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Research Article

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Application of Convolutional Neural Network in Detecting Pneumonia on Chest X-ray Images

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Abstract Pneumonia is a deadly disease which has taken so many lives in Nigeria. According to UNICEF press release in 2019, Nigeria contributes the highest number to global pneumonia child deaths. Pneumonia claimed the lives of more than 800,000 children under the age of five, in 2019 globally, or one child every 39 seconds, according to a new analysis. This paper presents a Deep Learning approach in detecting Pneumonia from X-ray Images. The paper presents a Convolutional Neural Network in detecting Pneumonia images on a Chest X-ray. We used a Chest X-ray dataset downloaded from kaggle.com. This dataset contains 3883 pneumonia images and 1349 normal images which makes it a total of 5232 inside the train folder. The model was built and trained using a convolutional neural network with 64 neurons, 128 batch size, 9 number of epochs, 2 hidden layers and 2 output layers which represents Normal Chest X-ray Image and Pneumonia Image. The results obtained revels that convolutional neural network has an accuracy of 98.20% at an epoch of 9. It is also encouraged that further research is done by increasing the number of training epochs to see if it will improve on the accuracy of our result and also to be deployed to be used in real time system.

Keywords Pneumonia, Chest X-ray, Deep Neural Network, Tensorflow, Keras

1. Introduction

Pneumonia is a deadly disease which has taken so many lives in Nigeria. According to UNICEF press release in 2019, Nigeria contributes highest number to global pneumonia child deaths. Pneumonia claimed the lives of more than 800,000 children under the age of five, in 2019 globally, or one child every 39 seconds, according to a new analysis. Nigerian children made up the highest number of those who died, with an estimated 162,000 deaths in 2018 – 443 deaths per day, or 18 every hour. In Nigeria, 19% of child deaths were due to pneumonia in 2018, and it was the biggest killer of children under-five in 2017. Pneumonia is a deadly disease and takes so many children lives – even though this is mostly preventable. And yet, this killer disease has been largely forgotten on the global and national health agenda. The biggest risk factors for child pneumonia deaths in Nigeria are malnutrition, indoor air pollution from use of solid fuels, and outdoor air pollution. According to World Health Organization Pneumonia is a form of acute respiratory infection that affects the lungs. The lungs are made up of small sacs called alveoli, which fill with air when a healthy person breathes. When an individual has pneumonia, the alveoli are filled with pus and fluid, which makes breathing painful and limits oxygen intake.

Pneumonia is the single largest infectious cause of death in children worldwide. Pneumonia killed 808 694 children under the age of 5 in 2017, accounting for 15% of all deaths of children under five years old. Pneumonia can be spread in a number of ways. The viruses and bacteria that are commonly found in a child's nose or throat can infect the lungs if they are inhaled. They may also spread via air-borne droplets from cough or sneeze. In addition, pneumonia may spread through blood, especially during or shortly after birth. More research needs to be done on the different pathogens causing pneumonia and the ways they are transmitted, as this is of critical importance for treatment and prevention.

The frequency and morbidity of pneumonia in the intensive care unit (ICU) compel providers to implement robust prevention plans. Our knowledge of how best to prevent nosocomial pneumonia, however, it is patchy and incomplete. Some of our bedrock assumptions about how best to prevent pneumonia have been recently been challenged (e.g., oral care with chlorhexidine), the evidence base for some widely practiced interventions remains surprisingly sparse (e.g., head of bed elevation), one persistent component of many hospitals' bundles may facilitate pneumonia (e.g., stress ulcer prophylaxis), our most powerful potential prevention strategy remains mired in controversy despite multiple high-quality trials (i.e., selective digestive decontamination), and rigorous studies of some very promising interventions have failed to include pneumonia as an outcome (e.g., minimizing sedation and spontaneous awakening and breathing trials) [1]. This paper proposes a deep learning approach using Convolutional Neural Network in detecting Pneumonia from a chest x-ray images.

2. Related Work

Differential Diagnosis of Tuberculosis and Pneumonia using Machine Learning [2] made analysis on the existing health care practice system and also proposed how machine learning techniques can be used for differential diagnosis of Tuberculosis and Pneumonia which are often misdiagnosed due to similar symptoms at early stages. The dataset they used contains information based on symptoms and clinical test reports which helped them in the diagnosis of Tuberculosis and Pneumonia. They used three machine algorithms in training the model. These algorithms are as follows based on the accuracy of their result: Gaussian Naïve Bayes 92.9%, Decision Tree 93.85% and Random Forest Classifier 97.64%.

