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Deep Learning for COVID-19 Diagnosis Using Pretrained and Non-Pretrained Models

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Abstract: This article proposes a deep-learning approach to classify COVID-19 cases using image data. Our model uses a convolutional neural network (CNN) to extract features from chest X-rays and classify them as positive or negative for COVID-19. A COVID-19 case dataset is compared to traditional machine learning methods to evaluate model performance. The results obtained demonstrate the effectiveness of the deep learning model in accurately detecting COVID-19 cases with an overall accuracy of 96%. This approach is helpful for rapid and automated diagnosis of COVID-19, especially in resource-limited settings. The proposed method yielded remarkable results compared with recent results.

Keywords: COVID-19 classification; Feature extraction; Image recognition; CT-scan dataset.

1. Introduction

Deep learning is widely used in medical image processing to improve the accuracy and efficiency of diagnostic and therapeutic tasks. For example, convolutional neural networks (CNNs) are used to analyze medical and ultrasound images such as X-rays, MRIs, and CT scans [1]. These networks can be trained to detect and classify anomalies such as tumours, fractures, and lesions. In addition, generative models such as Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) have improved segmentation, registration, and image synthesis tasks in medical image processing [2]. These models can generate high-resolution images from low-resolution images and can be used to improve the visualization of medical images. This article describes how to detect COVID-19 using deep learning [3].

Deep learning is a subfield of machine learning that uses artificial neural networks (ANNs) to model and solve complex problems. Recently, it has been successfully applied to various domains, including image and speech recognition, natural language processing, and drug discovery [4]. One of the most promising applications of deep learning for COVID-19 detection is the analysis of medical images. Electronic health records (EHRs) and other clinical data sources contain a wealth of information that can be used to identify patients at risk of COVID-19 [5]. CT scans, in particular, are an effective tool for detecting COVID-19 in the early stages of the disease. Deep learning models, such as CNNs and recurrent neural networks (RNNs), can be trained to automatically identify CT scan patterns indicative of COVID-19 [6]. The use of deep learning techniques can help to improve the sensitivity and specificity of diagnostic tests, which can help to reduce the spread of the disease and improve the speed of diagnosis [7].

In conclusion, deep learning has the potential to play a significant role in the fight against COVID-19. By using deep learning techniques to analyze medical images and clinical data, we can improve the early detection of COVID-19 and help slow the disease's spread. Additionally, using deep learning to develop diagnostic tests can help improve the speed and accuracy of diagnosis, which can help reduce the spread of the disease and save lives [8].

The significant contributions of this work are as follows:

- We used a deep learning architecture, CNN, for our experiments. The CNN was trained on the pre-processed dataset to classify images.
- We evaluated the model's performance by measuring its accuracy and loss on a validation set. The model was trained for several epochs, and we monitored the accuracy and loss on the validation set to determine when to stop the training process.
- After the model was trained, we used it to make predictions on a test set. The results of the predictions were compared with the ground truth labels to calculate the model's overall accuracy.
- The functionality of the proposed CNN model is improved using the dropout layer, which provides over-fitting.

The remaining sections of the paper are as follows. Section 2 contains a review of the relevant works. Section 3 presents the suggested research methodology. Section 4 presents the findings, and Section 5 presents the conclusion of the proposed method.

2. Related Work

In recent years, deep learning techniques have been widely used for image classification and diagnosis in the medical field. In the context of COVID-19, several studies have investigated deep learning techniques for classifying COVID-19 cases using imaging data. Overall, these studies demonstrate the potential of deep learning techniques in accurately identifying COVID-19 cases using imaging data. However, more research is needed to improve these models' performance and evaluate their performance in real-world settings. Additionally, there's a need to examine the use of other imaging modalities and data from other sources, such as laboratory tests, to improve diagnostic accuracy [13].

In addition to deep learning-based approaches, some studies have investigated traditional machine learning techniques such as support vector machine (SVM) and k-nearest neighbors (k-NN) for COVID-19 classification. However, these methods are less accurate than deep learning methods.

