trains and fine tune the network. (Khan & Park, 2021) presented a light-weight CNN technique used for detection of COVID-19. The proposed model was trained on 22,000 X-ray datasets. Their research was conducted on a binary dataset of COVID-19 patients and X-ray image of normal lung. Polat, Özerdem, Ekici, Akpolat, and Technology (2021) proposed CNN based algorithm used for automatic detection of COVID-19 with chest images of computed tomography (CT). the proposed model employed the ground truth from images screen by radiologist, which was analyse for image segmentation procedure, using the 16040 CT images gotten through segmenting images to raw. In this paper, a review of the CNN and various

dataset used in the study, performance and evaluation of COVID-19 is presented. The paper is divided into four parts, the first presents the method and material used in the study of the pandemic, the second presents the various CNN techniques in covid-19 detection and evaluation, the third part review some limitation, and in the fourth part a list of available datasets for COVID-19 is presented.

LITERATURE REVIEW

Fangoh and Selim (2020) presented a CNN-XGBoost model use for Covid-19 detection in chest X-ray images. The proposed model integrates the feature extraction technique of CNNs with XGBoost prediction capabilities and a machine learning technique called tree boosting. (Srinivasan, Singh, Biradar, & Revathi, 2021) proposed an enhanced model for detection of person, covid-19 social distance defilement detection, facial detection and face masks detection through object detector, CNN and clustering based binary classifier. Umri, Akhyari, and Kusri (2020) present a covid-19 detection model aim at investigative the 100 X-ray chest images of covid-19 victims and chest images of 100 X-ray. The proposed model adopts the hybridization of Contrast Limited Adaptive Histogram Equalization (CLAHE) and CNN technique to design and analyse the dataset of different instances in achieving a good detection outcome. Bassi and Attux (2021) proposed covid-19 image detection using dense CNNs and Transfer learning (TL) to handle chest X-ray image classification according to 3-labels: COVID-19, pneumonia, and normal. The proposed model fine-tuned networks that are pre-trained on ImageNet with double TL method and NIH Chest X-ray14 dataset.

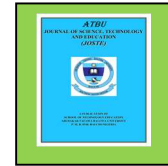
Narin, Kaya, Pamuk, and Applications (2021) proposed five-pre-trained CNN-based model namely, ResNet50, ResNet101, ResNet152, InceptionV3 and Inception-ResNetV2, design for Covid-19 pneumonia patient detection applying chest X-ray images. The proposed model designed three distinct binary classifier using COVID-19, normal, viral pneumonia and bacterial pneumonia as classes

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with cross validation. (Rahman et al., 2021) proposed the application of diverse image development method, namely, histogram equalisation (HE), CLAHE, balance contrast enhancements technique (BCET), gamma corrections, and image complements on detection of covid-19. The U-Network algorithm was newly developed which was compared with the standards U-Network algorithm for lungs segmentations. (Das et al., 2021) presented a Deep CNN-based model for detection of COVID-19 infected victims using the images of Chest X-Ray. The proposed model used various state of the art CNN models such as, DenseNet201, Resnet50V2 and InceptionV3 which were trained separately with separate prediction outcome.

Islam, Islam and Asraf (2020) presented the amalgamation of two deep learning algorithm, that is, CNN and Long-short-term-memory (LSTM) to detect COVID-19 automatically using Chest-X-ray images. For detection through the extracted features, the proposed model used feature extraction and LSTM algorithm. (Ismael & Şengür, 2021) proposed a deep learning framework applied in detection and classification of COVID-19 and images of normal Chest X-ray using

feature extraction, fine-tuning CNN, and training of an improved images. ResNet18, ResNet50, ResNet101, VGG16, and VGG19 were applied for extracting deep features, while Support Vector machine (SVM) was used for classification with linear quadratic, Gaussian and cubic functions of Kernel. (Dutta, Roy, & Anjum, 2021) presented the application of transfer learning technique with CNN for COVID-19 disease detection using CT images presented. The proposed system was developed using multilayer CNN with transfer learning Inception V3 model.

