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The Impact of Using Convolutional Neural Networks in COVID-19 Tasks: A Survey

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Abstract: Artificial Intelligence (AI) is considered a robust tool that is widely used in different computer tasks. Machine Learning (ML) as an essential type of AI and deep learning (DL) is merely a branch of (ML). DL can mainly be helping to fast analysis of the medical images, especially the complex images, and this can speed up an early diagnosis of diseases. The Covid-19 pandemic has spread rapidly within societies, creating real panic for all people. Convolutional Neural Network (CNN) is a sub-class of DL which is used to classify medical images. Researchers have exploited the merits of CNNs to deal with COVID-19. This merits and diversity enabled researchers and workers in this field to devise new methods used to detect early cases, predict patients, diagnose patients, design vaccines and drugs and others. This paper aims to conduct a comprehensive survey of the previous works that used CNNs to implement different tasks associated to Covid-19 in order to enrich researchers and provide sufficient information for new works in the same field.

Keywords: Artificial Intelligence (AI), Convolutional Neural Networks (CNN) , COVID-19, Deep Learning (DL)

1. Introduction

The first case of COVID-19 (Coronavirus disease 2019) was discovered at the end of 2019 for a Chinese citizen, specifically in Wuhan, Hubei Province, China [1]. Then the disease began to spread very quickly inside China, and then exceeded that to infect citizens of other countries. Consequently, the World Health Organization warned of it and classified it as a pandemic. The seriousness of the disease lies in the infection of a number of people at a high speed as soon as they contact or meet the infected person [2].

Computer science includes many fields, one of the most important and widely used fields is the ***Artificial Intelligence (AI)***. Artificial intelligence aims to solve real-world problems in addition to building systems that have the ability to learn and think like humans. Therefore, it is sometimes called machine intelligence [3].

Artificial Intelligence including any technology which enables the computers to simulate human behavior in solving complex functions [4]. Therefore, AI is consisted of many fields, one of them is the ***Machine Learning (ML)*** [2]. It has proven overwhelming success due to the ability to gain knowledge and gradually improve the behavior of learning. Due to its ability to achieve practical successes, machine learning is considered a backbone of artificial intelligence [5].

ML contains many branches, the most important one is the ***Deep Learning (DL)*** [6]. It is important to note that humans did not interfere with the design of its layers, but rather that they learned through certain procedures. Moreover, DL has the ability to solve complex problems and it can achieve impressive results [7]. DL is used in many domains, which included the processing of huge datasets [8], that are generated from various sources such as, sensors, monitoring systems, smartphones and many others [9]. As many techniques can implement on these massive datasets like clustering, classification, regression,...,etc [10].

Deep learning techniques are classified into three types: supervised, semi-supervised, and unsupervised learning. Any model is trained with a known input-output pair in the supervised learning. Semi-supervised learning can be defined as an intermediate state between supervised and unsupervised cases. In this case, a training data contains both labeled and unlabeled values. The third type is the unsupervised learning, in it, a model treats relationships between the data elements where these elements are classified without the need for their labels [11].

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In deep learning, there are many techniques, the ***Convolutional Neural Networks (CNN)*** is considered one of the most widely used and successful technique in the field of image processing. In this technique, the feature extraction step can be automatically included during the training data with less computation cost. Accordingly, deep learning techniques are among the most accurate in this field [8], [12].

This paper presented as a review to display the most important scientific papers that were used in performing various tasks of the Covid-19 based on CNNs. The dataset type, feasibility and benefit for each research were briefly explained as well as the accuracy comparison of previous studies.

2. CONVOLUTIONAL NEURAL NETWORKS (CNN)

In general, Convolutional Neural Networks (CNN) are similar to the traditional Artificial Neural Networks (ANNs) in terms of the fact that they contain many neurons which can be described as self-optimized during the learning phase [13]. Every neuron stills receive an input and perform an operation. One of the main variations between them is that CNN mainly used in the pattern recognition within images. Architecturally, any neural network is either feedback or feedforward network type. CNNs are feedforward types where the data is flowing in only one direction [8].

Historically, CNN was first designed in 1980 for solving some issues like image classification. After that, it is implemented on the recognition field such as the handwritten digits [14].

In the early 1990s, a large number of researchers relied on ANN, because the training CNN needs powerful computers and a huge amount of data which are difficult to provide. Additionally, training multi-layered neural networks were challenging, and other technologies are considered as successful alternatives [15]. CNN differs from Multilayer Perceptron (MLP) in that it is characterized by using the weight sharing. CNN can be applied to find out if a person has COVID-19 or not and it has also been used successfully to predict the confirmed cases [16]. Indeed, CNNs are belonging to the supervised learning [17].

Artificial intelligence is a powerful and effective tool that helps diagnose, treat and make decisions about COVID-19. Many models are designed to train the data on the pandemic during the previous period in order to obtain the best results from identifying cases of infection in a faster and automatic way [18].

CNN works as follows, first, the images are treated by the computer as input, then they are converted to a specific format that can be processed. This means that the images are transformed into an array. Then comes the turn of the system to determine which image belongs to a label based on the array information. The effect of the difference was trained during the training phase.

