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Prediction of Pneumonia using Deep Feature Extraction and Convolutional Machine learning Techniques on Chest X-Ray Dataset

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ABSTRACT

Pneumonia is a disease which affects the lungs of the human beings. Globally, Pneumonia accounts for nearly sixteen percentage of mortality of children who are below five years. World Health Organisation mentions that four million pre-mature deaths happen per year due to the illness associated with standard air contamination, which encompasses the direction of the study towards pneumonia detection. It is very important to predict these diseases in the early stage for successful treatment and to increase the life span. Usually, this disease can be diagnosed from chest X-ray images by an expert radiologist. But there arise a problem of unclear chest X-ray images in diagnosing the disease clearly. Therefore, computer-aided prediction systems are needed to guide them. In this study, we used Deep convolutional neural network and Vgg16 for diagnosing purpose. We also used Auto Encoder Neural Network and Random Forest classifier for detecting the disease accurately.

Keywords: ***Deep learning methods, Feature Extraction, Deep CNN, VGG16, Classification***

1. INTRODUCTION

Pneumonia is a type of infection that affects human lungs. Pneumonia remains a threat to human health. X-ray imaging of chest is being convenient and highly accurate that makes it to be renowned method for pneumonia diagnosis. In comparison to ComputedTomography (CT), X-ray has been renowneddue to minimum cost and imaging convenience. Nevertheless, manual digitalised image interpretation consumes more time and remains challenging for radiologists. Hence, in-depth understanding of computer aided automated systems could assists the radiologists for promptand better pneumonia diagnosis. Accordingly, a modified deep learning approach has beenrecommended in the present study that adopts VGG 16, deep CNN, auto encoder and Random Forest model for classifying the sample X-ray images. Features, which are the basic components of a data set, could be described as the measurable attributes of the problems observed. Many of the features present in the dataset are similar or redundant with varied scales. Other features are observed to be irrelevant to the issues to be predicted and consequently affect the performance of the classification algorithm. To obtain optimum features, modification of the search trouble withreliable objective function must be attained towards the multidimensional area. The proposed model has been motivated by the beneficial characteristics of VGG16 and deepCNN to extract reliable features. Accordingly dimensionality reduction to rule out non-linear data has been performed by auto-encoder based technique.This is followed by reliable classification process with CNN weight Tuned and Cross Validated Random Forest(CNN WT : CVRF) in which Random Forest algorithm classifies the features by generating several decision trees in training stage and attains higher classification accuracy. Accordingly CNN weight adds value to the classification process. Cross validation is accepted globallyand functions as a standard procedure for the precise selection of the modelling procedure. K fold cross validation is adopted to obtain better sampling distributions and classification efficiency. Further RF algorithm with proper k fold cross validation has been observed to be less susceptible to over fitting problem. Hence the proposed Deep Feature Extraction- CNN weight Tuned Random Forest

could effectively handle outliers and prevailing noise and outperforms the state of art methods in terms of several performance metrics like accuracy, sensitivity and specificity.

1.1 AIM AND OBJECTIVES

The main aim of this research is to propose possible deep learning methodologiesfor pneumonia detection and to smartly reveal the existence or absence of the disease.

The following research objectives areframed in accordance to the above stated aim

- To perform data pre-processing for removal of unwanted and non-redundantinformation in the dataset.
- To execute a reliable feature extraction model with the proposed deep CNN and VGG-16 for selecting highly distinctive features. Such distinct features could promote simplified classification process.
- To reduce the dimensionalities using the introduced Deep Stacked Auto encoder neural network which minimize the over fitting issue. This step overcome the difficulties of non-linear data and consequently enhances the classifier performance.
- To classify the processed features into normal and pneumonia affected(abnormal) by the newly developed CNN-WT: CVRF classifier.
- To evaluate the effectiveness of the proposed system in terms of recall,precision, accuracy and F-measure for confirming the out-performance of theadopted deep learning techniques.

