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Lung Nodule Detection using Deep Learning Algorithm

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A B S T R A C T

Nowadays lung cancer has become a huge death-threat which is threatening human health worldwide. Lung nodules are one of the major issues for cause of Lung Cancer. Lung nodule classification plays an important role in diagnosis of lung cancer which is essential to patients' survival. Lung nodules is a small growth in the lung. Nodules are described in two types. Benign and Malignant Nodules. Benign Nodules are noncancerous and do not spread to other parts of the body whereas Malignant Nodules are cancerous and can grow or spread quickly. The symptoms caused by the Malignant lung nodules are shortness of breath, wheezing or hoarseness, Chest Pain, Back Pain and Fatigue. The Detection and classification of lung nodules can be done by using convolutional neural network and we can get texture features of lung image to analyses the nodule detection. The dataset which will be in images form which are extracted by using Computed Tomography (CT). CT images are the most effective means to detect lung cancer nodules. The Algorithms which been used to detect the Lung nodules are Convolutional Neural Network (CNN) and Transfer learning. The Lung nodule detection is mainly used to detect early stage of lung cancer and the sizes of the nodules. The transfer learning will be applied in small labelled medical image dataset by using pre-trained model dataset. The dataset is taken from the LUNA16 (Lung Nodule analysis 2016) of CT images form.

Keywords:Lung Cancer, Transfer Learning, Convolutional Neural Network, Computed Tomography, LUNA16.

1. INTRODUCTION

Lung Cancer is the most common malignancy and is the leading cause of the cancer deaths worldwide. Lung Cancer deaths are increasing day by day. One of the reasons for Lung Cancer is lung nodule. Lung Cancer is also known as Lung Carcinoma. A Lung nodule is an abnormal growth that forms in a lung. One person may have one nodule on the lung or several nodules. Nodules develop in one lung or both. There are two types in lung nodule. One is Benign and another one is Malignant Nodules. Benign Nodules are non-Cancerous. They do not spread to other parts of the body. Most lung nodules are benign. Malignant Nodules are Cancerous and they spread all over the body very quickly. Malignant Nodules are led a person to death. According to reports approximately 18% death rates are cancerous.

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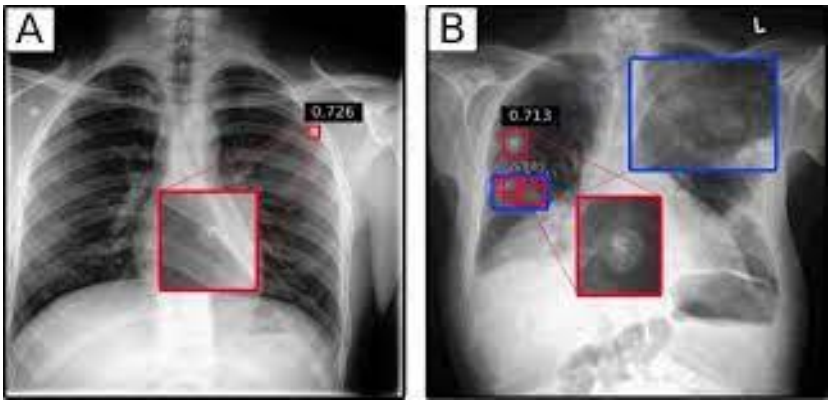

Figure 1: Original Image and Fake Image

Deep learning such as Convolutional Neural Network, Transfer Learning and 3D Thoracic MR Images are used to detect and classify the lung nodule. Convolutional Neural Networks (CNN) to improve the classification performance of pulmonary nodules in CT scans. They give the accurate results in for classification and detecting the lung nodules. CNN has three layers which are named as convolutional layer, pooling layer and fully connected layer. The CNNs utilize convolutional layers to extract features and each layer plays its role for extracting the nodules. The complex features are extracted by the last convolutional layer which are utilized in fully connected layers to extract the complete shape information. The features such as edges are extracted by the first convolutional layers. Whereas, the middle pooling and convolutional layers extract features with considerable complexity. For more accurate results we intended to use 3D Thoracic MR Images. By using this method, we can accurately separate the Benign and malignant nodules at early stage of lung cancer to avoid the chance of death.