Karthik, Menaka anad Hariharan (2021) proposed customised CNN model that mines data shapes to captures delicate differences amid ill and normal-X-ray which could further allow automation of learning in latent feature. The proposed model acquires some exceptional convolutional structure of the filter for different types of pneumonia, by limiting some filters from the layers of the convolution to attain maximum respond to a specific type of COVID-19 and pneumonia.

Table 1: Related survey on Covid-19 Detection Techniques

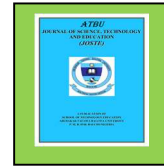
References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Fangoh & Selim, 2020)	CNN-XGBoost	DarkCovidNet (Alam, Al Riyami, & Materials, 2018) and nCOVnet (Panwar et al., 2020)	The integration of CNN feature extraction model, XGBoost prediction and tree bosting.	MobileNet V2	The 3-class experiment model obtained F1-score of 82.69% and 80.10% for test set and validation set respectively, while the 2-class experiment model obtained F1-score of 91.61% and 90.45% for test set and validation set respectively.

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References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Srinivasan et al., 2021)	(Srinivasan et al., 2021)	Resnet50, Xception, for face detection MobilenetV2, RetinaNet MobileNetv1 and DSFD Detector for facemask classification	The applied YOLOv3, DBSCAN, dual shot face detector (DSFD) and MobileNetV2 binary classifier on surveillances video dataset.	DarkNet-53, DFSD and MobileNet V2	The proposed model was evaluated and achieved using accuracy of 91.2%, F1-score of 90.79%, and prediction time of 7.12s for 78 frames of video.
(Umri et al., 2020)	CLAHE and CNN	VGG-16 Transfer learning	The use of CLAHE on CNN to enhance image quality by contrasting and shaping the X-ray images to improve accuracy.	CNN	With the application of CNN model, the result shows a tremendous achievement compared to the use of VGG16 transfer learning.
(Bassi & Attux, 2021)	Dense CNNs and Transfer learning (TL)	Twice Transfer learning and simple Transfer learning	The proposed model fine-tuned networks that are pre-trained on ImageNet with double TL method and NIH Chest X-ray14 dataset. A new output neuron keeping was proposed, which enhance the double TL method.	DenseNet-121	The result shows an accuracy of 100% on their dataset. It also increases performance strictly on the training process due to double TL.
(Narin et al., 2021)	CNN-Based model	ResNet101, ResNet152, InceptionV3 and Inception-ResNetV2,	The proposed model designed three distinct binary classifier using COVID-19, normal, viral pneumonia and bacterial pneumonia as classes with cross validation	ResNet50	The ResNet50 model achieves best classification result with 96.1%, 99.5%, and 99.7% accuracy on dataset-1, Dataset-2 and Dataset-3 respectively

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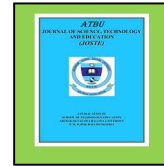
References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Das et al., 2021)	Deep CNN-Model	DenseNet201, Resnet50V2 and InceptionV3	The CNN-Based models were joint together through a technique called weighted average ensemble method in other to predict a class value.	CNN	The proposed model was tested on Chest-X-Ray images acquired at public domain, with classification accuracy of 91.62%, higher than Current CNN models and benchmark model.
(Ismael Şengür, 2021)	Deep learning models with SVM	ResNet18, ResNet101, VGG16, and VGG19	Deep CNN models were applied for extracting deep features, while Support Vector machine (SVM) was used for classification with linear quadratic, Gaussian and cubic functions of the Kernel	ResNet50	The Resnet50 and SVM classifier with linear kernel achieved an accuracy of 94.7% which outperformed other models.
(Dutta et al., 2021)	Transfer learning with CNN	VGG-16, VGG-19, Xception, InceptionResnet, InceptionV3, NasNetlarge, Desnet121, ResNet50v2	The system was developed using multilayer CNN with transfer learning Inception V3 model. It applies convolution and pooling for feature extraction, while the transfer learning technique encompasses dataset ImageNet weights.	Deep CNN	The proposed model outclassed other models that operated with CT image scan data for the reason that inception V3 model and deep neural network architecture were combined

