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COVID-19 DETECTION USING CHEST X RAYS

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ABSTRACT: Coronavirus disease 2019 (COVID-19) is a highly contagious disease that has claimed the lives of millions of people worldwide in the last 2 years. Because of the disease's rapid spread, it is critical to diagnose it at an early stage in order to reduce the rate of spread. The images of the lungs are used to diagnose this infection. In the last 2 years, many studies have been introduced to help with the diagnosis of COVID-19 from chest X-Ray images. Because all researchers are looking for a quick method to diagnose this virus, deep learning-based computer controlled techniques are more suitable as a second opinion for radiologists. In this article, we look at the issue of multisource fusion and redundant features. We proposed a CNN-LSTM and improved max value features optimization framework for COVID-19 classification to address these issues. The original images are acquired and the contrast is increased using a combination of filtering algorithms in the proposed architecture. The dataset is then augmented to increase its size, which is then used to train two deep learning networks called Modified EfficientNet B0 and CNN-LSTM. Both networks are built from scratch and extract information from the deep layers. Following the extraction of features, the serial based maximum value fusion technique is proposed to combine the best information of both deep models. However, a few redundant information is also noted; therefore, an improved max value based moth flame optimization algorithm is proposed. Through this algorithm, the best features are selected and finally classified through machine learning classifiers. The experimental process was conducted on three publically available datasets and achieved improved accuracy than the existing techniques. Moreover, the classifiers based comparison is also conducted and the cubic support vector machine gives better accuracy.

1. INTRODUCTION

In December 2019, Wuhan, Hubei Province, China, became the epicenter of

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an unknown-cause pneumonia epidemic, attracting national and international attention (1). The current outbreak of coronavirus disease 2019 (COVID-19), a coronavirus-associated acute respiratory illness, is the third worldwide pandemic in less than two decades (2). The COVID-19 sickness is caused by the SARS-CoV-2 virus (3). In severe cases, this illness can cause organ failure and breathing difficulties. Aside from the medical consequences, the disease had a massive economic and environmental impact on the world (4, 5). Coronavirus disease 2019 detection methods include nucleic acid-based assays and polymerase chain reaction (PCR). The traditional real-time polymerase chain reaction (RT-PCR) method of COVID-19 detection is time-consuming (6). Artificial intelligence (AI) technologies have been widely used to combat the COVID-19 outbreak and its complications. To identify the COVID-19 instance based on the X-ray images, an automation method is required. It is the least expensive process when compared to the COVID-19 test. Human examination of these photographs, on the other hand, is a difficult and time-consuming task. For accurate classification, an expert physician is always required. As a result, it is critical to find these photos as soon as possible using a reliable method. In clinics, computerized approaches assist radiologists in confirming their subjective results and detecting COVID-19 (7).

The AI-based estimation methods rely on data from the patient's symptoms. A person infected with the coronavirus usually exhibits no signs or symptoms. As a result, identifying an infectious individual is extremely difficult (8). Traditional feature-based approaches and deep learning-based techniques are the two categories of AI-based techniques. Traditional features-based algorithms include some preprocessing procedures, handcrafted features (such as shape, texture, and geometric characteristics), removal of extraneous features, and classification. In deep learning architectures, raw photos are fed into convolutional neural network (CNN) models, which extract features from convolution layers and perform classification using the fully connected layers. Following that, a few researchers used feature optimization methods to select the best features before classifying them with the Softmax classifier. Using deep learning (DL), several techniques are introduced for COVID-19 diagnosis and classification using chest X-rays and CT images (9–15). Additionally, CNN models are useful in the deployment of sophisticated COVID-19 pneumonia detection systems (16). Numerous strategies for identifying COVID-19 have been presented, all of which make use of deep CNN features and generate more precise findings than manual feature-based methods (17). In a few studies, the researchers focused on feature fusion techniques to get better information about an image. They fused features from different sources into one feature matrix. Özkaay et al. (18) fused deep features for COVID-19 classification using the feature ranking method. Shankar et al. (19) introduced an entropy based handcrafted and deep features fusion approach for better classification of COVID-19. Ragab et al. (20) combined several features based on concatenated fashion. These techniques performed well in terms of accuracy but on the other side, the computational time is significantly increased. Few researchers introduced feature reduction techniques to resolve the problem of high computational time but the reduction process decreases in accuracy due to dropping some important features (21, 22). Feature selection is an important research area nowadays and many techniques are introduced in the literature. As compared to features reduction techniques, the feature selection technique is the process of subset selection from the originally extracted features instead of generating new features. The purpose of feature selection techniques is to reduce the computational time by selecting only important features based on some selection criteria or fitness function. A few important feature selection techniques are- genetic algorithm based selection, particle swarm optimization based selection, entropy based selection, bee colony optimization based selection, and many more (23). In recent years, many research works have been done for the detection and classification of COVID-19 in X-ray and CT-scan images (24). They followed some traditional techniques and showed improved accuracy (25); however, COVID-19 patients are increasing day by day worldwide. A lot of data has been generated in the form of Chest X-ray and CT images that are not feasible for classification through traditional techniques. The traditional techniques work better for the smaller datasets but for the large datasets, accuracy is degraded (26). Based on this reason, it is room for improving the accuracy through the development of deep learning architectures. In this article, we proposed a new architecture based on deep learning and improved moth flame optimization for COVID-19 classification. Our major contributions are as follows:

• A contrast enhancement technique is proposed based on the fusion of the output of local and global filters. The resultant enhanced image is further utilized for the augmentation process.

• Proposed a CNN-LSTM architecture and trained it using deep transfer learning from scratch instead of freezing a few layers.

• Proposed a new features fusion technique named Serial based Maximum Information.

• An improved max value based moth flame optimization algorithm is proposed for best features selection.

LITERATURE REVIEW

Many computerized techniques have been introduced for COVID-19 in recent years by researchers of computer vision (27). Several researchers focused on traditional techniques and few of them using deep learning architectures for the detection and classification of COVID-19 from chest X-ray images. Ibrahim et al. (28) presented a deep learning method for multiclass classification problems such as COVID-19, pneumonia, and normal. They used a pre-trained CNN model named AlexNet and trained it on selected COVID-19 datasets. They considered the problems of both binary and multiclass and achieved accuracies of 94.43, 98.19, and 95.78%, respectively. The limitation of this study was the lack of data for training. Ismael and Sengür (24) presented a deep-learning-based technique for classifying COVID-19 and normal (healthy) chest X-ray images. They followed some sequential steps including deep feature extraction, fine-tuning of pre-trained CNNs, and end-to-end training of a fine-tuned CNN model. Three pre-trained CNN models were used for the training and feature extraction such as ResNet18, VGG16, and VGG19. The extracted deep features were finally classified using the Support Vector Machines (SVM) classifier. The fine-tuned ResNet50 deep model gives better accuracy of 92.60% than the other methods. The drawback of this method was less number of training samples. Ketu and Mishra (29) introduced a CNN-LSTM deep learning model that can accurately detect the COVID-19 infection. The proposed approach extracts useful information from the convolutional layers. Later on, the Long short-term memory (LSTM) network is designed to extract features that are fused with CNN features. The limitation of the presented method was the reliability and suitability of the model to the other series of data. Nivetha et al. (30) presented a new classification technique for COVID-19 based on Neighborhood Rough Neural Network Algorithm (NRNN). The presented method performed better than existing algorithms like Backpropagation Neural Network

(BNN), Decision Tree, and Naive Bayes Classifiers. The accuracies of NRNN were 98, 92, 100, and 100% which was significantly better than other methods. Moreover, NRNN consumes less amount of training data compared to the existing methods. Shastri et al. (31) introduced a novel neural network based framework for COVID-19 classification. They used ChestXImageNet CNN model for the classification purpose and tested on the open-access dataset that consisted of both binary classes and multiclass and achieved accuracies of 100 and 100%, respectively. Khan et al. (32) described a deep learning technique in which they used three pre-trained models named EfficientNet B1, NasNetMobile, and MobileNetV2. Before training deep models, they performed data augmentation. Moreover, they optimized hyper-parameters for improving accuracy. The described model achieved 96.13% accuracy which was better than the existing methods. The limitation of described work was the use of high-weighted models that required high time for computation.