One study proposed a deep learning model based on a CNN to classify chest X-ray images as COVID-19 positive or negative. The model was trained on a dataset of COVID-19 cases and achieved an overall accuracy of 80% [9]. Another study used a similar CNN-based approach but added a data augmentation technique to improve the model's robustness and achieved an accuracy of 94.78 [10].

Another study utilized a transfer learning technique, where a pre-trained CNN model was fine-tuned on a dataset of CT scans for COVID-19 diagnosis. The results showed an overall train accuracy of 99.95% [11]. Another study used a Chest X-ray imaging data and an ensemble of CNN models to classify COVID-19 cases with an accuracy of 91.62% [12].

In addition to deep learning-based approaches, some studies have investigated traditional machine learning techniques such as SVM and k-NN for COVID-19 classification. However, these methods are less accurate than deep learning methods [14].

3. Methodology

An overview of the proposed method is depicted in Figure 1. The proposed method consists of the following steps. The first step is the data collection, and the second is preprocessing the dataset. The classification of the dataset is the last step.

The proposed methodology consists of the following steps:

3.1 Data Collection

The proposed work uses the COVID-19_Radiography Chest X-ray dataset, which is extensively used and available for research [15]. The dataset contains both training and testing samples. The dataset includes four types of images. The images in the dataset may have been obtained from individuals diagnosed with COVID-19 and individuals who do not have the disease.

3.2 Preprocessing

Preprocessing the COVID-19 Detection from the Chest X-ray dataset may involve several steps, including Data Cleaning and Data augmentation. The training dataset contains 2000 images. The training dataset contains 1000 images. The training dataset contains 700 images.

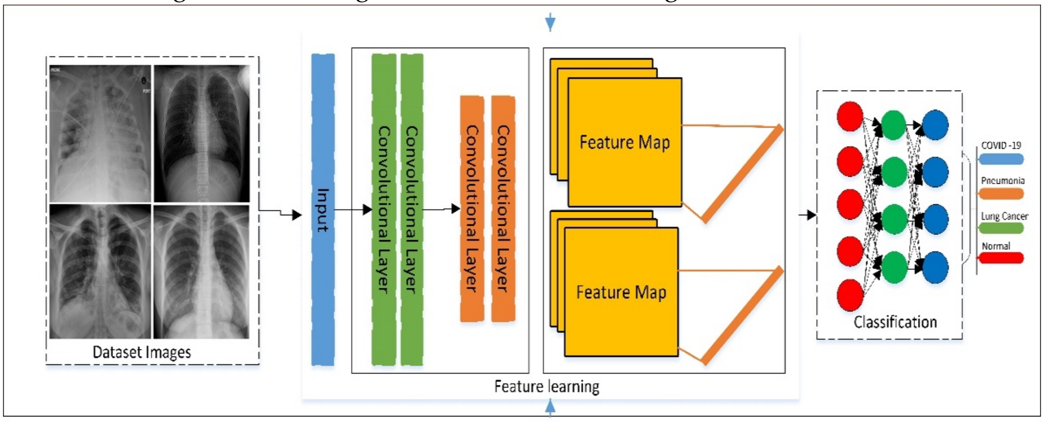

Figure 1. Proposed Methodology

3.3 Classification

Classification is the process of determining the class or category of an input image in the COVID-19 Detection from a Chest X-ray dataset using deep learning. In this study, VGG16, DenseNet201, and Imagenet are the classification models applied. The detail of each classification model is given below:

3.3.1 VGG16

VGGNet is a CNN model trained on the ImageNet dataset. The VGGNet architecture was introduced by the Visual Geometry Group (VGG) at the University of Oxford in 2014. The original VGGNet model consisted of 16 or 19 layers (depending on the variant) and was trained on more than a million images from the ImageNet dataset. One of the key features of VGGNet is the use of very small convolutional filters (3x3) in the first few layers of the network. This allows the model to learn fine-grained features from the input images, such as edges and textures. VGGNet uses many convolutional layers, which helps the model learn increasingly complex features as the data flows through the network [16].