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References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Karthik et al., 2021)	CSDB CNN + DFL	Squeezenet, DenseNet161, VGG16, ResNeXt32, ResNet50	The proposed model acquires some exceptional convolutional structure of the filter for different types of pneumonia, by limiting some filters from the layers of the convolution to attain maximum respond to a specific type of COVID-19 and pneumonia.	Residual CNN	The result shows a great potential in testing COVID-19 and attains 97.20% F-score and 99.80% accuracy on COVID X-ray dataset.
(Özdemir & Keleş, 2021)	CNN	DenseNet, VGGNet, EfficientNet	A CHALE including BEASF through adaptive sigmoid method for data pre-processing were deployed, transfer learning method, pretrained ImageNet method of various CNN architectures were also deployed on the proposed system	CNN	The proposed model achieves high result with F1-score of 0.99 via the efficientNetB5 system.
(Abbas et al., 2021)	4S-DT	VGG-19 and GoogleNet	The proposed model adopts TL on specific chest X-ray images with large scale detection and classification tasks, through general self-	ResNet-18	The proposed model was evaluated on 50000 Chest-X-ray images which attained an accuracy 99.8% and 97.74% on large and small datasets

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References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Chaudhary et al., 2021)	Efficient-CovidNet CNN	VGG-19, ResNet-50 and CovidNet	supervised sample decompositions method. The Efficient-CovidNet is design to learn filters which extract image features. The filters learned assist the framework to know and differentiate amidst various image classes input of the framework.	CNN	respectively with good real COVID-19 detection. The Efficient-CovidNet CNN was executed on public COVIDx dataset which achieved good Deep learning result for effective detection of COVID-19 applied in real-scenario.
(Oyelade et al., 2021)	CovFrame Net	ResNet, FCONet, Covid-CheXNet, Covid-DeepNet, VGG-19, nCOVnet, SVM+IOT, CoroNet, COVID-Net	was developed base on image pre-processing pipeline technique and CNN model for extracting features, classification, and measurement of performance. The new paradigm depends on CNN model that integrates modified pre-		The proposed model was evaluated using the NIH chest-X-ray dataset and database of COVID-19 Radiography which attained 0.1 accuracy, 0.85 precision/recall, 0.9 F-measure and 1.0 specificity. applied for pre-scanning of COVID-19 suspect and affirmation of COVID-19 detection.

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References	Proposed Algorithm	Compared Algorithm	Detection Techniques	Base Model/Feature Extractor	Result
(Mporas & Naronglerdrit, 2020)	DenseNet, ResNet and Xception		processed image method. The proposed study applied two different datasets available in public domain and various settings were used in testing the datasets differently. It combined the datasets and executed 10-fold cross-validation	CNN	The study shows a potential of developing a diagnostic utensil for detecting COVID-19 positive and negative cases via the Chest-X-ray images and deep CNNs.
(Mishra et al., 2021)	Deep learning and CNN	NASNetLarge, Inception-V3, DenseNet-201, ResNet-152-V2, Xception, VGG-16, VGG-19, InceptionResNet-V2 and MobileNet-V2.	The proposed model applied transfer learning for transmission of extracted knowledge through a pre-trained framework to the network that will be train.	CNN	The proposed model performance shows that the classification attained an 95% accuracy.

REVIEW METHODOLOGY

The review methodology chapter illustrates the review stages design to review the state-of-the-art works in the field of covid-19 detection and classification systems. We further elucidate the selection technique of the state-of-the-art studies which was achieved through a set of two criteria: inclusion and exclusion rule.

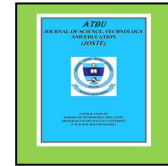
The review is divided into four parts each dealing with a specific aspect like Mathematical modelling, CNN applications, performance evaluation and available datasets. For each of the two parts, the items reviewed were presented in summary of each journal. In all a total number of 51 journal articles, reports, fact sheets and websites were reviewed. The items reviewed were all published between 2019 to 2022. Table 1 shows the

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structure of the review including the number of items reviewed and the main focus of the reviewed items.

Scopus, web of science, science direct, google scholar, ACM Digital Library as shown in Table 3.