Basically, CNN utilizes convolution kernels that aim for convolving with the pure images to extract features which are higher level [12]. CNNs are able to recognize an image rapidly and cheaply, these merits make CNNs to be applied in the field of COVID-19 to help in making a quick and accurate medical decision.

CNN consists of three layers, convolution, pooling and the fully-connected layers. The convolution layer is an effective layer in the working of CNNs, it converts an image over convolution operation. The pooling layer is responsible to decrease an image dimension, thus it will decrease the total number of model parameters, so the model computational complexity is also decreased. Finally, the fully connected layer includes the neurons, which connected to neurons in the neighbor two layers [19]. Fig.1. shows these three layers.

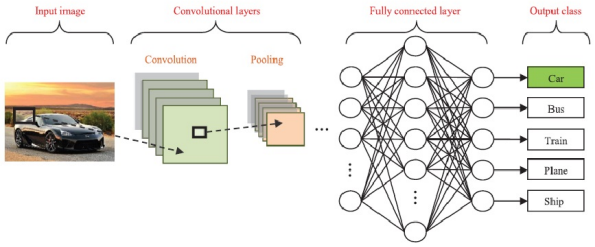

Figure 1. An architecture of CNN

More specifically, CNNs with several layers can be used in models to be more accurate in the diagnosis step to COVID-19. In other words, the number of each layer of CNNs isn't limited to 1, where [20] implemented a model that contains, 6, 6 and 3 layers respectively. Hence, it is possible to increase the number of each layer according the view of the model designer.

CNNs contain the step of feature extraction in the training phase instead of designed it manually. This step involves specific types of NN and their weights are allocated during the training phase. Furthermore, CNNs are able to produce best image recognition if its neural network of feature extraction is deeper [21]. Fig.2. illustrates the feature extraction step.

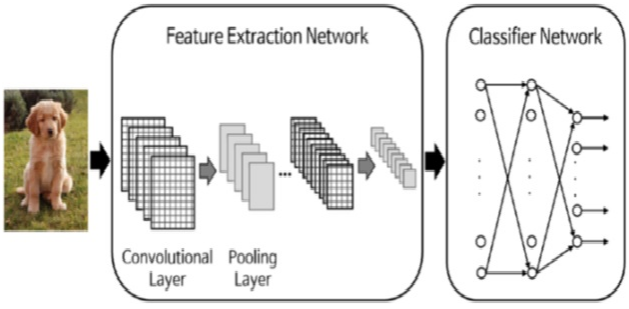

Figure 2. Feature extraction step in the architecture CNN

A. The medical field

The medical field is considered an important challenge of artificial intelligence because it contains uncertainty and missing data besides incomplete (or unknown) data, which sometimes cause difficulty to make the medical decision for a specific case [22].

Artificial intelligence is beginning to play an effective role in research works in the medical field on the basis that various data may contribute to a relevant result [23]. One of the most important reasons for the success of artificial intelligence in the medical field is that its results are trustworthy and interpretable by a human expert [24].

In the same context, deep learning techniques have achieved excellent results in this area, such as determining disease status based on the segmentation of medical images [25]. Since Convolutional Neural Networks are based on a huge data as input, it didn't face a problem when working in the detection of people infected with Covid-19 by segmenting those input data and analyzing them to make the decisions.

B. COVID-19

Due to the rapid spread of the disease in most countries of the world, it caused paralyze all sectors such as trade, industry, transportation. In addition to restricting people themselves with precautionary measures such as social distancing and home commitment to prevent its spread as well as the tremendous impetus on hospitals to provide medical services. At the same time, many countries in which the disease appeared have resorted to closing borders with other countries [26].

Commonly, AI has been used in various vital aspects in the medical field in general and in COVID-19 research in particular, including:

- Diagnosis and prediction of COVID-19.
- Monitoring cases of people infected with COVID-19.
- Drug and treatment of COVID-19.

In addition to using artificial intelligence applications to monitor the health of patients while they are infected with the Covid-19, some of these applications have been developed to be used to monitor their health even after they have recovered and can help to monitor the health practices that will be extremely effective in stopping the infection and spread of COVID-19.

It became clear that the number of research papers published on COVID-19, began to grow quickly and uniquely. At the same time, these articles need careful analysis to be used properly. For example, articles published from January 2020 until April 2021 on three platforms: MedRxiv, BiorXiv and ArXiv are shown in Fig. 3. These articles are related to COVID-19 and based on AI techniques.

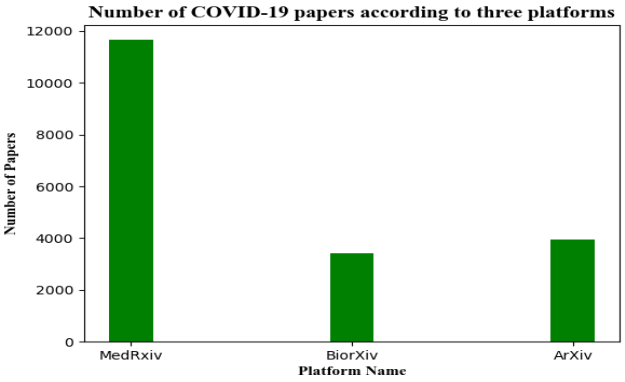

Figure 3. The number of COVID-19 papers according to platforms

The X-rays generally show that there is a clear difference between the normal cases and the cases of the patient with Covid 19 [27]. Fig. 4. illustrates this comparison.