2. LITERATURE REVIEW

This section deliberates the review of literature in accordance to the proposed work

The fast strategy and effectiveness of deep learning in the medical field has made it a significant feature for medical experts. The study **(Chouhan et al., 2020)** intended to ease the detection process of pneumonia for novices and experts. A deep learning framework has been recommended to detect pneumonia by the use of Transfer Learning (TL). The results attained from the implementation of the suggested method afforded better outcomes. Yet, the accuracy rate has to be improved through the integration of high deep networks (DN) to an ensemble. In addition, the networks have to be trained with large datasets to attain effective outcomes. Similarly, the paper **(Jaiswal et al., 2019)** explored a technique to determine pneumonia as well as to understand the way in which the size of the lung image hasa major role in the performance of the model. The introduced Mask RCNN providedadditional efficiency for accurate outcomes. Theuse of thresholds while training also paved the way for effective model performance. The L2 regularization and dropout prohibited over fitting with the use of image augmentation. Though the model is effective, it provides weak results at times on the training set in accordance with the test. The study aimed to expand the proposed model architecture with the use of computer vision and DL in various medical imaging areas. Consequently, the article **(Rajaraman et al., 2018)** recommended a fast, accessible andautomatic system that supports physicians in diagnosing pneumonia.

The Neural Network (NN) and Multi- layer Perceptron (MLP) has been compared for detecting as well as classifying pneumonia **(Saraiva et al., 2019).** Cross-validation has been performed for validating the models. This helps to evaluate the generalization ability. The proposed models afforded classification outcomes. CNN showed 94% accuracy. Whereas MLP showed 92% accuracy. Hence, CNN is found to be effective than MLP. Similarly, the article **(Li et al., 2019)** executed PNet, which is a deep learning based frameworkfor detecting pneumonia. Numerous X-ray images of the chest have been gathered from a hospital have been applied for training and later evaluation is done. Effective outcomes have been accomplished. The suggested method showed 92.7% accuracy. However, the accuracyhas been found to be low. Followed by this, the paper **(Jozef Saul et al., 2019)** presented a technique to classify the existence of pneumoniain an X-ray image. Image processing has been applied prior to training of deep learning model to make the X-ray image features clear. This helps in making the classification process easier. Subsequently, Residual Neural Network (RNN) and CNN have been employed for classification. The proposed technique exhibited a classification accuracy of 78%. Whereas varied pre-processing techniques might be required for training the algorithms. Moreover, an algorithm has been devised that significantly minimizesthe parameter cost as well as the model error.

The study aimed to expand the proposed model architecture with the use of computer vision and deep learning in various medical imaging areas. Consequently, the article **(Rajaraman et al., 2018)** recommended a fast, accessible and automatic system that supports physicians in diagnosing pneumonia. Various methods were complemented and used that werealready consolidated from integrations ofMachine Learning (ML) classifiers with CNNs. The implementation has been done in real-time. This remains available to people via an IoT system that pertains to the medical field. Real-time results have been obtained through the incorporation of an X-ray image into the system. The results explored that the VGG16 model accomplished 93.6% and 96.2% in distinguishing the disease as viral and bacterial and detecting the disease concurrently. The accuracy has to be further improved to enhance the prediction accuracy. In future, the patient has to be monitored periodically in addition to the affected area. This will support the pulmonologist to analyze the ongoing condition of the patients through visual analysis. Moreover, few CNN models have beenimplemented by the use of TL methodology **(Moujahid et al., 2020).** These models have been used for detecting pneumonia. A better outcome has been obtained. The proposedmodel has to be adapted specifically for X-ray images of the chest in the near future. The training stage also consumed more time that relies on the algorithm complexity, which has to be optimized effectively. Similarly, the study**(Ayan and Ünver, 2019)** used TL, data augmentation and fine-tuning techniques. The same parameters have been utilized during network training to compare them. Theperformance of both the networks have beencompared on the test data using various metrics and the outcomes explored that the proposedXception model performed better than Vgg16 for pneumonia diagnosis. Contrarily, the proposed Vgg16 model performed effectivelyfor identifying the normal cases. The outcomes explored that the Vgg16 performed efficiently than Xception by 87% accuracy. On the other hand, Xception performed better than Vgg16 by 85% sensitivity. However, the accuracy rate is found to be low. In addition, the study **(Rustam et al., 2020)** explored that CNNs are effective toclassify pneumonia on the basis of lung X-ray. This has been confirmed by the results that showed training accuracy as 97% and testing accuracy as 91%.