Academic Database Sources/search technique

Different academic datasets were retrieved based on adequate and related articles on covid-19 detection via the CNN techniques. The research papers were adequately scrutinized through the application of elementary studies including other various techniques. The research process employed in review paper cut-across relevant papers through different academic database which include, springer, IEEE Explore,

THE SEARCH TERMS

The fundamental search keywords were diligently and technical selected to establish one of the best effective search keywords. The following keyword were used to find an important research paper from a reputable academic database, such as, covid-19, covid-19 + detection, covid-19 + CNN, Covid-19 + classification.

Table 2: Summary of search terms

S/N	Academic Database sources	Domain site	No. of Review papers
1.	Springer	http://www.springer.com/	8
2.	IEEE Explore	http://www.ieeeexplore.ieee.org/	27
3.	Science direct	http://www.sciencedirect.com/	6
6.	Google scholar	http://www.scholars.google.com/	12

The primary search technique was adopted to achieve a highly appropriate search key. Applying the stated goals, some of this search terms such as, covid-19, covid-19 + detection, covid-19 + CNN, Covid-19 + classification with CNN were used to retrieve the prioritize papers from the selected reputable academic database. The selection of the existing

studies was explained best on the principle of inclusion and exclusion rule, as shown in Table 3.

Explicit inclusion and exclusion criteria

In order to have direct focus on the subject matter and to avoid biases of any kind in the review of articles, we adopted various principles in the selection of the articles which are enumerated in the Table 4

Table 3: Inclusion and exclusion rule

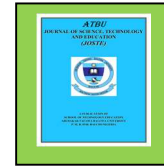
S/N	Inclusion rule	Exclusion rule
1.	The research strategy was directed toward covid-19 detection using CNN	Covid-19 activities is not captured in this research.
2.	The research area was peer reviewed and Journals in reputable academic database or conference papers	The research area was not peer and Journals in reputable academic database or conference papers
3.	the texts of the research paper were written in English language	the texts of the research papers were written in English language
4.	The papers articles are either published survey or research papers	The papers articles are not published survey or research papers or magazine or flash bulletin.

Data gathering and analysis of results

The articles reviewed are in consonant with the reality of the day, acknowledging the

growing threat of ransomware attacks in modern digital world. The devastating effect of the malware on information and information systems

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of most reputable companies and organizations has led to huge losses. Dealing with the threats has become a mirage of nightmare to the information security experts. The two strong drivers that led to the growth of this malwares include the ever-changing technological landscape where new information technology systems are fast implemented as compared to the

security components which are meant to protect them, and lack of policy initiative, proper understanding and training of the end users on the use and application of information technology facilities.

Table 4: Proposed taxonomy of COVID-19 detection and classification Covid-19 Dataset

References	Datasets	Sources	Data size & Number of samples
(Fangoh & Selim, 2020)	COVIDx dataset	COVID-Net (Worldometer, 2020)	The dataset consists of 5 different CXR image datasets. The dataset consists 607 COVID-19 CXR images, 6063 non-COVID-19 pneumonia CXR image and 8851 normal CXR images.
(Srinivasan et al., 2021)	Mask and unmask faces	(Srinivasan et al., 2021)	The images are all resized to 416x416 and 128x128 for detecting person and for facial detection, respectively. the dataset comprising of 11,792 labelled images
(Umri et al., 2020)	X-ray chest image, covid-19 X-ray chest images and normal X-ray chest images	GitHub (Umri et al., 2020) and Kaggle (Umri et al., 2020)	The datasets consist of 200 X-ray chest images and 100 covid-19 chest images X-ray and 100 normal X-ray chest images.
(Bassi & Attux, 2021)	NIH ChesXray-14	US national Institute of Health (Bassi & Attux, 2020)	The Chest X-ray 14 is among the supreme dataset which constitute, 112,120 1images obtained from 30,805 patients. The images are reshaped to 224 x 224 size, with 3-channels, mean and standard deviation normalized on the network's training in ImageNet.
(Narin et al., 2021)	dataset-1, Dataset-2 and Dataset-3	-	The Dataset-1, Dataset-2, and Dataset-3 were haphazardly distributed into 2-independent datasets using 80% for training and 20% for testing.
(Rahman et al., 2021)	COVQU dataset (CXR images and Segmented		The COVQU dataset consist of 18,479 CXR images across 15,000 patients. The X-Ray images were resized to appropriate the image size criteria of 256x256 pixel for U-net model,