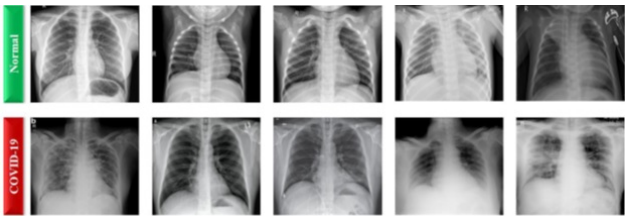

Figure 4. The main difference between normal and COVID-19 cases

C. Related Work

Since the emergence of the Covid-19 pandemic, many researchers have begun to publish their research on the causes of the disease, methods of treatment and prevention of its spread. While others used modern computer technologies such as AI in early diagnosis, treatment, and other tasks. In this section, we will discuss some researcher surveys that used AI.

The authors in [28] focused on detecting and diagnosing a person when infected with the Coronavirus, using data mining methods. Where they reviewed some of the artificial intelligence techniques and algorithms and how to develop them in order to predict the cases. Eight works were included and discussed in this work.

According to [29], the effective role of artificial intelligence in several areas related to the Corona virus has been reviewed. These areas included screening, digital contact tracing, prediction and digital contact tracing. These research works contributed significantly to reducing human intervention in these areas. The articles that are reviewed in this work as follows, 4 articles for screening, digital contact tracing, successfully implemented in 36 countries, 4 articles for prediction and 3 articles for vaccination and drugs.

In [30], the authors reviewed 30 articles which are carefully analyzed. These articles used various artificial intelligence methods to accurately diagnose people with

COVID-19. All articles were picked from different platforms including MedRxiv, ArXiv, and Google Scholar on the role of AI (especially deep learning) in diagnosing COVID-19 using CT scans of the chest.

The work in [31] hypothesized that there are two types of machine intelligence, namely, artificial intelligence, which was developed based on solid computing, and computational intelligence, which was developed based on soft computing. Computational intelligence can adapt to different conditions by applying its techniques. These techniques were divided into five classes, namely, neural networks, evolutionary computation, computational learning, probability and finally fuzzy logic. However, the researchers reviewed many articles under these techniques to combat COVID-19. Part of this work relied on detecting the patient with Covid-19 through three-dimensional computed tomography of the chest.

The literature review which presented by [32] displayed the clinical applications based on AI such as treatment, diagnosis, monitoring patients. Then, the author reviewed several works to detect the injured, such as using neural networks and deep neural networks on CT scans, as well as combining deep neural networks and other algorithms. Also, the author displayed some articles that used evolutionary algorithms. Finally, the author discussed some AI applications in epidemiology and also pharmaceutical studies.

3. BIOMEDICAL DATASET

The dataset that has been used to perform many tasks related to COVID-19 by many researchers is a variety such as text dataset, social media dataset, speech dataset and biomedical dataset. AI techniques which used in COVID-19 applications and models are concerning to the biomedical datasets, so this type of datasets used extensively. In general, biomedical datasets can be categorized mainly into two types that are, Chest radiography (X-ray) and Computed Tomography (CT) [33], [34].

According to radiology, the above two types fall under the class of chest radiograph imaging to detect the pneumonia diagnosis [33]. The comparison between the two types above includes X-ray which is the cheapest and most popular. Moreover, it emits less radiation [35]. On the other hand, a CT is more difficult [36].

Generally, there is a lack in the biomedical available datasets for the COVID-19 especially, X-ray images [33].

To understand the performance of each study or model built using CNN that discussed in this paper, it becomes necessary to explain the type of dataset used in each article will be covered below.

Deep Learning and its relation to implementing a specific task for COVID-19 based on two types of biomedical datasets that are x-ray images and CT images [37].

4. REVIEW OF STUDIES BASED CNNS

This section aims to cover and explain the studies that have relied on CNN in carrying out various tasks of COVID-19. In order for this study to be comprehensive for a variety of datasets, studies that did not rely on CT and X-ray datasets have been also analyzed like that relied on protein sequences. Furthermore, this study was not limited to studies that depended on the accuracy metric, but analyzed studies that used another measures.

In [38], the authors designed a convolutional neural network to detect COVID-19 from chest X-ray (CXR) images. This CNN is known as COVID-Net. They also introduced COVIDx dataset which was collected from five repositories. It consists 13,975 CXR images collected from 13,870 patients. The dataset was divided into 80 % as training data and 20 % as test data. The main objective of the research is to provide sufficient information to specialists working in the diagnosis of COVID-19 to improve the screening step. Firstly, the proposed model (COVID-Net) was pre-trained on the ImageNet dataset, secondly it trained on the created dataset (COVIDx). COVID-Net was compared with other deep neural network architecture such as VGG-19 and ResNet-50. The study proved that COVID-Net model is better in terms of results besides that it is less complex architecturally and computationally from others. The network designed in this work tested the dataset and achieved an accuracy of 93.3 % for distinguishing normal pneumonia, typical pneumonia, and COVID-19. Additionally, it achieved 91.0 % sensitivity and 98.9 % of the positive predictive value (PPV).

