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Classification of pneumonia caused by Covid-19 based on deep learning model

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Abstract. With the unexpected spread of Covid-19 in 2019, such disease took away millions of people's lives. Therefore, investigating and curing Covid-19 become a very mandatory issue in different areas, such as biology, medicine, and statistics. This paper investigates different models of CNN in deep learning of computers in analyzing X-ray pictures of normal pneumonia and Covid-19 caused pneumonia patients. The database is from Kaggle and contains over 8000 images of X-rays of the chest. Besides, this paper discusses the imaging process technology, such as ConvNeXt, to edit X-ray images more convenient for computers to analyze and dispose of. According to the comparison of the sequential model and DenseNet model in CNN, the sequential model has better performance and accuracy. In the conclusion part, this paper also investigates whether better image processing work can improve the performance of models. Overall, these results shed light on guiding further exploration of both analyzing and distinguishing Covid-19 patients and normal pneumonia patients in order to decrease the work of hospitals and cure different patients in time.

Keywords: Deep Learning, Covid-19, CNN model.

1. Introduction

Covid-19 has been an epidemic since 2019 and influenced millions of people living on earth. During the history of viruses, there are many other kinds of viruses, like SARS, MERS and Flu, but none of them has a similar duration and range of Covid-19. Since 2019, research on Covid-19 appeared at an explosive rate, such as the invention of vaccines, the prediction of pneumonia caused by Covid-19, drugs caring for Covid-19, etc. With the development of technology, different and efficient prediction methods were created for patients: X-ray images can let doctors know where the disease is; and plasma therapy can be used to cure disease, but there has not an exact solution to predict this disease.

With the development of AI learning, like machine learning and deep learning, such technology improved the detecting speed and accuracy and decreased the cost of diagnostics. Since Covid-19 will infect people with breathing in the air, from almost everywhere that people can breathe, it is necessary for hospitals to distinguish between infected patients and normal patients. One serious case occurred in the United Kingdom at Queen Alexandra Hospital. Since almost all chest X-rays of patients, over 20,000 pictures, were not formally reviewed by radiologists or clinicians, three lung cancer patients suffered significant harm because their X-rays were not properly assessed [1].

In the field of computer vision, deep learning has shown its ability to classify images with superhuman accuracy and speed. In addition, deep learning is being explored vividly in the field of

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medical image processing. Therefore, CT (Computerized Tomography) technology can help hospitals to scan healthy people and Covid-19 infected patients and create data for analyzation. Starting in March 2020, different organizations, such as hospitals or governments, upload their data online in different repositories, such as Kaggle or Github, for the public to analyze the differences between healthy people and Covid-19 patients [2,3]. The main purpose of this work is to classify chest X-ray images of patients infected with coronavirus by using CNN model. By comparing and drawing analogies with early work in this field, there will be more potential and accurate models of analyzing chest X-rays of normal patients and Covid-19 patients to prove their usefulness.

The motivation of this paper is aimed to find a more efficient and accurate model to classify the Covid-19 patients' and normal pneumonia patients' Chest X-ray. This paper discusses different CNN models for classifying chest X-ray scans, such as the Sequential model and DenseNet model.

2. Methodology

This section will provide information of classifying Covid-19 patients and normal patients. Making models for distinguishing different X-rays always needs a large database that contains both normal lungs and infected lungs. In this model, one of the challenges with working with medical diagnostic datasets is the large class imbalance present in such datasets. Therefore, the management of missing data is mandatory. The loss function can be expressed as:

$$L_{cross-entropy}(x_i) = -(y_i \log(f(x_i)) + (1 - y_i) \log(1 - f(x_i))) \quad (1)$$

When the data is unbalanced, using the normal loss function will cause the model to be biased towards the dominant class. The solution given is to use the weighted loss function:

$$L^w{}_{cross-entropy}(x_i) = -(w_p y \, log(f(x_i)) + w_n(1 - y_i) \, log(1 - f(x_i))) \quad (2)$$

Where w_p and w_n represent the positive weighted and negative weighted in the database. The model used to classify X-ray pictures is CNN (Convolutional Neural Networks) model, which is introduced at the 1980s. The convolutional layer uses neurons that are only connected to a small "receptive field" of the previous layer. These neurons are applied to different regions of the previous layer, operating as sliding Windows on all regions and efficiently detecting the same local pattern at each location. This preserves spatial information and shares the learned weights.

