COVID-19 Detection from Chest X-ray Images using CNN

Elif Aşıcı
Department of Computer Engineering
Istanbul Sabahattin Zaim University
İstanbul, Turkey
elif.asici@std.izu.edu.tr

Alaa Ali Hameed
Department of Computer Engineering
Istanbul Sabahattin Zaim University
İstanbul, Turkey
alaa.hameed@izu.edu.tr

Akhtar Jamil
Department of Computer Engineering
Istanbul Sabahattin Zaim University
İstanbul, Turkey
akhtar.jamil@izu.edu.tr

Jawad Rasheed
Department of Computer Engineering
Istanbul Sabahattin Zaim University
İstanbul, Turkey
jawad.rasheed@izu.edu.tr

***Abstract*—After Covid-19 was detected in China in December 2019, it spread rapidly and affected the whole world. The similarity of COVID-19 disease with other lung infections makes it difficult to make an accuracy prediction and diagnosis. In addition, with the high spread rate of COVID-19, the need for a fast system and method for diagnosing cases has increased over time. For this reason, studies in the field of health have increased rapidly to prevent this pandemic disease, and various methods base on artificial intelligence (AI) have been developed to support health practitioners in quick decision making. This study focuses on COVID-19 identification with CNN using X-ray images. Moreover, the proposed method was compared with some recent studies for COVID-19 classification. The result presented are in line with the start of the art method as the proposed method provides a good recognition rate for the detection of Covid-19 .**

Keywords – Covid-19, CNN, Deep Learning, Image Processing, artificial intelligence

I. Introduction

The new type of coronavirus, which was first detected in China on December 12 and turned into a pandemic in a short time, is a contagious virus that causes respiratory tract infection and can be passed from person to person. It has been confirmed by studies that it is transmitted by contact or airborne respiratory tract [1]. This virus spread rapidly among people and affected the whole world. The disease causes various problems in the human body. According to research, the disease has been found to damage the lungs, brain, liver and many other organs [2]. Biomedical studies are among the computer sciences such as artificial intelligence, deep learning, image processing, and these fields, in this period, apply various methods in the stage of detecting the disease on the bodies of people and investigating the damage caused by the disease on the organs with studies on treatment and diagnosis in medicine [3]. For example, it is possible to see the damage caused by lung disease on radiological images such as x-rays.

Various methods commonly used in computer science, such as deep learning and image processing, have helped make successful biomedical analysis. These methods include many mehods such as SVM [4], CNN and Random Forest [5] and are widely used. In this article, a classification was made according to the features extracted using the deep learning model CNN on Covid-19 patients with chest radiographic images. The aim of the study is to determine the model that gives the best accuracy, recall, precision and f1-score, as well as compare it with the work of other researchers. In this article, CNN was used as the classification method and the accuracy, recall, precision and f1-score values were found to be 95.9, 96, 96 and 96 respectively. Similary, in [6] authors proposed two commonly used classifiers were selected: logistic regression (LR) and CNN for COVID-19 identification from x-ray images. Moreover, principal component analysis (PCA) was applied to reduce the dimensionality and increase the processing speed. A detailed survey of the recent developments in COVID-19 identification using AI techniques can be found in [7].

In this study, it was aimed to make early and accurate diagnosis upon the increasing prevalence of the Covid-19 virus, and for this, a study was carried out on the CNN method, a deep learning model, in order to facilitate studies in the field of health. Examples of current studies using Covid-19 X-ray images have been given, and a situation analysis has been made in relevant areas.

II. Related work

In this study, a deep learning approach using chest x-ray was developed to be an alternative and supportive to traditional diagnostic tools. The purpose of this deep learning approach with convolutional neural networks (CNN) architecture is to diagnose Covid-19 disease from X-ray images and to make a classification accordingly.

In the first study reviewed [8], a new artificial neural network, Convolutional CapsNet, was proposed for the detection of COVID-19 disease on chest X-ray images with capsule networks. The proposed approach is designed to provide rapid and accurate diagnosis of COVID-19 diseases with dual classification and multi-class classification. The proposed method obtained an accuracy of 97.24% and 84.22% for dual class and multi class, respectively. It has been observed that the study on dual class gives better results. In the study, it was concluded that capsule networks can classify effectively even in a limited data set.