According to [34], five convolutional neural network CNNs were proposed which called: ResNet50, ResNet101, ResNet152, InceptionV3 and Inception-ResNetV2 based pre-trained transfer learning model. It aims to detect the patient that has coronavirus based on the chest X-ray radiographs. Three datasets were used; all of them are binary datasets. The first dataset contains 341 images for COVID-19 patients and 2800 normal images. The second dataset contains 341 images for COVID-19 patients and 1493 viral pneumonia images. The last dataset contains 341 images for COVID-19 patients and 2772 bacterial images. Each dataset was partitioned into 80 % training data and 20 % testing data. The ResNet50 network model achieved the highest accuracy among all others, it achieved 96.1 %, 99.5 % and 99.7 % to datasets 1,2 and 3 respectively.

The main objective of the model in [39] is to detect a patient infected with COVID-19 and distinguish them from the uninfected person. Mainly the model depended on the technologies of medical imaging. The CNN used for the above model proved to be effective and successful. The model was based on CT scans of the chest. They presented COVID-19 neural network (COVNet) for extraction many representative features which are two-dimensional (local) and 3D dimensional (global) [40]. AI with 3D Deep Learning is a successful implementation for predicting

the patients infected by COVID-19 [41]. The dataset in this work contains 4.356 chest CT screening that gathered from 3.322 patients with age (49±15) years. The sensitivity achieved is 90 % for COVID-19 [39].

Deep Learning with X-ray has been applied in [42] by using transfer learning, where detecting an abnormality in a medical image is an achievable goal. Through CNN the knowledge that has been extracted from specific data will be transferred to other data to solve a specific problem [43]. The datasets used in this work are two datasets. Each one contained 224 images to COVID-19 disease [42]. The model utilized a CNN involves 19 layers and it is known as VGG19 (Visual Geometry Group depended on the CNN with 19 layers) [44]. In general, the model can eliminate the leakage of the data that occurred when reached the maximum images to similar case (patient) [41]. The model achieved an accuracy of 96.78 % and a sensitivity of 98.66 % [42].

According to [27], the model proposed a COVIDX-Net (Visual Geometry Group (VGG19) and Dense Convolutional Network (DenseNet201)). The model aims to help workers in this field to automatically diagnose COVID-19. The type of images that were used is the chest X-ray [44]. However, this dataset contains 50 images, which are equally divided into 25 images of normal patients and 25 images of COVID-19 patients. The core idea of the work is to build a model dependent on seven various deep CNN (DCNNs) architectures which are VGG19, DenseNet201, ResNetV2, Xception, InceptionV3, MobileNetV2 and InceptionResNetV2 [32]. They proved that VGG19 and DenseNet have the best accuracy among all others with 90 %.

The authors in [45] used the deep convolutional network and transfer learning. This study hypothesizes that AI technologies are able to extract certain graphical features to patients of COVID-19 and then providing a clinical diagnosis. The type of image that used was CT images, 1065 images of pathogen-confirmed COVID-19. To classify the CT images, the Region of Interest (ROI) part of the lungs for every image is detected. After that, the transfer learning is applied for the features extraction. Lastly, all images are classified [46]. There are two types of validation: internal and external. The internal validation achieves accuracy 89.5 % while the accuracy of external validation is 79.3 % [45]. The study aims to stop the spread of the disease by quickly diagnosing it [47].

In [48], CNN was built (with transfer learning) to examine the significance of all features which were extracted previously. This network is known as MobileNet-v2. The study is to distinguish between seven classes of lungs, one of which is COVID-19. The type of image used as a dataset was X-ray image and its total is 3905 images, 455 images are for COVID-19 and the rest for other diseases. First of all, the features are extracted by CNN and then those features are checked. For Covid-19 the accuracy and sensitivity achieved 99.18 % and 97.36 % respectively [49].

The work of [50] is to suggest a new method which is able to detect COVID-19 automatically depended on deep CNN with transfer learning. The dataset involved 423 images of COVID-19, 1579 normal chest X-rays and 1485 viral pneumonia images and the type of biomedical dataset is chest X-ray images. To implement the study goal, five deep CNNs are trained, i.e. VGG19, DenseNet201, ResNet101, Inceptionv3 and CheXNet. The transfer learning method was utilized with aid of the image augmentation for training the five CNN architectures [51]. When an image augmentation was applied, DenseNet201 is the best architecture, while CheXNet is the best when image augmentation wasn't applied. Practically, all five networks were trained for classifying two classes, a) normal and COVID-19 b) normal, viral and COVID-19. For each class, an architecture was trained with image augmentation and without it. The accuracy and sensitivity for every class are 99.7 %, 99.7 % and 97.9 %, 97.9 % respectively [50].