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References	Datasets	Sources	Data size & Number of samples
	lung CXR images)		pixel of 299x299 for InceptionV3, and 224x224 for all network
(Das et al., 2021)	Chest-X-ray images	Kaggle, GitHub, Twitter, Doij	Sirm, The Chest X-ray images were resized to 224 X 224 resolution and also split into training, test and validation data each with 771, 118, 117 images respectively.
(Islam et al., 2020)	X-Ray images		The dataset consists of 4575 Chest-X-ray images and 1525 COVID-19 images. The dataset was divided into two, 80% was used for training while 20% for testing
(Ismael & Şengür, 2021)	Chest-X-ray images	Github, 2020; Kaggle, 2020; Radiology assistant, 2020	The Chest X-ray images were resized to 224 X 224 resolution and also split into 75% training set and 25% test set.
(Dutta et al., 2021)	COVID-19 CT scan ImageNet dataset	Kaggle https://www.kaggle.com/andrewmvd/covid19-ct-scans	The dataset for training images were 279 for positive COVID and 279 COVID negative images, while validation, 70 images were covid positive and also 70 images where negative covid. The training set and the validation set were split into 80% and 20% respectively.
(Karthik et al., 2021)	COVID-19 Chest-X-ray	Joseph Cohen Dataset (Cohen, Morrison, & Dao, 2020), Radiopaedia (Sanyaolu et al., 2020), AG Chung Dataset (COVID & Actualmed-COVID-chestxraydataset, 2020), ActualMed Dataset (Chaudhary et al., 2021), SIRM (Radiology, 2020), RSNA Challenge (Kaggle, 2020), Public data provided by the National Institutes of Health Clinical Center Paul Mooney dataset (Karthik et al., 2021)	The dataset was gathered from different sources, yielding a total of 558 COVID-19 Chest-X-ray
(Özdemir & Keleş, 2021)	COVID CXNet dataset and	NIH Chest X-ray dataset centre	the dataset consists of the two classes, namely Covid-19 CXNet dataset with 780 images and Normal class

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References	Datasets	Sources	Data size & Number of samples
(Abbas et al., 2021)	normal images Chest X-Ray Dataset (Unlabelled)	(Candemir et al., 2013; Jaeger et al., 2013; D. S. Kermany et al., 2018; Wang et al., 2017)	The dataset consists of 50000 unlabelled Chest-X-ray images of various dataset. 336 cases with signs of tuberculosis, 326 normal class, 5863 chest-X-ray images of two kind, namely pneumonia and normal class, 43475 chest-X-ray images.
(Chaudhary et al., 2021)	COVIDx dataset	GitHub	The COVIDx dataset consist of 13,975 Chest-X-Ray images from 13,870 patients. It is group in 3 types: COVID-19, normal, pneumonia.
(Porwal et al., 2020)	Chest-X-ray dataset	GitHub	The Chest-X-ray images consist of 198 Covid-19 patients with X-ray images, streptococcus and acute respiratory distress syndrome. The datasets contain 78 Covid-19 images and 120 normal class images.
(Oyelade et al., 2021)	NIH Chest-X-ray datasets and COVID-19 images		The NIH Chest-X-ray datasets and the COVID-19 images were resized from high-resolution of 888 × 882 and 1024 × 1024 to 220 × 220.

Table 5: Performance Evaluation Metrics in the review papers

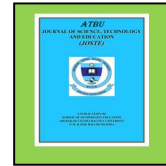
References	Hardware/software Utilization	sensitivity	Precision	True positive Rate	False positive Rate	Recall	Accuracy	F1-score	Specificity
(Fangoh & Selim, 2020)		X	X	X	X	X	X	√	X
(Srinivasan et al., 2021)		X	X	X	X	X	√	√	X
(Umri et al., 2020)	The dataset is executed through the Google Colab.	X	√	X	X	√	√	√	X
(Bassi & Attux, 2021)		X	√	X	X	√	√	√	X
(Narin et al., 2021)	The experiment was performed on Google Collaboratory Linux	X	√	X	X	√	√	√	√