3. Data Analysis

3.1. Data Description

Deep learning relies on large amounts of annotated data. The digitization of radiology workflows enables medical organizations to organize and classify large amounts of digital images. Kaggle provides this dataset, which contains chest X-rays from both Covid-19 patients and normal pneumonia patients from Guangzhou Women and Children's Medical Center. There is a total of 5863 images in this dataset, which are divided into normal and pneumonia training sets, test sets, and validation sets. In the training set, 1,341 were normal and 3,875 were pneumonia. For the analysis of chest X-ray images, all chest X-rays are first quality controlled by removing all low-quality or unreadable scans. The images were then scored for diagnosis by two expert doctors, which were then approved for use in training the AI system.

3.2. Data Processing

However, with normal X-ray pictures, the distribution of pixels is not good enough for the computer to compute. In this case, each image was resized to 320 × 320 pixels without preserving the aspect ratio, which is called normalization of data. Normalization of data is an essential step and is often used to maintain numerical stability in the CNN architecture. As shown in Figure 1, the distribution of pixels is very decentralized, which has a large variance. Figure 2 shows the distribution of pixels after normalization, which leads to 0 variance. By normalization, the CNN model may learn faster, and gradient descent is more likely to be stable [4]. Therefore, in this study, the pixel values of the input

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images were normalized in the range of 0-1. The images used in the considered dataset are grayscale images, rescaled 320 × 320 with pixel values.

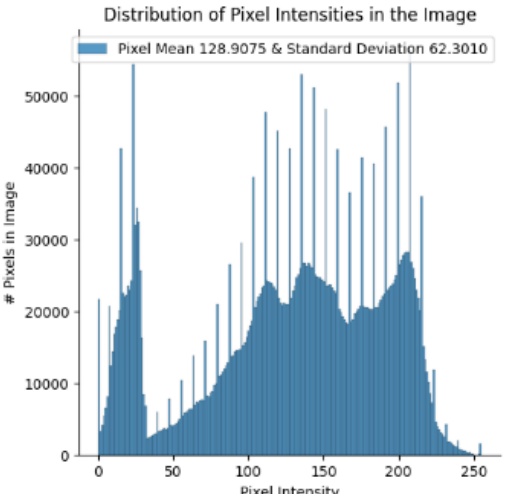


Figure 1. Distribution of Pixel Intensities in the Image (before normalization)

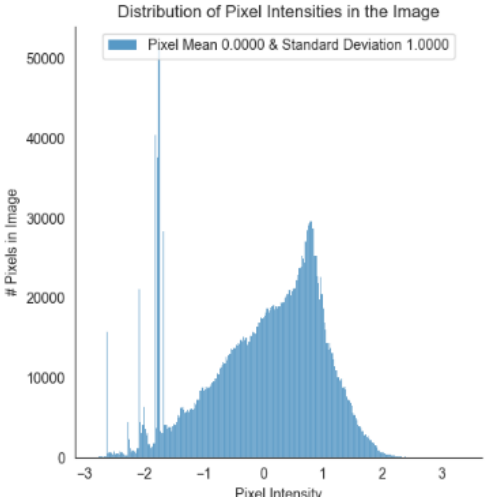


Figure 2. Distribution of Pixel Intensities in the Image (after normalization)

4. Experimental Settings

In this project, the CNN model is created by the Sequential model from Keras model packages. This layer creates a convolution kernel that is convolved with the layer input to produce a tensor of output. If use_bias is True, a bias vector is created and added to the outputs. Finally, if activation is not None, it is applied to the outputs as well. Besides, set filters to 32, 64, and 128 to illustrate different performances of different dimensions of output space. After comparing different activations, 'relu' activation has the best performance.