The model presented in [52] based on CNN and Support Vector Machine (SVM) to detect a patient who has coronavirus. The type of biomedical dataset was X-ray images and three classes were included COVID-19, normal (healthy) and pneumonia. They proposed 13 CNNs architectures which are, AlexNet, Vgg16, Vgg19, MobileNetV2, ShuffleNet, Xception, Resnet50, Resnet18, Resnet101, Inceptionv3, Inceptionresnetv2, GoogleNet and Densenet201. The idea of the model is to extract deep features and then will transfer them to SVM to classify these features [53]. The result of the model proves that ResNet50 with SVM is the best one while it achieved accuracy and sensitivity of 95.33 % and 95.33 % [52].

A new method was suggested in [54] by combining CNN with an optimization algorithm (Gravitational Search Algorithm) therefore, the method known as GSA-DenseNet121-COVID-19 that aims to diagnose COVID-19 [5]. The purpose of using the optimization algorithm in this method is to determine the best parameter value for the architecture DenseNet121 and thus achieves the best possible accuracy [54]. Taking into consideration parameters number needs to be decreased during the processing [37]. The type of biomedical dataset was the chest X-ray image. Two datasets were used, the first dataset was from the GitHub repository that contains 150 images (chest X-ray plus CT images) where 126 images of them were infected cases by COVID-19 and 24 images to others diseases. The second dataset was a chest X-ray from Kaggle website that includes 5811 images where 1538 of them were healthy cases and 4273 images were pneumonia. The proposed method achieved 98 % accuracy results [54].

The authors of [12] utilized two object detection models that are, YOLOv3 and Faster R-CNN to detect the masked faces in real-time. You Only Look Once version3 (YOLOv3) is a modern system for detecting objects in

real-time. It is an accurate and fast detector. The model YOLOv3 contains 53 convolutional layers. Both models were trained on images with two classes that are people with and without a face mask. They applied the bounding boxes idea in these models and the dataset is a mixing of MAFA, WIDER FACE and other images. The Faster R-CNN model achieved the higher precision of 62.0 % while YOLOv3 model achieved 55.0 %.

A CNN model was proposed in [55] to analyze the clinical images of COVID-19 patients and then detect skin lesions for them. Training included three classes patients have COVID-19, healthy controls and 18 common skin cases. The overall dataset that was used in this study comprises 7053 images. The goal of the model is to distinguish between the patients who have COVID-19 and normal cases by detecting their cutaneous manifestations.

In [56], a special COVID-19 dataset related to protein sequences according to several countries has been used. It consists of 26 countries and it aims to predict the country based on these protein sequences where many features were extracted from the protein. Different classifiers were used, Linear Regression, K-Nearest Neighbor (with different value like 20,50,150 and 201), Support Vector Machine (with different kernel like RBF, linear, sigmoid and polynomial), Naive Bayesian, Decision Tree and Random Forest.

According to these studies which explained in section 4, Table I provides sufficient information about it in terms of publication year (Year), DataSet Name (DSN), DataSet Type (DST), Image Number (IN), Patients Number (PN) and the metric of every study (where Acc. is Accuracy, Sen. is Sensitivity and Pre. is Precision).

TABLE I. DESCRIPTION OF PREVIOUS STUDIES

Ref.	Year	DSN:DST:IN:PN	Metric %
[12]	2021	Mixture	Pre.:62.0
[27]	2020	ChestX.ray:ChestX.ray:50:25	Acc.:90.0
[34]	2021	Dataset1:X.ray:3141:341	Acc.:96.1
		Dataset2:X.ray:1834:341	Acc.99.5
		Dataset3:X.ray:3113:341	Acc.99.7
[38]	2020	ImageNet:CT:104009:1489	Acc.:99.1
[39]	2020	NewData:ChestCT:4356:3322	Sen.:90.0
[42]	2020	X.ray2Class:X.ray:1428:224	Acc.:96.7
		X.ray3Class:X.ray:1442:224	Acc.94.7
[45]	2021	NewData:CT:1065:259	Acc.:89.5
[48]	2020	NewData:X.ray:3905:—	Acc.:99.1
[50]	2020	NewData:ChestX.ray:423:—	Acc.:99.7
[52]	2020	GithubData:X.ray:381:48	Acc.:95.3
[54]	2021	Mixture:ChestX.ray:150:—	Acc.:98.0
		X.ray:5811:—	Acc.:98.0
[55]	2021	Clinical Dataset:—:7053:459	Acc.:98.9
[56]	2020	SARS-Cov-2:Protein Sequence:—:—	Acc.:79.5

Moreover, Fig. 5. indicates a comparison of accuracy between these previous studies, where it relied on CT and X-ray datasets and that were measured by the accuracy metric.