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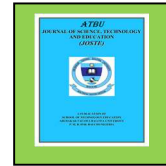
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References	Hardware/software Utilization	sensitivity	Precision	True positive Rate	False positive Rate	Recall	Accuracy	F1-score	Specificity
	server on Ubuntu 16.04 operating system, and Tensor Processing Unit (TPU) hardware for free.								
(Rahman et al., 2021)		√	√		X	√	√	√	√
(Das et al., 2021)	We have used Google Collaboratory GPU (Tesla K80 12GB GDDR5 VRAM), Python 3.7 and TensorFlow 2.2.0.	√	X	X	X	X	√	√	X
(Islam et al., 2020)	Executed on GPU NVIDIA GTX 1050 Intel (R)core (TM) i7-2 GHz processor consisting of 4 GB and 16GB RAM. Python and Keras with TensorFlow were used as executable platform.	√	X	X	X	X	√	√	√
(Ismael & Şengür, 2021)	The proposed model used MATLAB software with NVIDIA Quadro M4000 GPU of 8GB RAM	X	X	X	X	X	√	X	X
(Dutta et al., 2021)	The proposed system was executed in Google Colab through TensorFlow framework with a	X	√	X	X	√	√	√	X

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References	Hardware/software Utilization	sensitivity	Precision	True positive Rate	False positive Rate	Recall	Accuracy	F1-score	Specificity
	GPU of 1.40 GB and RAM of 1.66 GB.								
(Karthik et al., 2021)	The proposed model was executed on Google Colab. with 12GB NVIDIA Tesla K80 GPU using PyTorch.	X	X	X	X	X	√	√	X
(Özdemir & Keleş, 2021)		X	X	X	X	X	X	√	X
(Abbas et al., 2021)	The study was conducted on Personal Computer with the specification of, 3.70 GHz Intel-Core i3-6100 double, NVIDIA firm providing Quadra-P5000GPU, and 8.00 GB RAM	√	X	X	X	X	√	X	√
(Chaudhary et al., 2021)	The experiment was conducted on Kaggle Kernel 4-core CPU, with 16-GB RAM and Nvidia Tesla P100 GPU settings	√	X	X	X	X	√	X	X
(Porwal et al., 2020)	The proposed model used CNN using python programming language	√	X	X	X	X	√	X	X
(Oyelade et al., 2021)	The study was conducted on Google Colab	√	√	X	X	√	√	√	√

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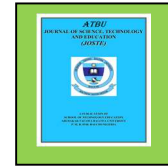
References	Hardware/software Utilization	sensitivity	Precision	True positive Rate	False positive Rate	Recall	Accuracy	F1-score	Specificity
	platform with 2-core Intel(R) Xeon(R) CPU at 2.30GHz, 13GB RAM and 33GB hard drive and GPU Tesla P100-PCIE 16GB								
(Mporas & Naronglerdrit, 2020)		X	√	√	X	X	√	X	X
(Makris et al., 2020)	The study was performed on Ubuntu 18.04 LTS 64-bit, Intel-core i7-8550U CPU at 1.80GHz x 8 and 16 GB RAM.	√	√	X	X	√	√	√	√
(Mishra et al., 2021)	The experiment was conducted on Ubuntu LTS-18.04 LTS 64-bit, Intel Core-i7-8550U CPU with 1.80GHz x 8, and RAM of 16GB using python with Keras and Tensorflow-V4	X	X	X	X	X	√	X	X
(L. P. Soares & Soares, 2020)	The model was executed using Python with TensorFlow and Keras using Google Collaboratory virtual environment.	X	X	X	X	X	√	X	X

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References	Hardware/software Utilization	sensitivity	Precision	True positive Rate	False positive Rate	Recall	Accuracy	F1-score	Specificity
(Khasawneh et al., 2021)		X	X	X	X	X	√	X	X
(Castiglione et al., 2021)		√	√	X	X	√	√	X	√
(Tang et al., 2021)		√	√	X	X	X	√	√	√
(Madaan et al., 2021)		X	X	X	X	X	√	X	X
(Khan & Park, 2021)	The study was run using Python with keras and Tensorflow-V2 on Jupyter Notebook (GeForce RTX 2080 Ti GPU)	√	X	X	X	X	√	X	X
(Polat et al., 2021)	The study was conducted in MATLAB environment executed on Intel Core i7 8700, and NVIDIA GeForce ROG-STRIX of 256-bit, 8GB GPU, with 16 GB RAM memory.	√	√	X	X	X	√	√	√