In another study discussed, [9] proposed CoroNet, a Deep Convolutional Neural Network model, to automatically detect COVID-19 infection from chest X-ray images. The proposed model was seen to be based on the pre-trained Xception architecture in the ImageNet dataset, and a new dataset was created by collecting COVID-19 and other chest pneumonia X-ray images from two different public databases, and then end-to-end training was carried out with this dataset. As a result, CoroNet was trained and tested on the prepared dataset and the experimental results showed that the proposed model gave an overall accuracy of 89.6%. When the study was repeated for 3-class classification, it was seen that the accuracy value changed to 95%.

In the last study we reviewed [10], deep learning supported automated detection schemes for COVID-19 and other pneumonia are recommended using a small amount of COVID-19 chest X-rays. CNN-based architecture, called CovXNet, proposes an architecture that uses deep convolution. Because of the high similarity of the X-ray images, many chest X-rays were first used for curving the recommended ones.

In the proposed method, different forms of CovXNets are designed and trained with X-ray images of various resolutions. A stacking algorithm is used for further optimization of the predictions. As a result, different results were obtained in two and multiple classification studies. Accuracy values for two, three and four classes, respectively, were specified as 98.1%, 95.1% and 91.7%.

In these three related studies [8-10], it is clearly seen in Table 2 that each study conducted a classification study on the number of different classes such as two, three, and our study with classification studies on three classes in the sample studies from Table 2. If compared, we have obtained the highest accuracy result with the architecture of the proposed CNN model.

III. METHODOLOGY

A. Deep Learning

Deep learning is an exciting branch of machine learning that is a subfield of artificial intelligence. Deep learning is used to teach machines and systems things that people can do with large amounts of data used in machine learning methods. Some of the most exciting and challenging topics such as the detection of certain objects in the image [11], exploration of the environment in autonomous vehicle systems, natural language processing [12] are among the subjects of interest of deep learning [13] [14].

B. CNN Metod

Convolutional neural networks (CNN), a deep learning technique, is a powerful neural network. Deep Convolutional Neural Network is a special type of Neural Networks that performs exemplarily in various competitions related to computer vision and image processing. Some of CNN's exciting areas of application and study include Image Classification and Segmentation, Object Detection, Video Processing and Speech Recognition. Deep CNN's strong learning ability is primarily due to the use of multiple feature extraction stages that can automatically learn representations from the data. The availability of large amounts of data and advances in hardware technology have accelerated the search in CNN’s.

A typical CNN architecture usually includes alternate convolution layers. The arrangement of CNN components plays a fundamental role in designing new architectures and thus achieving improved performance [15].

C) CNN Layer Structure

- ***Convolutional Layer:*** In this layer, which forms the basis of CNN, the transformation process is performed by circulating a certain filter created on all images in the data set. Dividing an image into small blocks helps to extract feature motifs [15].

- ***Pooling Layer:*** It is the layer used to reduce the creep size of the representation, parameters within the network and the number of calculations. In this way, incompatibility in the network is checked. Summarizes similar information in the neighborhood of the recipient area and gives the dominant response in this local area [15].

- ***Activation Function:*** This function serves as a decision function and helps to learn complex patterns. With the selection of an appropriate activation function, the deep web is turned into a nonlinear structure, thus accelerating the learning process [15].

- ***Batch normalization:*** Batch normalization is used to address issues with internal covariance shift in feature maps. Internal covariance shift is a change in the distribution of values of hidden units and slows convergence [15].

- ***Dropout:*** It is one of the most used networking techniques in deep learning. When working with large data sets, memorization may often occur in the model. In order to prevent this, the main goal is to increase the learning of the network by removing some connections or units in the network and to prevent memorization [15].

- ***Fully connected layer:*** The fully connected layer is mostly used at the end of the network for classification. Unlike pooling and convolution, this is a global process. It takes input from the feature extraction stages and analyzes the output of all previous layers globally. As a result, it creates a nonlinear combination of selected features used in data classification [15].