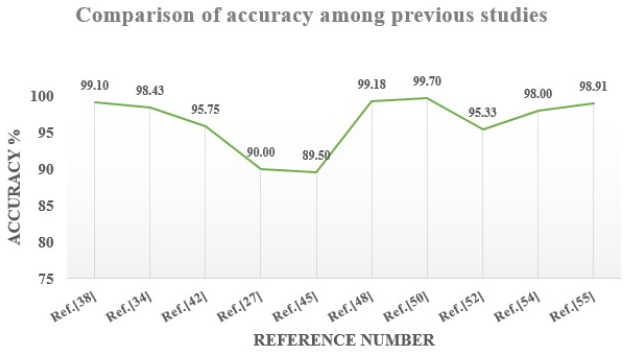

Figure 5. The comparison of accuracy between previous studies

5. Conclusions and Future Work

To limit the rapid spread of COVID-19, researchers are beginning to find realistic ways to detect, diagnose, predict the disease early in addition to other tasks.

Artificial intelligence (AI) represents the backbone of computer science because of its diverse methods and techniques, as researchers have benefited greatly from the diversity of these technologies. Lately, deep learning is considered an active and pivotal field of AI. Convolutional Neural Networks (CNN) are one of the most important deep learning techniques that have been applied widely and successfully in medical field. After the spread of the Covid-19 pandemic around the world, there is an increasing interest in the implementation of the CNNs in COVID-19 to prevent or reduce the spread of the pandemic.

This paper presents a systematic review about the using of Convolutional Neural Networks (CNNs) in COVID-19 tasks. However, the current paper includes a variety of research papers and studies that relied on CNNs to perform tasks related to COVID-19, in order to provide adequate support for future research papers in terms of providing sufficient information from structures, datasets, network methods, as well as the different methods of CNNs networks used in COVID-19.

In the future work, we will explore the methods and architectures for cloud computing to detect and predict the COVID-19 pandemic. As well as the applying of cloud intelligent systems in this field because of the great importance of it.

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References

[1] N. Zhu, D. Zhang, W. Wang, X. Li, B. Yang, J. Song, X. Zhao, B. Huang, W. Shi, R. Lu *et al.*, "A novel coronavirus from patients with pneumonia in china, 2019," *New England journal of medicine*, 2020.

[2] A. Erraissi and M. Banane, "Machine learning model to predict the number of cases contaminated by covid-19," *International Journal of Computing and Digital Systems*, vol. 9, pp. 1–11, 2020.

[3] D. Poole, A. Mackworth, and R. Goebel, "Computational intelligence," 1998.

[4] C. Janiesch, P. Zschech, and K. Heinrich, "Machine learning and deep learning," *Electronic Markets*, pp. 1–11, 2021.

[5] R. Sujath, J. M. Chatterjee, and A. E. Hassanien, "A machine learning forecasting model for covid-19 pandemic in india," *Stochastic Environmental Research and Risk Assessment*, vol. 34, pp. 959–972, 2020.

[6] J. Schmidhuber, "Deep learning in neural networks: An overview," *Neural networks*, vol. 61, pp. 85–117, 2015.

[7] Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," *nature*, vol. 521, no. 7553, pp. 436–444, 2015.

[8] W. Rawat and Z. Wang, "Deep convolutional neural networks for image classification: A comprehensive review," *Neural computation*, vol. 29, no. 9, pp. 2352–2449, 2017.

[9] H. A. Al-Khamees, N. Al-A'Araji, and E. S. Al-Shamery, "Survey: Clustering techniques of data stream," in *2021 1st Babylon International Conference on Information Technology and Science (BICITS)*. IEEE, 2021, pp. 113–119.

[10] H. A. Al-Khamees, N. Al-A'Araji, and E. Al-Shamery, "Data stream clustering using fuzzy-based evolving cauchy algorithm," *International Journal of Intelligent Engineering and Systems*, vol. 14, pp. 348–358, 2021.

[11] S. Bhattacharya, P. K. R. Maddikunta, Q.-V. Pham, T. R. Gadekallu, C. L. Chowdhary, M. Alazab, M. J. Piran *et al.*, "Deep learning and medical image processing for coronavirus (covid-19) pandemic: A survey," *Sustainable cities and society*, vol. 65, p. 102589, 2021.

[12] S. Singh, U. Ahuja, M. Kumar, K. Kumar, and M. Sachdeva, "Face mask detection using yolov3 and faster r-cnn models: Covid-19 environment," *Multimedia Tools and Applications*, vol. 80, no. 13, pp. 19 753–19 768, 2021.

[13] M. Liu, J. Shi, Z. Li, C. Li, J. Zhu, and S. Liu, "Towards better analysis of deep convolutional neural networks," *IEEE transactions on visualization and computer graphics*, vol. 23, no. 1, pp. 91–100, 2016.

[14] Y. LeCun, B. Boser, J. Denker, D. Henderson, R. Howard, W. Hubbard, and L. Jackel, "Handwritten digit recognition with a back-propagation network," *Advances in neural information processing systems*, vol. 2, 1989.

[15] L. Mohimont, A. Chemchem, F. Alin, M. Krajecki, and L. A. Steffenel, "Convolutional neural networks and temporal cnns for covid-19 forecasting in france," *Applied Intelligence*, pp. 1–26, 2021.