The image dataset considered in this study is small and the CNN program has not utilized an effective processor that degrades the system efficacy. Thus, a high processor has tobe added to enhance the CNN programs. Likewise, the paper **(Prayogo et al., 2020)** proposed an imaging classification of X-ray by the use of Siamese Convolutional Network (SCN). This methodology is often utilized for Similarity Learning (SL). The proposed architecture produced accuracy at a rate of 80% and F-measure at a rate of 80%. The study also explored the compared image that has been usedto assist the decision from the classification outcomes. Hence, the introduced model possessed effective outcome as well as details incomparison to the equivalent techniques like CNN. However, various training data have to beincorporated to enhance the performance of the model as the pair result quantity is combinatory.Numerous experiments have to be carried out to set the hyper-parameters for enhancing the model. Class Activation Map (CAM) is yet tobe applied to improvise the result visualization, which is appropriate for SCN. This would expand the comparison image purpose and afford an efficient understanding of outcomes. On the contrary, binary classification has been used along with deep CNN to retrieve a medicalimage for pneumonia detection **(Dureja and Pahwa, 2020).** The strategy utilized here provides better outcomes. It also exhibits the reduction in manual labelling time. Accuracy has been obtained as 93.9%. Yet, the accuracy isfound to be low **(Ibrahim et al., 2021)**.

2.1 RESEARCH GAP

Several research gaps are identified and are discussed here.

- The Conventional model (Jaiswal et al., 2019) has to be improvised by incorporating more layers. Thus, the proposed study usesDeep CNN which comprises of various layers due to which it is capable of performing efficient learning and avoid over fitting issue thereby increases the classification efficacy.

- Employment of mere VGG 16 leads to slow training process and consequently the network weight themselves causing huge bandwidth.

- Few of the existing studies have not performed appropriate segmentation to explorethe correct infected area of the lungs (Rajaraman et al., 2018).

- Traditional dimensionality reduction process like PCA possesses trade-off between dimensionality reduction and information loss.

- Despite reliability, the accuracy rate is low for the existing system (Moujahid et al., 2020).The present study uses Deep CNN and VGG-16 for enhancing the classification performance. Both have numerous layers in which

VGG16 performs individual feature representation of X-ray images effectively that result in better prediction.

- The prevailing studies have not employed the strengths of dual networks in an effective manner for accomplishing successful outcomes to diagnose pneumonia from the X-ray images (Ayan and Ünver, 2019).
- Apart from the above described research gaps over fitting issues due to non-linear data, generalizability, bias in dimensionality reduction, and computational complexity has to be mitigated to increase the detection rate.

3. PROPOSED METHOD

This section briefly explains the proposed methodology with a comprehensive architecture frame in figure 1.