Diagnosis of Pneumonia from Chest X-Ray Images Using Deep Learning [3] proposed a convolutional neural network models Xception and Vgg16 for diagnosing of pneumonia. They used transfer learning and fine-tuning in their training stage. Their test results showed that Vgg16 network exceed Xception network at the accuracy with 0.87%, 0.82% respectively. However, the Xception network achieved a more successful result in detecting pneumonia cases. As a result, they realized that every network has own special capabilities on the same dataset.

Deep Learning Approach for Prediction of Pneumonia [4] presents a deep neural network based on convolutional neural networks (CNN) and residual network along with techniques of identifying optimum differential rates using cosine annealing and stochastic gradient with restarts to achieve an efficient and highly accurate network that helped to detect and predict the presence of pneumonia using chest x-rays. They downloaded a chest x-ray dataset from kaggle.com which they used in training. Their model was first trained with smaller 64 images using CNN and then, they steadily increase in image size for better efficiency. After training, their model accomplished an accuracy of 92.9%.

Classification of Images of Childhood Pneumonia using Convolutional Neural Networks [5] described a comparative classification of Pneumonia using Convolution Neural Network. They used a dataset labeled Optical Coherence Tomography (OCT) and Chest X-Ray images for classification which was made available by [8] with a total of 5863 images, with 2 classes: normal and pneumonia. They used cross-validation of k-fold in evaluating the generalization capacity of the models. The classification of their model gave an accuracy of about 95.30%.

An Efficient Deep Learning Approach to Pneumonia Classification in Healthcare [6] presents a convolutional neural network (CNN) model to classify and detect the presence of pneumonia from a collection of chest X-ray image samples. They trained a convolutional neural network model from scratch to extract features from a given chest X-ray image and classify it to determine if a person is infected with pneumonia. This model could help mitigate the reliability and interpretability challenges often faced when dealing with medical imagery. They said Unlike other deep learning classification tasks with sufficient image repository, it is difficult to obtain a large amount of pneumonia dataset for this classification task; therefore, they deployed several data augmentation algorithms to improve the validation and classification accuracy of the CNN model and achieved 0.9531, 0.9373 training and validation accuracy.

Classification of Bacterial and Viral Childhood Pneumonia using Deep Learning in Chest Radiography [7] proposed a novel CAD system to identify bacterial and viral pneumonia in chest radiography. The method they used consists of two parts which are lung regions identification and pneumonia category classification. The left and right lung regions are segmented and extracted with a fully convolutional networks (FCN) model. The model is trained and tested on the open Japanese society of radiological technology database (JSRT, 241 images) and Montgomery County (MC, 138 images) dataset. After segmentation, a deep convolutional neural network (DCNN) model was used in classifying the target lung regions. Features of the target lung regions are extracted automatically and the performance is compared with that of manual features. Finally, they fused the DCNN features and manual features together and put them into support vector machines (SVM) classifier for binary classification. Their proposed method was evaluated on a dataset of Guangzhou Women and Children's Medical Center, China, with 4,513 pediatric patients in total, aged from 1 to 9 years old, during the period from 2003 to 2017. The performances are measured by different criteria: accuracy, precision, sensitivity, specificity and area under the curve (AUC), which is a comprehensive criterion. The experimental results showed better accuracy (0.8048±0.0202) and sensitivity (0.7755±0.0296) in extracting features by DCNN with transfer learning. The values of AUC varied from 0.6937 to 0.8234 and an ensemble of different kinds of features slightly improved the AUC value from 0.8160±0.0162 to 0.8234±0.0014.