[16] C.-J. Huang, Y.-H. Chen, Y. Ma, and P.-H. Kuo, "Multiple-input deep convolutional neural network model for covid-19 forecasting in china," *MedRxiv*, 2020.

[17] X. Liu, J. Van De Weijer, and A. D. Bagdanov, "Exploiting unlabeled data in cnns by self-supervised learning to rank," *IEEE transactions on pattern analysis and machine intelligence*, vol. 41, no. 8, pp. 1862–1878, 2019.

[18] R. Vaishya, M. Javaid, I. H. Khan, and A. Haleem, "Artificial intelligence (ai) applications for covid-19 pandemic," *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, vol. 14, no. 4, pp. 337–339, 2020.

[19] K. O'Shea and R. Nash, "An introduction to convolutional neural networks," *arXiv preprint arXiv:1511.08458*, 2015.

[20] A. A. Reshi, F. Rustam, A. Mehmood, A. Alhossan, Z. Alrabiah, A. Ahmad, H. Alsuwailem, and G. S. Choi, "An efficient cnn model for covid-19 disease detection based on x-ray image classification," *Complexity*, vol. 2021, 2021.

[21] P. Kim, "Matlab deep learning," *With machine learning, neural networks and artificial intelligence*, vol. 130, no. 21, 2017.

[22] A. Holzinger, "Interactive machine learning for health informatics: when do we need the human-in-the-loop?" *Brain Informatics*, vol. 3, no. 2, pp. 119–131, 2016.

[23] A. Holzinger, "Introduction to machine learning and knowledge extraction (make)." *Mach. Learn. Knowl. Extr.*, vol. 1, no. 1, pp. 1–20, 2019.

[24] A. Holzinger, "From machine learning to explainable ai," in *2018 world symposium on digital intelligence for systems and machines (DISA)*. IEEE, 2018, pp. 55–66.

[25] Y.-N. Chen, C.-C. Han, C.-T. Wang, B.-S. Jeng, and K.-C. Fan, "The application of a convolution neural network on face and license plate detection," in *18th International Conference on Pattern Recognition (ICPR'06)*, vol. 3. IEEE, 2006, pp. 552–555.

[26] V. Murty and A. K. Sharma, "Impact of covid'19 pandemic on indian electrical distribution system," *International Journal of Computing and Digital Systems*, vol. 10, pp. 1–11, 2021.

[27] E. E.-D. Hemdan, M. A. Shouman, and M. E. Karar, "Covidx-net: A framework of deep learning classifiers to diagnose covid-19 in x-ray images," *arXiv preprint arXiv:2003.11055*, 2020.

[28] A. S. Albahri, R. A. Hamid, J. K. Alwan, Z. Al-Qays, A. Zaidan, B. Zaidan, A. Albahri, A. AlAmoodi, J. M. Khlaf, E. Almahdi *et al.*, "Role of biological data mining and machine learning techniques in detecting and diagnosing the novel coronavirus (covid-19): a systematic review," *Journal of medical systems*, vol. 44, pp. 1–11, 2020.

[29] S. Lalmuanawma, J. Hussain, and L. Chhakchhuak, "Applications of machine learning and artificial intelligence for covid-19 (sars-cov-2) pandemic: A review," *Chaos, Solitons & Fractals*, vol. 139, p. 110059, 2020.

[30] I. Ozsahin, B. Sekeroglu, M. S. Musa, M. T. Mustapha, and D. Uzun Ozsahin, "Review on diagnosis of covid-19 from chest ct images using artificial intelligence," *Computational and Mathematical Methods in Medicine*, vol. 2020, pp. 1–10, 2020.

[31] V. S. Tseng, J. J.-C. Ying, S. T. Wong, D. J. Cook, and J. Liu, "Computational intelligence techniques for combating covid-19: a survey," *IEEE Computational Intelligence Magazine*, vol. 15, no. 4, pp. 10–22, 2020.

[32] M.-H. Tayarani-N, "Applications of artificial intelligence in battling against covid-19: a literature review," *Chaos, Solitons & Fractals*, p. 110338, 2020.

[33] S. Minaee, R. Kafieh, M. Sonka, S. Yazdani, and G. J. Soufi, "Deep-covid: Predicting covid-19 from chest x-ray images using deep transfer learning," *Medical image analysis*, vol. 65, p. 101794, 2020.

[34] A. Narin, C. Kaya, and Z. Pamuk, "Automatic detection of coronavirus disease (covid-19) using x-ray images and deep convolutional neural networks," *Pattern Analysis and Applications*, pp. 1–14, 2021.

[35] N. N. Das, N. Kumar, M. Kaur, V. Kumar, and D. Singh, "Automated deep transfer learning-based approach for detection of covid-19 infection in chest x-rays," *Irbm*, 2020.

[36] B. Antin, J. Kravitz, and E. Martayan, "Detecting pneumonia in chest x-rays with supervised learning," *Semanticscholar. org*, 2017.

[37] M. M. Islam, F. Karray, R. Alhajj, and J. Zeng, "A review on deep learning techniques for the diagnosis of novel coronavirus (covid-19)," *IEEE Access*, vol. 9, pp. 30 551–30 572, 2021.