REVIEW UNIQUENESS

This paper is unique compared to other review papers on covid-19 detection using CNN. We reviewed recent advances in different literatures ranging from 2019 to 2022, with summary on the proposed model, method, results, comparison and conclusion. We also include the research gap/future direction from some journals with adequate structured summary on the dataset used, data sources, data resolution, feature extraction model, detection techniques,

performance evaluation, hard ware/software utilization

REVIEW PAPER RESEARCH GAP/FUTURE RESEARCH DIRECTION

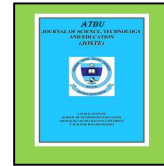
The review papers discussed the various commendations that could assist in handling the expansion of covid-19 detection using the CNN models. Notwithstanding, the review papers revealed some challenges and research gap which could possibly resulted due to

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priorities. The summary of the research gaps analysed in the review papers are clearly discuss as follows:

1. Fangoh and Selim (2020) provides a research gap for their architecture, which include the improve hyper parameter tuning and use of various base models for transfer learning and also more vigorous experiment on the outcome of validation and testing sets for CNN models training.
2. The model achieved great in terms of accuracy and prediction time; the following areas were identified as the research gap which required further improvement. Firstly, it takes longer time in processing video on person detection module. An improve person detection model could be implemented to reduce the prediction time with better accuracy. Secondly, the computation for social distancing and the classification of mask should be separated to run concurrently and adopt parallelism. Lastly, the dataset is not widely used for all system due to lack datasets.
3. Bassi and Attux (2021), the clinical research and huge datasets are required to guarantee the generalisation of quality output. In the future, the classification achievement of various CNN models can be tested by adding the quantity of COVID-19 chest X-ray images in the dataset (Narlin et al., 2021).
4. Islam et al. (2020) provided the following gap, firstly, lack of available dataset of COVID-19 images, secondly, their work concentrates on posterior-anterior (PA) sight of X-ray, therefore it can't distinguish some views of X-rays like anterior-posterior (AP), lateral, and many more. Thirdly, the outcome of the proposed model wasn't compared with radiologists.
5. Ismael and Şengür (2021) Presented a future work, stating that more images of COVID-19 chest X-ray should be

provided using deeper CNN models to execute the COVID-19 detection. In addition, lung diseases should also be considered because COVID-19 infection shows various growth having dissimilar imagistic structures, and also the use of GUI to assist radiologist in COVID-19 detection

6. Karthik et al. (2021) stated that in the future, the model should be extended run with different pneumonia, some lung infections to acquire definitive structure that will assist radiologists.
7. Oyelade et al. (2021) recommended a future research direction by stating the exploring high value of chest-X-ray images evolving new cases to fine tune the CNN model. The also stated the deployment of their model on web and mobile apps for laboratory operation
8. Tang et al. (2021) provided a research gap stating that the training set and the validation set through data augmentation, can extend translation, rotation, shearing, cropping, and image scaling. This technique can further overwhelm the overfitting in training the model. In addition, longer training of the CNN models through higher epochs number could be considered, which will enhance accuracy performance of the classification. Lastly.

CONCLUSION

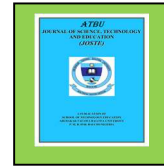
In conclusion, COVID-19 has spread rapidly all over the world creating an emergency situation. Various CNN models have both shown to be reliable tools detection of this pandemic. Most of the implementations were Convolutional Neural Network (CNN) on X-ray and CT images. Several datasets concerning the COVID-19 have been collected and shared open source. However, much work is needed to be done in terms of providing the public with a wide variety of data types and from many regions as possible. Also, other CNN and modelling applications in healthcare should be explored in regards to this COVID-19.

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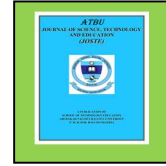
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