Classification of chest X-ray images to identify COVID-19

LÓPEZ CH. ALEJANDRA VERÓNICA[1] AND SALAZAR COLORES, SEBASTIÁN[2]

[1] Engineer Faculty. Universidad Autónoma de Querétaro.
[2] CIO (Optical Investigation Center)

Compiled November 28, 2023

One of the complications of a new virus or disease in the world, such as the last world pandemic of COVID-19 is that the the scientists need to discover information about the new disease. Technology is always helpful to do it and one example is the implementation of neural networks to classify images, for example, chest Xray to identify COVID-19. This paper tries to demonstrate that artificial intelligence can be an extraordinary help in obtaining more information about patients.

http://dx.doi.org/10.1364/ao.XX.XXXXXX

1. INTRODUCTION

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has emerged as a global health crisis. First identified in December 2019 in the city of Wuhan, Hubei province, China. The term "COVID-19" stands for "coronavirus disease 2019," reflecting the year when the outbreak was initially recognized. This highly contagious respiratory virus belongs to the coronavirus family

Governments, healthcare systems, scientists, and more communities around the world have mobilized in an unprecedented effort to curb the spread of the virus, mitigate its impact, and develop effective strategies for vaccination and treatment.

Neural networks (NN), a subset of machine learning inspired by the human brain's structure and function, have proven to be invaluable in analyzing complex medical data, improving diagnostics, predicting patient outcomes, and advancing personalized treatment approaches. Also, these approaches are based on image analyses, such as Xray, in this particular case, chest Xray.

It is certain that doctors will be not replaceable by artificial Intelligence, however, the use of NN to analyze data and predict or classify images provides extra information about the patient. For example, the classification of chest Xray of patients with COVID-19. In this paper, the classification of COVID Xray is the focus.

2. DEFINITIONS

1. Transfer learning: Transfer learning is a machine learning technique where a model trained on one task is adapted for a second related task. The idea is to leverage knowledge gained from solving one problem and apply it to a different but related problem. This is particularly useful when the amount of labeled data for the target task is limited compared to the source task.
2. Overfitting: Overfitting is a common problem in machine learning where a model learns the training data too well, capturing not just the underlying patterns but also the noise or random fluctuations present in that specific dataset. As a result, an overfitted model performs well on the training data but poorly on new, unseen data. Overfitting can occur when a model is too complex relative to the amount and quality of the training data.
3. Dropout: Dropout is a regularization technique commonly used in neural networks to prevent overfitting. It helps mitigate overfitting by randomly "dropping out" (i.e., setting to zero) a subset of neurons during training.
4. Data Augmentation: Data augmentation is a technique used in machine learning to artificially increase the size of a training dataset by applying various transformations to the existing data. The goal is to expose the model to a broader range of variations in the input data, helping it generalize better to new, unseen examples. Data augmentation is commonly used in computer vision tasks, such as image classification, object detection, and segmentation, but can also be applied in other domains.

3. METODOLOGY

As the objective of this exercise is to classify the Xray images in COVID and NORMAL patients, the implementation of a neural network pre-trained is a good option to decrease the training time and also use a stable architecture provided by Keras.

The dataset used for this investigation is a set of chest Xray images to evaluate the COVID-19 virus. It contains 1695 images of Chest X-rays of patients with COVID-19 and 1827 images of lungs free of virus.

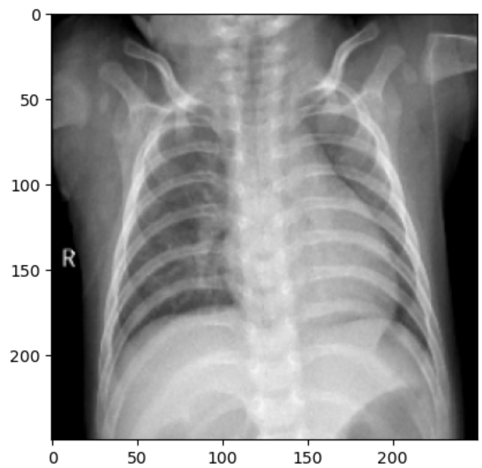

Fig. 1. Example of chest X-ray patient without Covid-19

As the first step, the images and labels were concentrated in a H5 file. Using different functions of Python the images and labels were shuffled and stored in the H5 file. This implementation is useful to manage and store a large number of data when it is required. Another way to store a large amount of data is using the data Dataset function of Tensorflow. It is a function that allows to creation of a tensor and the storing of the data to fit a model directly. In this exercise, the data Dataset is demonstrated but not used to fit the model because the data will be separated into train, test, and val datasets.

The first neural network to implement transfer learning is ResNet50, it is a 50-layer convolutional neural network (48 convolutional layers, one MaxPool layer, and one average pool layer). The architecture was imported and compiled with optimizer Adam (Learning rate 0.001), Mean Square Error (MSE) as loss function, and accuracy metric.