In addition to improving the accuracy of models, DenseNet also is putted into testing models. DenseNet is a convolutional network, in which layers are connected to all other deeper layers, but are not connected to the previous layers. For example, 2nd layer will not be connected to 1st layer, but will be connected to 3rd, 4th, and deeper layers. By comparing the results of the Sequential model and the DenseNet model, will make the performance of this model better to analyze Chest X-ray of normal pneumonia patients and Covid-19 patients.

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5. Experimental Results and Discussion

To evaluate generalization performance, we performed 10 resampling scenarios 100. The dataset is divided into 80% training data to train the model, 15% testing data to test model's accuracy, and 5% validation data for validation accuracy. When using deep learning, hyperparameters and tuning without verification sets and/or cross-validation can easily lead to overfitting. This model estimates and recalculates the average loss of validation of all samples to identify the best CNN model. At last, these results will be calculated for each fold of tests and get the average of all results. Figure 3 shows that the more dimensions the model has, the less loss it will be. Figure 4 shows the accuracy's evolution with large dimensions.

The first CNN model created using the performance of the sequential model has an accuracy of around 85%. The larger the dimensions of the model, the better the performance. The test accuracy of this method is 81.25%, and the training accuracy is 92.5%. Figure 5 represents the diffusion matrix of last achievement of model.

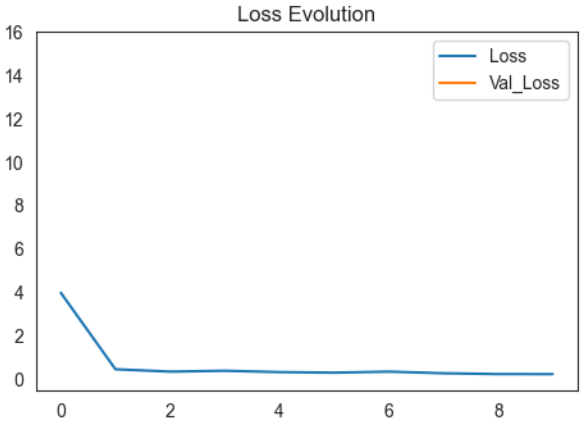


Figure 3. Loss Evolution of Sequential Model

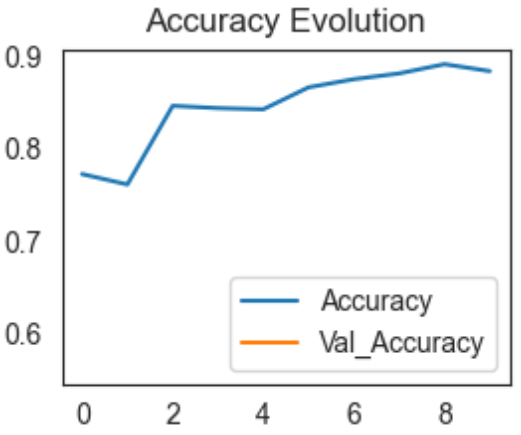


Figure 4. Accuracy Evolution of Sequential Model

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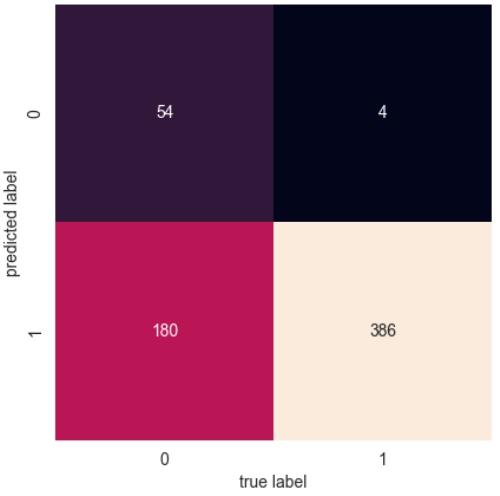


Figure 5. Diffusion Matrix

Another model is DenseNet model, which has about 70% precision. The test accuracy of it is 62.25%, and the train accuracy is 55%, which is not satisfied with the demand of accuracy. The loss evolution plot is shown in Figure 6, and the accuracy evolution plot is shown in Figure 7. It obviously by analyzing the difference between Figure 4 and Figure 7, the sequential model's performance is better than DenseNet model.

