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Comparative Performance Analysis of Convolutional Neural Network Models Based Lung Cancer Classification on Computed Tomography

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Abstract—*The survival rate of lung cancer depends upon early identification of lung nodules which is an efficient way to minimize the death rate of patients. This paper presents comparative analysis of VGG-16 and Improved VGG-16 network models. These models eliminate the need of manual feature extraction, as the network is fed with raw lung CT images from publicly available LIDC-IDRI dataset. Here, the lung images are classified into two classes such as benign and malignant. This paper presents comparative analysis of two models and hence VGG-16 method successfully achieved classification accuracy of 86%. Improved VGG-16 achieved classification accuracy of 97%.*
Keywords*— Lung Cancer, VGG-16, Improved VGG-16, Computed Tomography, Classification*

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I. INTRODUCTION

Identification of lung cancer is an efficient way to minimize the death rate of patients. It is a vital step to screen out the computed tomography (CT) images for pulmonary nodules for the diagnosis of lung cancer. Hence suitable mechanism should be adopted to detect and identify this disease in the initial stage to save the life of large number of peoples suffering from lung cancer. If it is detected and identified in primary stage then survival rate of many number of patients can be improved. Later after disease identification, by providing proper diagnosis can reduce the death rate of patients. So, in order to avail a suitable and instantaneous outcome the importantly, applying recent techniques of machine leaning in the medical image processing field by enhancing the amount of duplication for the methods use can increase the accuracy of the classification. Therefore, proper timely detection and identification in the prior stage will definitely improve the level of survival and can decrease the death rate.

The medical images taken in most of the earlier studies comprise of computed tomography (CT), magnetic resonance, and mammography images. The expert doctor of this domain uses these images for analysis to detect and identify the various levels of lung cancer by using suitable techniques. The different laboratory and clinical steps are being used including chemical treatment to destroy or stop the duplications of malignant cell, targeted therapy and also radiotherapy. All these procedures adopted to identify and detect the cancer diseases are lengthy, costlier and more painful for the patients. Thus, to overcome all these problems suitable machine learning techniques for processing these medical images were used which comprise of CT scan images. CT scan images are preferred compared to other images because CT images are less noisy as compared to MRI and X-Ray reports.

II. LITERATURE REVIEW

Ryota Shimizu *et.al,* [6] proposed a system to detect malignancy of lung based deep neural network. The learning model uses urine to detect different substances. The model provides an accuracy of 90% while detecting malignancy of lung but it does not determine the category or nature of cancer. Po-Whei Huang *et.al,* [7] presented a system which achieves an accuracy 0f 83.11% with the ROC area as 0.8437. Here the system classifies malignant tumour and benign tumour from given CT images using support vector classifier based on a number of fractal-based features collected from fractional Brownian motion model. Vaishali C. Patil [8] has presented a lung tumour recognition using CT images. To detect disease malignancy, the computer aided design system was used. Image processing techniques were used to eliminate noise from CT images. After segmentation, a variety of classifiers such as Artificial Neural Networks and Support vector machine were used to determine different stages of lung cancer to enhance efficiency and to minimize error rate. Ailton Felix *et.al*,

[9] proposed a 3D CAD System to extract texture features and 3D Margin Sharpness Features from LIDC dataset. This system classifies small pulmonary nodules with diameters between 3-10mm. In this task they used three Machine Learning Algorithm: Random Forest, Multilayer Perceptron and K-Nearest Neighbor. Sri Widodo *et.al*, [11] proposed a Principal Component Analysis for classification of pulmonary nodules and artery automatically on chest CT scan image. In this study they consider 3 steps. The first step is lung organ segmentation using Active Appearance Model, the second step is segmentation of nodule using the morphological method and the third step is to classify pulmonary nodules and artery using PCA technique. Experimental result shows that the accuracy of the classification system is 90%.

Rui Xu *et.al,* [13] introduced a deep Convolutional neural based system for the lung segmentation in CT scans for both mild and severe diseases. It's not easy task for radiologist to detect lung diseases which have complex opacities in ROI. So Deep-CNN model is introduced for lung segmentation. In these complex opacities is considered as a texture-based problem in which pixel is classified as one inside or outside in ROI. This problem is solved by using CNN based model. This system takes 42 computed tomography images with severe lung disease and 7 Computed Tomography images with a mild lung cancer which includes six kinds of opacities. The jacquard index of this model is more than the mostly used lung segmentation method. In this research various classifiers are used such as Naive Bayes classifier, decision trees, SVM, k-nearest neighbours, logistic regression. In the lung sound data decision tree classifier and SVM classifiers gives the great accuracy of decisions and results. It is assumed that with the increase in the input data, accuracy also increases. Pratiksha Hattikatti [15] proposed Convolutional Neural Network for finding the range of the lung texture pattern of diseases from computed tomography images. The term called interstitial lung disease includes various disease related to lung, characterization of lung tissue is an important element of CAD system for determining the interstitial lung diseases. The Convolutional neural network achieves accuracy of 94% with high sensitivity and same data is passed through SVM classifier which gives the accuracy of 86% only. It concludes that CNN gives more accurate results for interstitial lung diseases. Pouria Moradi [17] proposed 3D Convolutional Neural Network, which can reduce the false positive rate and provide high sensitivity in detecting lung cancer. The main objective of this research is to improve classification accuracy. Researcher achieved 91.23% accuracy for 3.99 false positive per scan using the method for combining different classifiers.

III. METHODOLOGY USED

A. VGG-16 & Improved VGG-16 Network Model

The proposed lung cancer Identification system using VGG-19 Model shown in the Figure-1 & 2 are mainly divided into two parts. In the first part, we are doing preprocessing before feeding the images and then were identifying the nodule that is used to train to ultimately classify the CT input images as malignant or benign for lung cancer to achieve the result.