3. Design Methodology

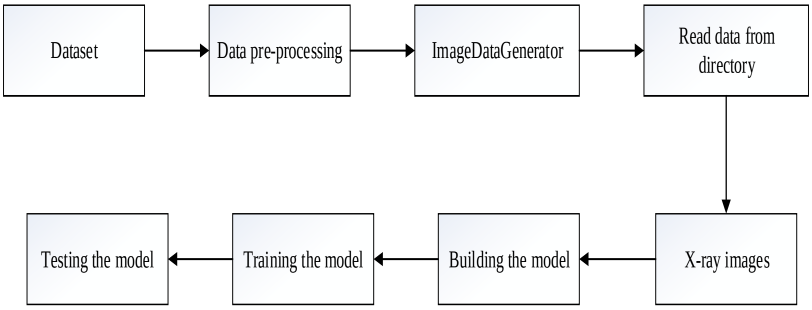

Figure 1: Architecture of the proposed system

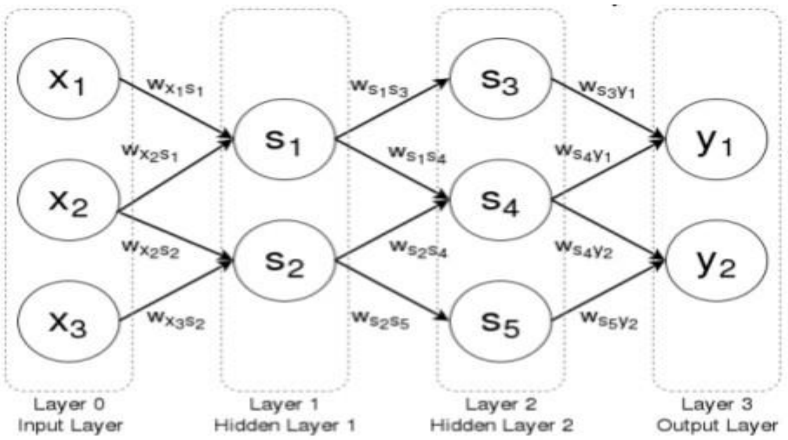

Figure 2: Architecture of a Neural Network with two hidden layers and two outputs

This system uses a chest X-ray image dataset which is downloaded from kaggle.com. This dataset contains train and test folder which have a two sub folders namely NORMAL and PNEUMONIA folder. We used the train folder in feeding and training the model. The dataset was pre-processed by creating directory variables. ImageDataGenerator is a module which is being used in reading images with the flow_from_directory function. The model was built using an input shape of 200 x 200 with a 3 bytes colour, two hidden layers, 64 input neurons and two output layer which represent a normal image and a pneumonia image. The dataset was trained using fit_generator function from keras which have an epoch of 9 and a batch size of 128. The dataset was tested base on accuracy.

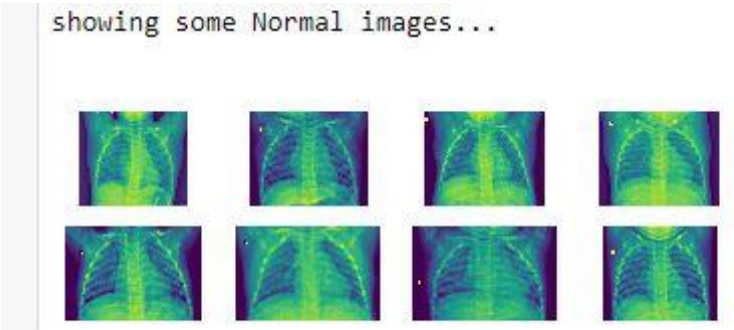

Figure 3a: showing some Normal images on Chest X-ray Images

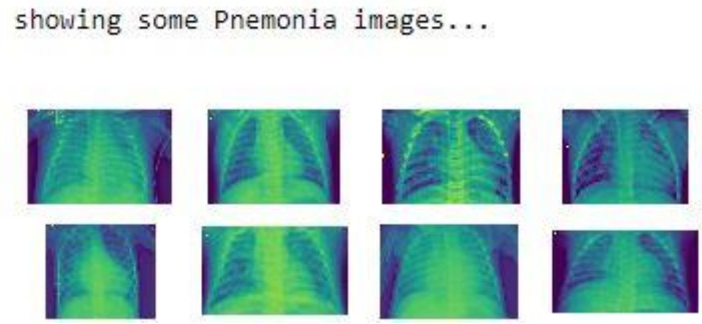

Figure 3b: showing some Pneumonia images on Chest X-ray Images

4. Result and Discussion

In this paper, a Chest X-ray image dataset was used in training the model. The dataset contains 3883 pneumonia images and 1349 normal images which makes it a total of 5232 inside the train folder. The images were processed using ImageDataGenerator in rescaling the image by 1/255. The images were read from directory using the flow_from_directory(). The images were further resized to 200 x 200 following a batch size of 128. After preprocessing, the model was built with a total of 64 input neurons, two hidden layers and two output which will either detect if there is a pneumonia present in a chest X-ray image. The model was trained using a Convolutional Neural Network with 9 numbers of epoch. The Convolutional Neural Network gave an accurate result of about 98.20% accuracy at an epoch number of 9.