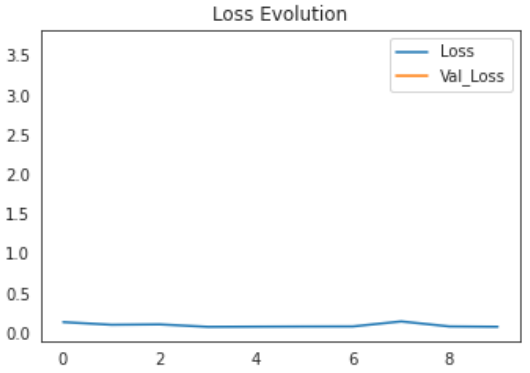


Figure 6. Loss Evolution of DenseNet Model

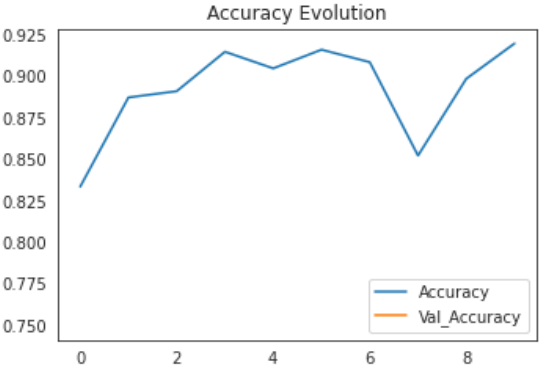


Figure 7. Accuracy Evolution of DenseNet Model

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6. Conclusion

The Covid-19 pandemic is an increasingly complex issue. As the number of cases continues to increase, a large number of cases may need to be tested quickly. In this work, two different CNN models in an attempt to classify patients affected by Covid-19 through chest X-ray scans are experimented with. The performance of the sequential model is better than that of DenseNet model.

Since the explosion of Covid-19 viruses, different models have been created and used to predict and classify them. The model of this essay cannot achieve the best performance of classification and predictions, but this essay may let people get aware of basic models and image processing. In addition, ConvNeXt can also be used for image processing, which can also improve the performance of the model [5,6].

References

[1] Commission, C. Q. Queen Alexandra hospital quality report. Available at, https://www.cqc.org.uk/location/RHU03 (2017).

[2] Faressayah, S. (2023, January 31). Chest X-ray medical diagnosis with CNN: DenseNet. Kaggle. https://www.kaggle.com/code/faressayah/chest-x-ray-medical-diagnosis-with-cnn-densenet/notebook

[3] Cavallo, A. U. , Troisi, J. , Forcina, M. , Mari, P. V. , & Garaci, F. . (2021). Texture analysis in the evaluation of covid-19 pneumonia in chest x-ray images: a proof of concept study. Current Medical Imaging Reviews.

[4] Mooney, P. (2018, March 24). Chest X-ray images (pneumonia). Kaggle. https://www.kaggle.com/datasets/paultimothymooney/chest-xray-pneumonia

[5] Swati, Z. N. K. , Zhao, Q. , Kabir, M. , Ali, F. , Ali, Z. , & Ahmed, S. , et al. (2019). Brain tumor classification for MR images using transfer learning and fine-tuning. Computerized medical imaging and graphics: the official journal of the Computerized Medical Imaging Society, 75, 34-46.

[6] Anilkumar B. Tumor. (2020). Classification using Block wise fine tuning and Transfer learning of Deep Neural Network and KNN classifier on MR Brain Images[J]. DOI:10.30534/ijeter/2020/48822020.