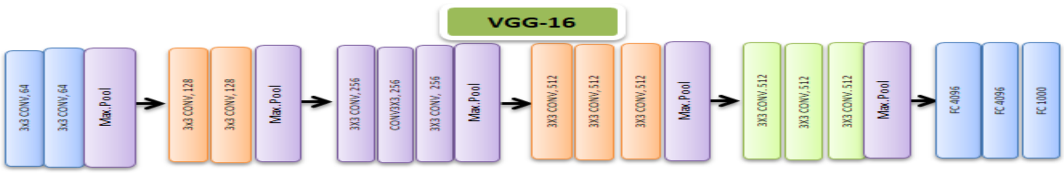


Figure 1: VGG-16 Network Model

Figure.2: Improved VGG-16 Network Model

The proposed VGG16 and Improved VGG16 architectural block diagram shown in figure.1&2 are mainly consists of the following layers: sixteen convolutional layers which follows, five max- pooling layers and one fully-connected layer. Improved VGG-16 is a version of VGG-16 that has been enhanced and adjusted to improve classification accuracy. The design of the Improved VGG-16 network model, which classifies malignant or benign at the output, uses the network's depth, kernel size, and extracted feature maps to achieve high classification accuracy. The architectural block design for the improved VGG-16 consists of 18 layers total—15 convolution layers, 6 max-pooling layers, and 3 completely linked layers with soft max layer. Relu activation function is applied following all convolutional layers, similar to the VGG-16 model. As shown in Figure 1&2, the network begins with a convolution layer, in which the first convolution layer takes the image with input size of 224 × 224 pixels. The second convolution layer consists of 32 feature maps with the convolution kernel of 3 × 3. The kernel size for max pooling layers is 2 × 2 and the stride of 2 pixels, and the fully-connected layer generates an output of 1024 dimensions. After applying these architectures, some images detected with cancerous nodules and some identified as non-cancerous.

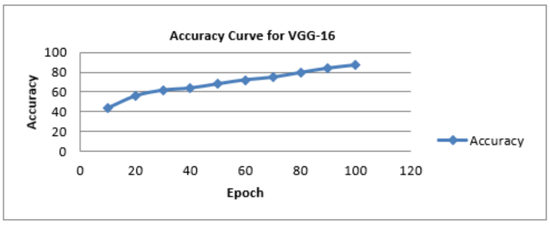
B. Training VGG-16 & Improved VGG-16 Network Model

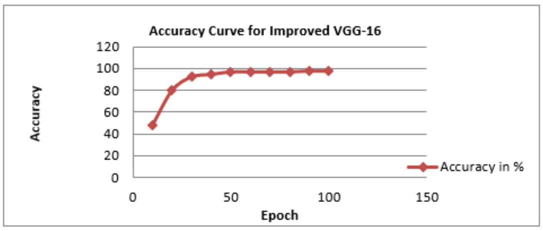
Back-propagation algorithms are used to train the VGG-16 and Improved VGG16 using CT images of size 224x224x3. It consists of two phase, training phase and testing phase. In the first phase trained using CT images are being used to train the network for the classification of lung as either cancerous or non-cancerous. In the testing phase an image unknown to the network is applied as input to classify as cancerous or noncancerous. For minimum loss of features images are trained and tested in the DICOM format itself by modifying the network parameters. The proposed designed network accuracy can be achieved by suitable evaluation.

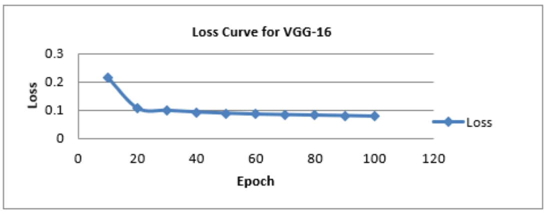
VI. RESULTS AND DISCUSSIONS

The dataset used in the research work belongs to LIDC-IDRI which is the Lung Image Database Consortium image collection (LIDC-IDRI) consists
of diagnostic and lung cancer screening thoracic computed tomography (CT) scans with marked-up annotated lesions. The inputs are the image files that are in DICOM format, it is important to note that in order to preserve the original values of the DICOM images as much as possible; no scaling.

Results of VGG-16 & Improved VGG-16 Models







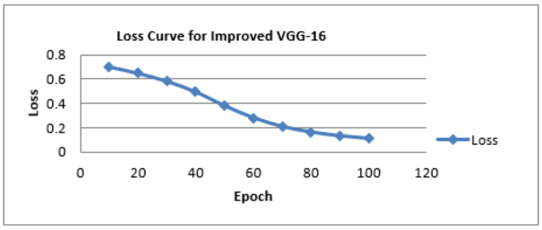


Figure.3 Results of Classification

In this research paper, Lung nodule classification models' comparative analysis has been made and it is implemented in MATLAB 2018b. The dataset used for training and testing purposes are taken from LIDC-IDRI to get familiarize with lung cancer. Here the images samples are used to feed the network model which is able to detect and identify the presence of cancer that is cancerous images and Non-Cancerous Images. As it is observed from the results that as training proceeds further classification accuracy will be increases with increase in the computation time, thereby decreases the percentage of loss as shown in above output graphs.

V. COCLUSION

In this research paper, VGG-16 and Improved Convolutional neural networks for classifying the CT images of lung into cancerous and non-cancerous were discussed and its comparative analysis has been done. Thus, Improved VGG-16 model's performance is better then VGG-16 model. Thus, preprocessing has been done before applying input CT images to network model to make equal sizes and format of the images. The dataset used in this research work belongs to LIDC dataset. Hence an accuracy of 86% is achieved with comparatively less false positive rates. Improved VGG-16 achieved accuracy of 97%.

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