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 198, 198, 32)      896
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 99, 99, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 97, 97, 32)        9248
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 48, 48, 32)        0
_________________________________________________________________
flatten (Flatten)            (None, 73728)             0
_________________________________________________________________
dense (Dense)                (None, 64)                4718656
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 130
=================================================================
Total params: 4,728,930
Trainable params: 4,728,930
Non-trainable params: 0
```

Figure 4: Summary of the Model

```
Epoch 1/9
40/40 [==============================] - 547s 14s/step - loss: 1.6525 - acc: 0.7768
Epoch 2/9
40/40 [==============================] - 521s 13s/step - loss: 0.2652 - acc: 0.9183
Epoch 3/9
40/40 [==============================] - 522s 13s/step - loss: 0.2625 - acc: 0.9122
Epoch 4/9
40/40 [==============================] - 519s 13s/step - loss: 0.1505 - acc: 0.9500
Epoch 5/9
40/40 [==============================] - 537s 13s/step - loss: 0.1496 - acc: 0.9547
Epoch 6/9
40/40 [==============================] - 524s 13s/step - loss: 0.2454 - acc: 0.9495
Epoch 7/9
40/40 [==============================] - 514s 13s/step - loss: 0.0525 - acc: 0.9804
Epoch 8/9
40/40 [==============================] - 504s 13s/step - loss: 0.7836 - acc: 0.9643
Epoch 9/9
40/40 [==============================] - 511s 13s/step - loss: 0.0461 - acc: 0.9820
```

Figure 5: The training process

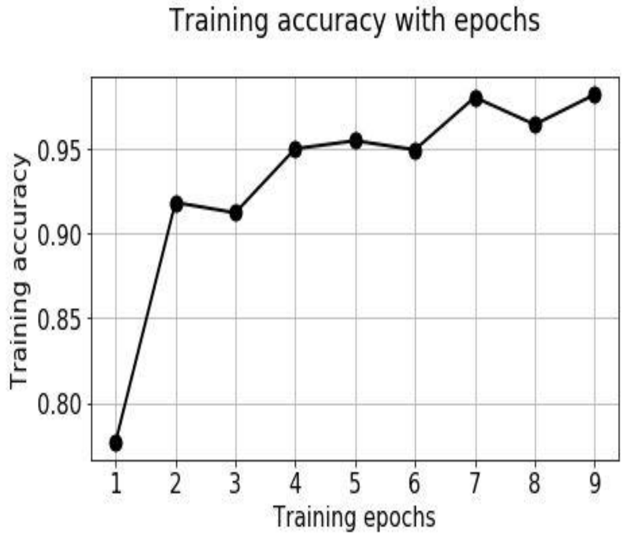

Figure 6: Accuracy against the number of training epochs

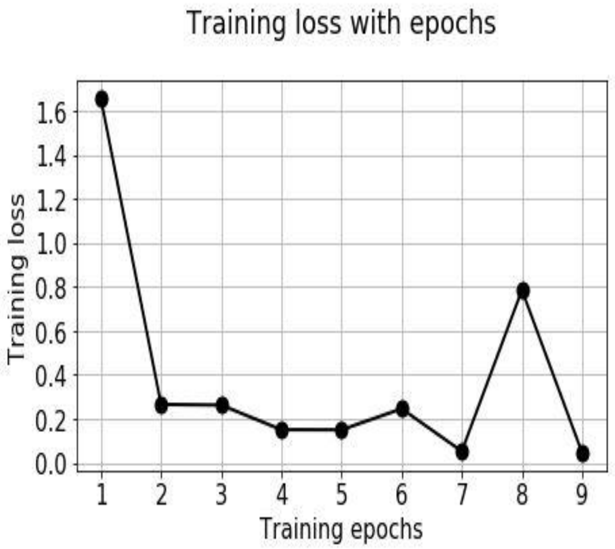

Figure 7: Loss values against training epochs

5. Conclusion and Future Work

This paper presents a convolutional neural network model in detecting Pneumonia on Chest X-ray Images. We used a Chest X-ray dataset which was downloaded from kaggle.com. The dataset has two folders which are the train and test folder. We used the train folder in training our model. The train folder contains two sub folders namely NORMAL and PNEUMONIA. These sub folders have a total number of 5232 images. After building and training our convolutional neural network model, the model had an accuracy of 98.20% at an epoch number of 9. This paper can further be extended by increasing the number of training epochs to check if the accuracy of result can be further improved on. Also, the paper can also be extended by deploying the trained model for production so that it can be used as a real system for detecting Pneumonia from Chest X-ray Images.

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