IV. DATA SET

In our experimental analysis, a data set that is accessible to everyone was used and the classification process was applied on three different classes. The entire dataset is X-ray images and each image has been converted to PNG format. Since Covid-19 is a new disease, the number of images related to this virus is limited. This study was conducted using the data set shared by a researcher named Tawsifur Rahman via the Kaggle website [16].

There are three classes in the dataset, namely the Covid class with X-ray images of Covid-19 patients, the Normal class with normal X-ray images, and the Viral class with the Viral Pneumonia X-ray images. In the data set, Covid-19, Normal, Viral classes are 1143, 1341 and 1345 data, respectively, and the total number of data is 3829. In the experimental analysis, 80% of the data set was used as training data and 20% as test data. Some samples for each class are shown in Fig. 1.

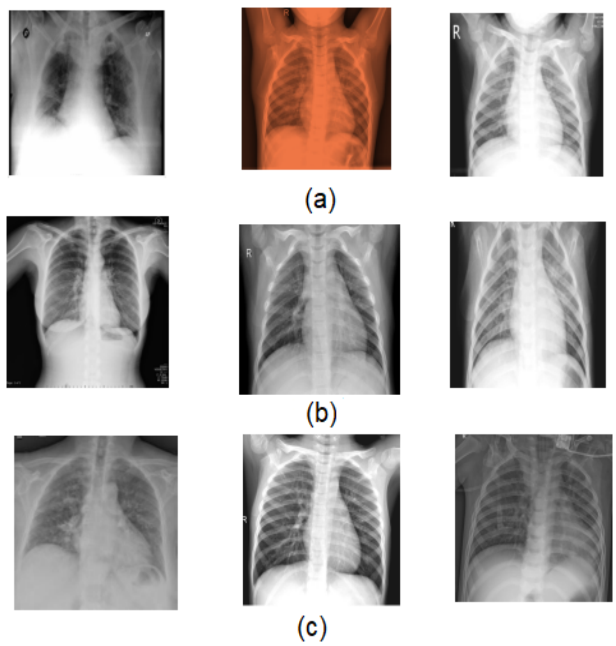

Fig. 1 Sample images used in this study. (a) Covid-19 cases (b) Normal cases (c) Viral Pneumonia cases.

V. PROPOSED METHOD

The CNN is used to classify the input images into three different classes as mentioned above. The CNN architecture used in the study is show in Fig. 2. As a processing step, we first resized all images to a fixez size 64x64 so that the model can input the images of same dimension. It also helped process every image with less time.

The layer structure of the CNN model is as follows and the operations started with the filter created in the Convolutional layer with a size of 11x11. Relu activation function is used in for each layer. For the last layer, Softmax activation function was used in the dense fully connected layer.

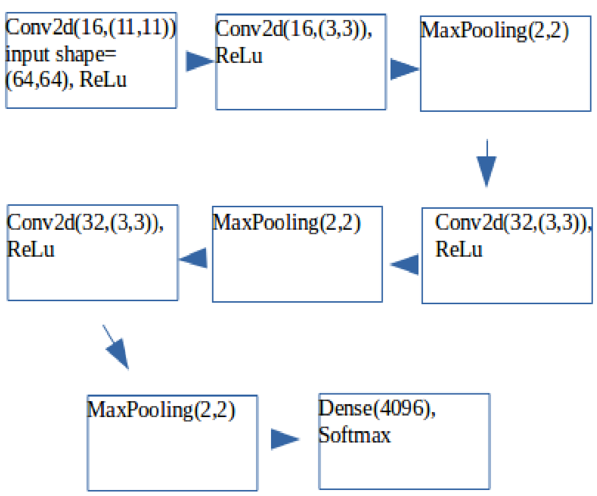

Figure 2 :Architecture of the CNN model used in the study

VI. EXPERIMENTAL RESULTS

A. Experimental setup

For the experimental purposes, the data set was divided into training (80%) and testing (20%) subsets. During the training, hyperparameters were also obtained that produced optimal results for CNN architecture such number of layers and batch size. Moreover, the experiments were run in Matlab © Environment with a processor of 2.7 GHz speed, RAM 16 GB and CPU.