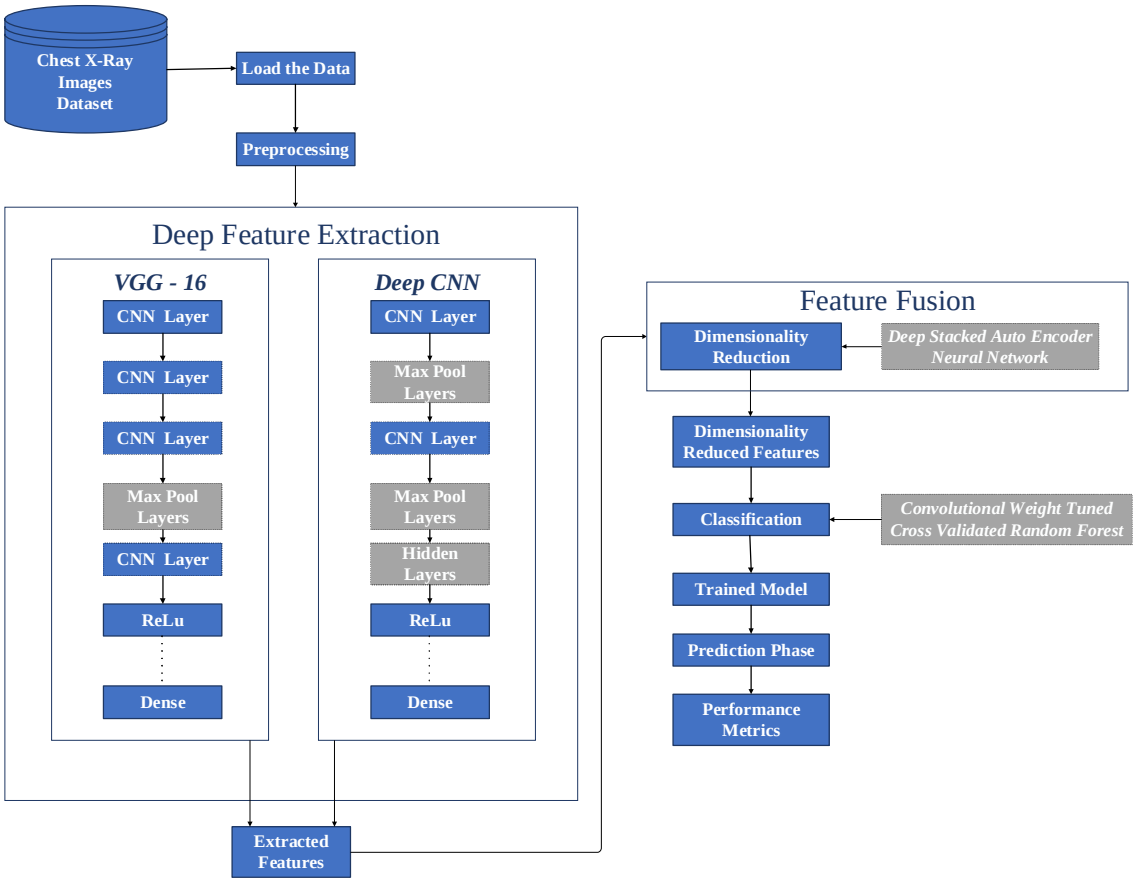

Figure 1: Overall Architecture of the proposed system

Initially, the Chest X-ray (CXR) dataset is loaded. Following this, pre-processing is performed to eliminate unwanted data. Previous methods employed several transfer learning methods and corresponding modifications on CNN to obtain better performance. However as discussed in the research gap they possess various limitation. Hence the proposed methodology utilized VGG 16 transfer learning with deep CNN for effective feature extraction. This method is observed to be highly advanced and believed to extract precise features from any provided dataset. The concatenated features will be subjected to dimensionality reduction through modified deep stacked auto encoder. Followed by dimensionality reduction, the convolutional weight tuned cross validated Random Forest classification process enhances the overall performance of the classification system. The effectiveness of the tuned CNN weights is proved with cross validation. The proposed advanced model is assured to learn and categorize normal and pneumonia affected patients.

3.1 MOTIVATION FOR ADOPTED DEEP LEARNING METHODS

To overcome the challenges of IDS, the study was motivated by the following advantages. The proposed system employed the combined characteristics of VGG16 and deep CNN due to high availability of pre-trained networks. Further the features are deduced automatically and subjected to optimal tuning for obtaining desired outcomes. Deep CNN could learn basic filters effectively and integrate them in a hierarchical manner. Accordingly, auto encoder accompanied by extra layer and non-linear activation can handle non-linearity in the image with several inbuilt layers. Meanwhile when compared with PCA, auto encoder can capture complex patterns and immediate changes in the pixel value. It does not need to learn dense layers and hence it is prone to huge parameters. Random forest classification algorithm is developed to produce more trees on subset data and merge the output of whole trees. It reduces the variance and over fitting issues in the trees and improves the accuracy. It gives accurate predictions than decision tree algorithm, it is easier to understand. It has the efficiency to handle large data sets. This algorithm will efficiently and effectively handles the non-liners parameters and it is out-perform than other existing algorithms.

3.2 FEATURE EXTRACTION

Feature extraction indicates a part of dimensionality reduction where the initial raw dataset gets divided and minimized to manageable groups. Thus, it will assist in easy data processing. Present work uses deep CNN and VGG-16 for feature extraction. It is discussed below.