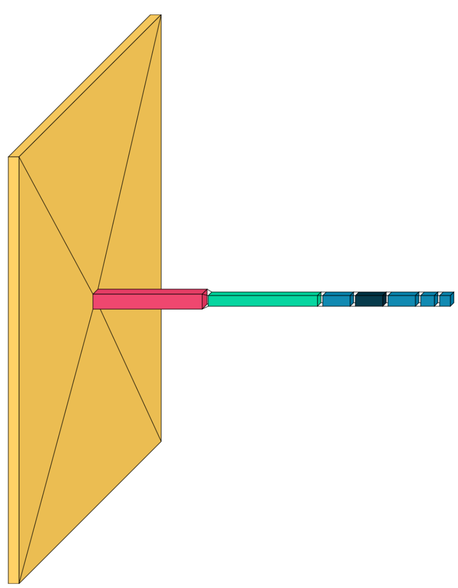

Fig. 2. ResNet50 arquitecture

One of the most popular neural networks to solve computer vision problems is the ResNet50, the architecture is robust and stable, which was te reason to choose this model for this scenario.

Using the transfer learning method, the trainable layers are disabled and then new Dense layers are added to a new sequential model. This process makes a pre-trained neural network with a lot of parameters and in theory, a very efficient model, however, it always depends on the application and the problem to solve. 3 Dense layers were added to the model, also 3 more layers of Dropout to avoid overfitting.

The second neural network architecture to test is MobileNet, it is a 53-layer convolutional neural network. The architecture was imported and compiled with optimizer Adam (Learning rate 0.001), binary cross entropy as loss function, and accuracy metric.

As in the previous network, the trainable layers were disabled and 3 dense layers were added, the difference with the ResNet50 is the number of neurons and the number of dropout layers.

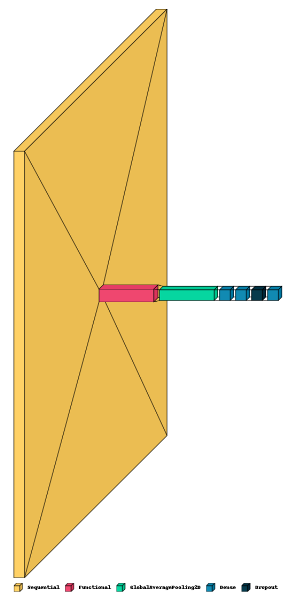

Fig. 3. Mobile Net arquitecture

In both examples, the number of epochs was set up in 20 and the validation data was provided to the model in the fit process. The batch size was 32. In the last layer, the activation function is sigmoid due to this is a binary classification. It is important to notice that it is not necessary to add a large number of layers to this specific task.

4. RESULTS

After a hard training and modification process of the neural networks, we validated that some NNs are better than others depending on the problem.

The hyper-parameters that were changed in this process were learning rate, number, and position of extra layers, type of layers (dense, dropout, etc), loss functions, activation functions, etc.

ResNet-50 has been widely used for image classification tasks and has been proven effective in various computer vision challenges, however, the performance with the ResNet50 was not good in this exercise. The accuracy of this model was low, the maximum number obtained was 0.55 percent. The performance of this model was unstable, that means in every test the result were very different.

The Mobile Net model was more useful than the first one. The highest accuracy was 97.33 percent, and the training time was shorter.

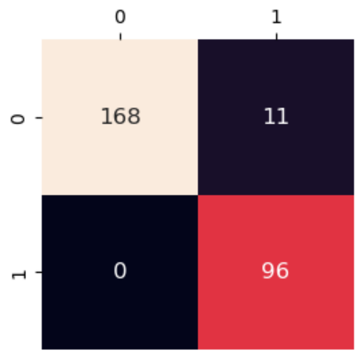

Fig. 4. Image of Chest X-ray patient wi.

As we can see in the confusion matrix, the MobileNet model was right in 264 images, and it failed in 11 images. This is a high accuracy, which means the model is ready to be used for future cases.

5. CONCLUSION

Transfer learning fosters quicker model convergence, reducing the computational resources and time required for training. This efficiency is vital in dynamic fields where rapid adaptation to new tasks and data is essential. Also, is very useful to reduce the lines of code and it allows one to jump directly to the training without having to be worried about building a convolutional architecture.

Due to the Mobile Net being the best option to solve this classification of Xray images, depending on the specific use case and hardware constraints, one may choose between different versions of MobileNet. In conclusion, MobileNet is a family of efficient convolutional neural network architectures designed for deployment on mobile and edge devices with resource constraints. Also, the choice of the specific ResNet variant depends on the complexity of the task at hand and the available computational resources.

Artificial intelligence can be the best assistant for doctors. It is obvious that scientists will use the technology to save or improve human life in any possible aspect. If an Xray image can provide important information as the state of the lungs of a patient, the doctors can avoid practice invasive test to diagnose COVID-19 or more diseases.

REFERENCES

1. Rahman, Alif COVID-19 Chest X-ray Image Dataset https://www.kaggle.com/datasets/alifrahman/covid19-chest-xray-image-dataset (2020).
2. Chollet, François Deep Learning with Python Manning Publications (2021).
3. Benoit Liquet, Sarat Moka and Yoni Nazarathy The Mathematical Engineering of Deep Learning (2023).
4. Chengwei Last-layer activation and loss function combinations https://www.dlology.com/blog/how-to-choose-last-layer-activation-and-loss-function/ (2017).
5. Torres, Jordi Python Deep Learning Alpha Editorial (2020).