B. Metric Calculation

The proposed method was evaluated using four different metrics: Accuracy (Acc), Precision (P), Recall (R) and F1-score. These metrics are defined as:

Accuracy: It is the value calculated by the ratio of correctly predicted areas in the model to the total data set. Recall: Positive is a metric value that shows how much of the transactions that need to be predicted as Positive. Precision: It is the value showing how many of the values predicted as Positive are actually Positive. F1-Score: It is the value showing the harmonic average of the Precision and Recall values.

Accuracy: TN+TP/TP+TN+FN+FP (1)

Recall: TP/TP+FN (2)

Precision: TP/TP+FP (3)

*F1-Score: 2*Precision*Recall / Precision+ Recall* (4)

C. Evaluation

Three different optimizers tested to see which optimizer performs best on the data set used in this study for three different class identification. The purpose of this is to obtain the result with the best accuracy value. Optimizers used are Adam, Adadelta and SGD optimizers. The overall results obtained for our experiments are summarized in Table I. The best optimizer in the study was Adam optimizer with 95.9% accuracy. The accuracy values of Adadelta and SGD optimizers are 95.4% and 92.1%, respectively.

Accuracy and error graphs of the results obtained from three different optimizers used in this study are shown in Fig. 4 - 8. The accuracy and error charts of Adam optimizer, which is the first optimizer used in the study, are given in Fig. 3 and Fig. 4 respectively. For the Adam optimizer, Accuracy: 95.9, Precision: 96, Recall: 96 and F1-Score: 96.

The accuracy and error graphs of Adadelta optimizer, which is the second optimizer used in the study, are given in Fig. 5 and Fig. 6 respectively. For Adadelta optimizer, Accuracy: 95.4, Precision: 95, Recall: 96 and F1-Score: 95.

The accuracy and error graphs of SGD optimizer, which is the last optimizer used in the study, are given in Fig. 7 and Fig 8, respectively. For SGD optimizer, Accuracy: 92.1, Precision: 92, Recall: 92 and F1-Score: 92.

TABLE I: THE OVERALL RESULTS OBTAINED FOR CNN (%)

Optimizer	Data	Classes	Acc	P	R	F1
Adam	X-ray images	3	**95.9**	96	96	96
Adadelta			95.4	95	96	95
SGD			92.1	92	92	92