3.2.1 DEEP CNN (DEEP CONVOLUTIONAL NEURAL NETWORK)

CNN is the type of FFANN (Feed Forward Artificial Neural Network) which is biologically stimulated through VCO (Visual Cortex Organisation). These are widely employable in several sectors like image recognition, NLP (Natural Language Processing) and the RS (Recommender Systems). Generally, CNN encompasses of two main parts such as convolutional and pooling layers. Convolutional layer provides feature maps as the output through the computation of dot-product of the filter and the local region of the feature map taken as input. Following this, non-linear function estimates the complex functions that squash the output of NN. Besides, pooling layer accomplishes down sampling to the feature maps by computing average or maximum value upon the sub-region. FC (Fully Connected) layers follow stacked convolutional and pooling layers. Softmax is the final FC layer which computes scores for individual class. The deep CNN is identical to CNN. However, deep CNN encompass of several layers such as 10 convolutional layers, one FC layer and 4 maxpooling layer to undertake classification. The present study uses deep CNN as it has the capability to avoid overfitting, thereby enhancing the classification accuracy.

3.2.2 VGG-16 (VISUAL GEOMETRY GROUP-16)

VGG is the standard form of deep CNN architecture having several layers. “Deep” indicates the layer count with VGG-16 that encompass of 16 convolutional layers. The VGG Nets rely on the vital features of CNN. Pre-trained version of network could be loaded on network that is trained on million images attained from ImageNet database. Pre-trained network could classify the images into thousand image categories. VGG-16 is the advanced CNN having pre-trained layers along with better realisation of what states an image with respect to colour, structure and shape. It is also deep and it is trained on several images with complicated classification tasks. Auto encoders are the kind of neural networks for dimensionality reduction which reduce the data to low dimensional latent space through stacking several non-linear transformations. They possess an encoder: decoder architecture in which the encoding maps the input to the latent space and the decoder is involved in the reconstruction of the input. The proposed system employs deep stacked auto encoder for dimensionality reduction.

3.2.3 CLASSIFICATION

Image classification is the method to categorize the groups of pixels within an image based on specific rules. Image classification is more important part in analyzing digital image. The proposed method uses Random Forest for this purpose. Random Forest is ensemble classifier and outperform in the detection of attacks when compared to other existing classifiers. Likewise Cross validation is the generally utilized technique for evaluating the predictive performance. In k-fold cross validation, original sample has been partitioned randomly to k equal sized subsamples, in which single subsample is recollected as the validation data for model testing and the balance k-1 subsample are utilized as training data. RF comprises several decision tress, minimum node size and reduced number of featured to split every node results in least classification error. Further the following advantages like the generated forest could be saved for future references, RF overcome the issue of over fitting and automatic generation of significant variables. During the generation of individual tress in RF, randomization has been applied for selecting the best node to split. This value has been found to be

equal to √A, where A represents the number of dataset attributes. But RF construct huge noisy trees that impact the accuracy thereby leading to wrong decision for new sample. Weight updating is an important aspect in training of neural network samples and influence the classification effectiveness and learning quality. Further weight updating occurs between the output layer and the hidden layer for matching the target output. Error is estimated in accordance with the original and the desired output. If the output matches the corresponding target then there exists no requirement of weight update. The training of neural network and reducing the prediction error depends on the determination of weight. The proposed system utilizes CNN for the purpose of weight update. The updated weights from CNN increased the classification accuracy thereby yielding better results.

4. SIGNIFICANCE OF THE STUDY

In recent years mortality due to pneumonia has been observed to be increasing at an alarming rate. Detecting this specific disease in its preliminary stage is important for reducing the death rate and improving the quality of life. On contrary, Deep Learning techniques in medical domain greatly afford doctors with rapid detection. Thus, adopting such neural network models with appropriate optimization could overrule the time complexities associated with treatment procedures. Thus, this study introduces trending and reliable methods for accurate and timely pneumonia detection.

5. CONCLUSION

The proposed system has been expected to outshine the prevailing limitation of intrusion detection like over fitting, with the technical advances of hybridized approach. Further the proposed system is expected to outperform the state of art methods in terms of accuracy, precision, recall and F score. The expected accuracy value will be more than 97% and the expected recall, precision, and F score will be more than 96%. This system could be efficiently used for detecting normal and pneumonia affected patients in any dataset.

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