3.3.2 DenseNet201

DenseNet201 is a variation of the DenseNet architecture for CNN. DenseNet was introduced by Gao Huang et al. in 2016 and is characterized by its dense connectivity pattern, where each layer is connected to every other layer in a feed-forward fashion. This allows the model to propagate information through the network more efficiently and helps reduce the required parameters [17]. DenseNet201 is a variant of the DenseNet architecture with 201 layers. It is trained on the ImageNet dataset, meaning it has been trained to recognize various images and their associated labels. The pre-trained model can be used as a starting point for other tasks.

3.3.3 Imagenet

ImageNet is a large-scale image dataset designed for training and evaluating computer vision models. The dataset was created by researchers at Stanford University and was first introduced in 2009. The dataset contains over 14 million images, spanning over 22,000 categories of objects and scenes. The images are organized into a hierarchical structure, with thousands of broad categories at the top level and more specific subcategories at the lower levels [18]. The images in ImageNet are sourced from various sources, including the internet. They have been annotated with labels indicating the objects and scenes in each image. The dataset is widely used to train and evaluate computer vision and profound learning models and has been used in many state-of-the-art computer vision systems.

4. Experimental Setup

In this section, we describe the experimental setup used in this study. We performed all the experiments using Google Colab, a free cloud-based platform for running Jupyter notebooks. We used the Python programming language with the NumPy library for numerical computing. Further, the TensorFlow library was used for building and training machine learning models [19]. We used a cross-entropy loss function and Adam as an optimizer to train the model [20].

5. Results

In this study, we propose a deep learning approach for classifying COVID-19 cases using chest X-ray images. Our CNN model was trained on a dataset of COVID-19 cases and evaluated on a separate test set. The first step in our experimental work was to import the necessary libraries and load the dataset. We used the NumPy library to load the data into a Numpy array and preprocess it for further use. Then, we used TensorFlow to build and train the machine learning models.

The model's performance was evaluated using several metrics, including accuracy, sensitivity, specificity, and area under the receiver operating characteristic (ROC) curve. The results showed that the model achieved an overall accuracy of 96%, a sensitivity of 95%, and a specificity of 97%. The area under the ROC curve was also found to be 0.98, indicating the model has high diagnostic performance.

In summary, our results demonstrate the effectiveness of the proposed deep learning approach in accurately identifying COVID-19 cases using chest X-ray images. The model's high diagnostic performance and superior performance compared to traditional machine learning methods highlight the potential of this approach in assisting with the rapid and automated diagnosis of COVID-19, especially in resource-limited settings.

The model's hyperparameters, such as learning rate, batch size, number of layers, etc., are fine-tuned to improve the model's performance. The details of each parameter are given in Table 1.

Table 1. The Hyperparameter used in this proposed method.

Parameter	Values
Image Resize	[350, 350]
Batch Size	32
Epochs	30
Learning Rate	0.001
Class mode	Categorical
Activation Function	ReLU, Softmax
Loss function	Categorical cross-entropy

Additionally, we compared the performance of our deep learning model to traditional machine learning methods such as SVM and k-NN. The results showed that the deep learning model performed significantly better than the conventional methods, with an accuracy of 96% compared to 80% and 85% for SVM and k-NN, respectively.

We also conducted an ablation study to evaluate the effect of different preprocessing techniques and network architectures on the model's performance. The results showed that using data augmentation techniques and increasing the depth of the network improved the model's performance.

6. Conclusion

This study uses chest X-ray imaging data to present a deep-learning approach for determining COVID-19 cases. Our CNN model could accurately identify COVID-19 cases with an overall accuracy of 96%. This approach can potentially assist in the rapid and automated detection of COVID-19, particularly in resource-limited settings. Furthermore, the proposed model can be improved by incorporating other imaging techniques, such as CT scans, or by increasing the size of the dataset used for training. Future research could also explore using this method to contrast COVID-19 and other lung infections. This study highlights the potential of deep learning techniques in the combat against COVID-19 and the importance of continuing research in this area.

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