*Acc = Accuracy, P = Precision, R = Recall, f1 = F1-score

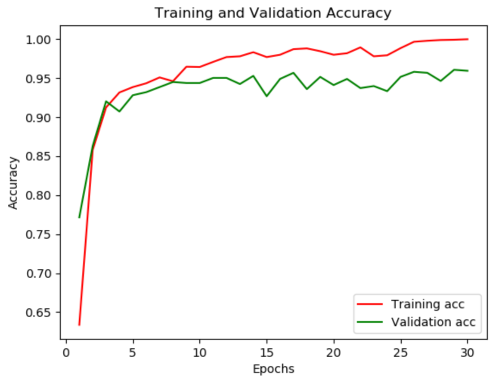

Figure 3: Adam optimizer accuracy graphs

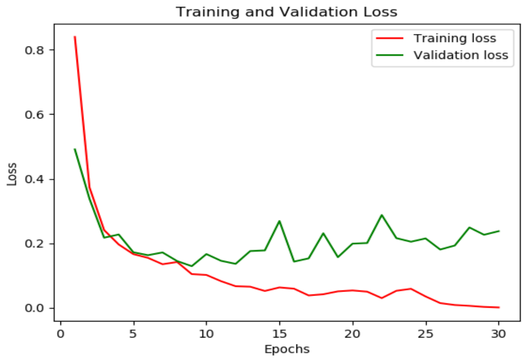

Figure 4: Adam optimizer error graphs

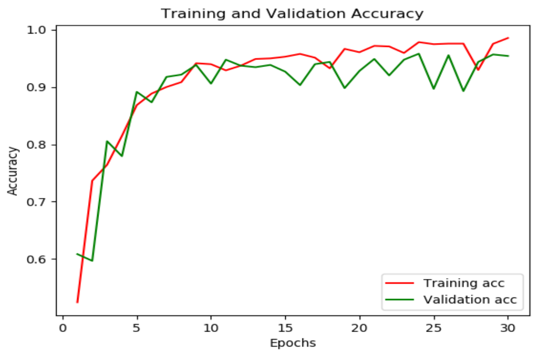

Figure 5: Adadelta optimizer accuracy graphs

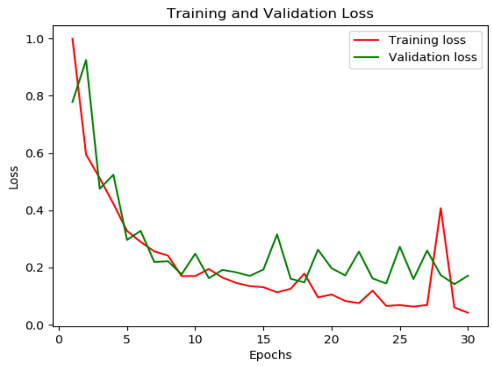

Figure 6: Adadelta optimizer error graphs

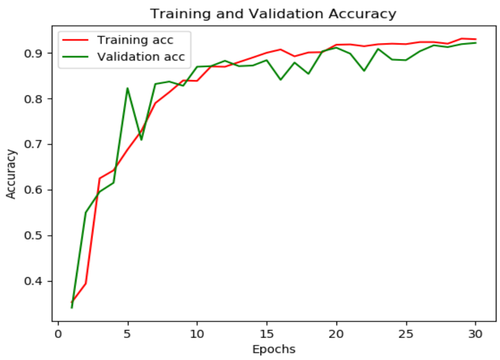

Figure 7: SGD optimizer accuracy graphs

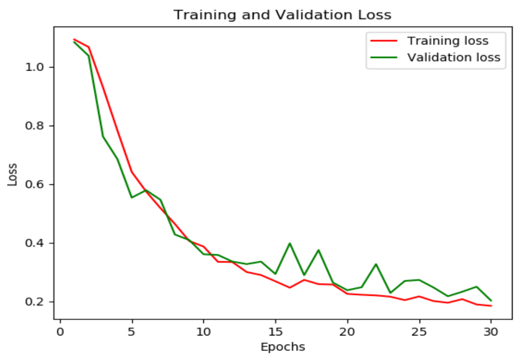

Figure 8: SGD optimizer error graphs

TABLE II :COMPARATIVE ANALYSIS OF PROPOSED METHOD WITH STATE OF THE ART TECHNIQUES FOR COVID-19 CLASSIFICATION FROM X-RAY IMAGES

Ref	Model/Method Type		Data Type	Class	Acc	P	R	F1-score
[8]	CNN-based Deep Convolutional CAPSNET		X-ray images	2	97.23	97.08	-	97.24
				3	84.22	84.61	-	84.21
[9]	Pretrained Xception-based Deep CNN CoroNet		X-ray images	2	99	98.3	99.3	98.5
				3	95	95	96.9	95.6
				4	89.6	90	89.92	89.8
[10]	Transferable multi-receptive features optimizer with Deep CNN-based CovXNet		X-ray images	2	98.1	98	92.83	98.5
				3	95.1	94.9	90.3	95.5
				4	91.7	92.9	89.9	92.6
Recommended	CNN	Adam	X-ray images	3	95.9	96	96	96
		Adadelta			95.4	95	96	95
		SGD			92.1	92	92	92

VII. CONCLUSION

In this study, we propose the CNN model, which is an important deep learning model for classifying the diagnosis of Covid-19 disease using chest x-rays. Classification processes were carried out on X-ray images of Covid, Normal and Viral classes with the proposed CNN model. The data set used in the study was divided into two as 80% training and 20% test data. During the training, the epoch value was determined as 30. The results obtained in the study have been tested for different optimizers of the CNN method. These are Adam, Adadelta and SGD optimizers and their accuracy values were found to be 95.9, 95.4 and 92.1, respectively. As a result of the comparison of the classification studies on three classes in the reference studies and our study, it is seen that the highest accuracy value was obtained with the architecture of the CNN model, which we recommend. Considering these results, it has been concluded that the subject and the study are worth improving.

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