[38] H. Gunraj, L. Wang, and A. Wong, "Covidnet-ct: A tailored deep convolutional neural network design for detection of covid-19 cases from chest ct images," *Frontiers in medicine*, vol. 7, 2020.

[39] L. Li, L. Qin, Z. Xu, Y. Yin, X. Wang, B. Kong, J. Bai, Y. Lu, Z. Fang, Q. Song *et al.*, "Artificial intelligence distinguishes covid-19 from community acquired pneumonia on chest ct," *Radiology*, 2020.

[40] M. R. Ibrahim, S. M. Youssef, and K. M. Fathalla, "Abnormality detection and intelligent severity assessment of human chest computed tomography scans using deep learning: a case study on sars-cov-2 assessment," *Journal of Ambient Intelligence and Humanized Computing*, pp. 1–24, 2021.

[41] K. Shankar, E. Perumal, P. Tiwari, M. Shorfuzzaman, and D. Gupta, "Deep learning and evolutionary intelligence with fusion-based feature extraction for detection of covid-19 from chest x-ray images," *Multimedia Systems*, pp. 1–13, 2021.

[42] I. D. Apostolopoulos and T. A. Mpesiana, "Covid-19: automatic detection from x-ray images utilizing transfer learning with convolutional neural networks," *Physical and Engineering Sciences in Medicine*, vol. 43, no. 2, pp. 635–640, 2020.

[43] K. Weiss, T. M. Khoshgoftaar, and D. Wang, "A survey of transfer learning," *Journal of Big data*, vol. 3, no. 1, pp. 1–40, 2016.

[44] A. Shelke, M. Inamdar, V. Shah, A. Tiwari, A. Hussain, T. Chafekar, and N. Mehendale, "Chest x-ray classification using deep learning for automated covid-19 screening," *SN computer science*, vol. 2, no. 4, pp. 1–9, 2021.

[45] S. Wang, B. Kang, J. Ma, X. Zeng, M. Xiao, J. Guo, M. Cai, J. Yang, Y. Li, X. Meng *et al.*, "A deep learning algorithm using ct images to screen for corona virus disease (covid-19)," *European radiology*, pp. 1–9, 2021.

[46] Z. Nabizadeh-Shahre-Babak, N. Karimi, P. Khadivi, R. Roshandel, A. Emami, and S. Samavi, "Detection of covid-19 in x-ray images by classification of bag of visual words using neural networks," *Biomedical Signal Processing and Control*, vol. 68, p. 102750, 2021.

[47] D. Keaney, S. Whelan, K. Finn, and B. Lucey, "Misdiagnosis of sars-cov-2: A critical review of the influence of sampling and clinical detection methods," *Medical Sciences*, vol. 9, no. 2, p. 36, 2021.

[48] I. D. Apostolopoulos, S. I. Aznaouridis, and M. A. Tzani, "Extracting possibly representative covid-19 biomarkers from x-ray images with deep learning approach and image data related to pulmonary diseases," *Journal of Medical and Biological Engineering*, p. 1, 2020.

[49] L. MOURA, C. DARTORA, C. Mattjie, R. BARROS, and A. M. M. da Silva, "Texture-based feature extraction for covid-19 pneumonia classification using chest radiography," *EAI Endorsed Transactions on Bioengineering and Bioinformatics*, 2021.

[50] M. E. Chowdhury, T. Rahman, A. Khandakar, R. Mazhar, M. A. Kadir, Z. B. Mahbub, K. R. Islam, M. S. Khan, A. Iqbal, N. Al Emadi *et al.*, "Can ai help in screening viral and covid-19 pneumonia?" *IEEE Access*, vol. 8, pp. 132 665–132 676, 2020.

[51] M. M. Taresh, N. Zhu, T. A. A. Ali, A. S. Hameed, and M. L. Mutar, "Transfer learning to detect covid-19 automatically from x-ray images using convolutional neural networks," *International Journal of Biomedical Imaging*, vol. 2021, 2020.

[52] P. K. Sethy and S. K. Behera, "Detection of coronavirus disease (covid-19) based on deep features," 2020.

[53] D. Singh, V. Kumar, M. Kaur *et al.*, "Classification of covid-19 patients from chest ct images using multi-objective differential evolution–based convolutional neural networks," *European Journal of Clinical Microbiology & Infectious Diseases*, vol. 39, no. 7, pp. 1379–1389, 2020.

[54] D. Ezzat, A. E. Hassanien, and H. A. Ella, "An optimized deep learning architecture for the diagnosis of covid-19 disease based on gravitational search optimization," *Applied Soft Computing*, vol. 98, p. 106742, 2021.

[55] J. Mathur, V. Chouhan, R. Pangti, S. Kumar, and S. Gupta, "A convolutional neural network architecture for the recognition of cutaneous manifestations of covid-19," *Dermatologic Therapy*, vol. 34, no. 2, p. e14902, 2021.

[56] W. Alkady, M. Zanaty, and H. Afify, "Computational predictions for protein sequences of covid-19 virus via machine learning algorithms," 2020.

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