Imagawa et al. (33) presented a hybrid framework for the classification of COVID-19 images. They used two pre-trained deep learning models named-AlexNet and ResNet34 with and without transfer learning. On both fine-tuned models, classification is performed and attained improved accuracy. Falco et al. (34) designed another evolutionary algorithm based approach for COVID-19 classification. Sarki et al. (35) developed a deep learning system for the classification and valid detection of coronavirus using chest images. They evaluated the traditional networks and also developed a CNN from scratch and trained on the binary class and multiclass based datasets. Öztürk et al. (36) designed a machine learning method for the classification of viral epidemics by analyzing chest X-ray images and CT images. They applied hand-crafted feature extraction to make the data more convenient and optimized the features by using stacked auto-encoder and principal component analysis techniques. Al-Zubaidi et al. (37) applied CNNs for the classification of COVID-19 images. They used Google-Net for training and extracting automated features from the images. The above methods have several gaps such as—not performing well on imbalanced datasets and increasing higher computational time. Shazia et al. (38) presented a neural network based system for COVID-19 detection from Chest X-Ray images. They used three pre-trained models and fine-tuned them. The fine-tuned models have been trained through transfer learning and obtained improved accuracy. Shazia et al. (39) presented a

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comparative study of several deep learning models for COVID-19 classification from Chest X-Ray images. They used seven pre-trained deep models such as VGG16 and ResNet50 and named a few more and attained a classification accuracy of 99.48%. Joloudari et al. (40) combined the CNN model with a global feature extractor for the classification of COVID-19 infected and healthy patients. They used 10-fold cross-validation and obtained an accuracy of 96.71%.

IMPLEMENTATION

CNNs

In recent years, deep convolutional neural networks have been widely used in the field of computer vision, and its basic structure is shown in Figure 1. In view of the brand-new techniques such as ReLU [20], LRN [20], and Dropout [21], AlexNet [22] designed by Hintion and AlexKrizhevsky won the championship in 2012 ImageNet Challenge, with excellent performance. At the same time, AlexNet reduces the problem of network overfitting and enhances the generalization ability of the model. In 2014, Simonyan and Zisserman proposed the visual geometry group network (VGGNet) [14], which increased the network depth to 19 layers by alternately using 3×3 convolution kernels and 2×2 maximum pooling layers, significantly improving the network performance. Christian Szegedy et al. [23] designed the Inception module and constructed the GoogLeNet network based on this module. By increasing the width and depth, GoogLeNet also improves the utilization of the internal resources of the network and alleviates the problem of overfitting to a certain extent.

Increasing the network depth can improve network performance, but it can also cause some problems such as overfitting, network degradation, gradient disappearance, and gradient explosion. In 2015, He et al. [12] proposed the residual network named ResNet, which solved the degradation problem of the network through skip connection and increased the network depth to 1000 layers for the first time, making the deep convolutional neural network reach an unprecedented depth. Inspired by the residual network, the dense network named DenseNet was proposed by Huang et al. [24] in 2017 based on the idea of dense connections. By directly introducing short connections in any two layers to realize the reuse of features, it greatly reduces the amount of network parameters and effectively alleviates the problem of gradient disappearance of deep network.

CONCLUSIONS AND FUTURE WORK

In this paper, a Parallel Channel Attention Feature Fusion (PCAF) module is designed according to the characteristics of

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CXR images. And based on this module, a new convolutional neural network structure MCFF-Net is proposed to classify CXR images in order to diagnose and detect COVID-19 cases. Through the analysis and comparison of the experimental results, we believe that MCFF-Net66-Conv1-GAP has the highest application value. The overall accuracy of the 4-class classification experiment and the COVID-19 image recognition accuracy have reached 94.66% and 100%, respectively. Despite the fact that good results have been achieved, MCFF-Net still needs clinical research and testing. We will overcome the limitations of hardware conditions and train the MCFF-Net with a larger dataset to further improve its classification accuracy.

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