2. RELATED WORK

Zhu, L., &Gao, J. describes about the detection of lung nodule with high false positive rate and low sensitivity with 2-d and 3-d dimensional convolutional neural network (CNN) as the lung nodules which cannot have good accuracy values in CT scan. Neuropeptide corella act as a neuro-modulator neuropeptide correlative substances in the plasma of patients will cause various types of lung injuries like nodules.As when long nodules were decreasing, the accuracy rate is having high because the pulmonary sarcoidosis is affecting the accuracy rate.The 2-d and 3-d convolutional neural network (CNN) were compared to reduce high false positive rate. Koo, Y. H., Shin, K. E., Park, J. S., Lee, J. W., Byun, S., & Lee, H. describes about classification of lung nodules in olden days were detected by chest radiography (CR). The CR scans are having low resolution on diaphragm and lung nodules. The deep convolutional neural network (DCNN) is used to detect lung nodules in CR scans and also detect pulmonary oedema, cardiomegaly and pleural effusion. The deep convolutional neural network (DCNN) having 25 layers and eight residual connections. The DCNN will handle noisy images of CR scans.

Chen, Y., Wang, Y., Hu, F., Feng, L., Zhou, T., & Zheng, describes about the comparisons of dense connection, pooling layer and input pixel size of CT image which are in convolutional neural (CNN) as dense connection and dropout layer will be utilized in lung dense neural network (LDNNET). LDNNET network purposes the CT images of lung nodule classification which it takes end-to-end advantage of deep learning and classify CT images without parenchymal

segmentation and lung nodule segmentation (pre-processing). The LDNNET is utilised to reduce overfitting. LDNNET is having Dense-Block and batch normalization (BN).Saba, T describes about the classification of lung nodule which was based on the voting of multiple classifiers.Multiple classifiers voting will reduce the noise and enhance the image quality. it is having multiple steps including lesion enhancement, segmentation, and features extraction. As the multiple classifiers having logistic regression, multilayer perceptron, and voted perceptron which are tested for the lung nodule classification using k-fold cross-validation process. It will detect false positive rate and reduced to generate a final set of computer-aided design (CAD) marks.

Ali, I., Muzammil, describes about detection of benign or malignant nodules in which malignant nodules are dangerous which lead to lung cancer. It can be detected by Convolutional neural networks (CNN) with transfer learning and Energy Level. Transfer Learning will transfer the knowledge of pre-trained modelled small dataset to another dataset. It is having three Convolutional Layers and one Energy Level (EL). The transferable texture in CNN will classify the performance of lung nodules. Backward propagation technique is used to learn the texture features during the training process.

Naik, A., Edla, D. R., & Kuppili, surveys the modules which are used to detect lung nodules for causing lung cancer. Deep Learning techniques are been used to classify the nodules. The techniques used are Recurrent Neural Network (RNN), Recursive Neural Network (RvNN), Deep Belief Network (DBN), Deep Boltzmann Machine (DBM), Auto encoder, Variation Auto Encoder (VAE), Stacked Auto Encoder, Deep Residual Network, Convolution Neural Network (CNN) and Generative Adversarial Network (GAN). The accuracy of regularized multiple kernel learning algorithm is 96.35% which is high when compared to other algorithm in deep learning.Zhang, B., Qi, S., Monkam, P., Li, C., describes MULTI-STRUCTURAL DEEP CNNS BASED METHOD to distinguish benign and malignant pulmonary nodules. The main aim of this paper is to overcome the limitations of single learner. The proposed method takes less amount time compared to previous model (single learner). However, the proposed model has limitations such as it produces higher computational cost which should be less and if the primary learner is deep CNN, then the training time should be longer and to be taken in account.

Wang, J., Wang,author describes nodule-size-adaptive deep model for candidate detection, false positive. This model uses FEN (feature extraction network), RPN (region proposal network) and RCN (region classification network). The main aim of the paper to overcome the challenges of automated detection of pulmonary nodule. The proposed model has superior performance in detection of small nodules and detects the candidate very fast.However, the proposed model fails detect each and every nodule and, in some times, it may recognize the small tissues as nodules.Kaung, Y., Landescribes multi-discriminator generative adversarial network (MDGAN) model combined with an encoder for the classification of benign and malignant pulmonary nodules.This paper uses unsupervised machine learning and unlabelled data for nodule detection. The main aim of this paper is to detect the nodules even by using unlabelled data. The proposed model has higher accuracy a sensitivity compared to other models. However, the excessive usage of discriminators only increases the complexity but not the efficiency.

Zheng, J., Yang, D., Zhu, Y., Gu, W., Zheng, B., Bai, C., ... & Wang, describes about Pulmonary nodules risk classification in adenocarcinoma using Deep Convolutional Neural network (CNN) with scale transfer module (STM) and incorporate

multi-feature fusion operation, named STM-Net.The main aim of this method is to predict the risk in early stage with accuracy. The proposed method has Computer Aided Diagnosis (CAD) and semi-supervised FCM clustering algorithm to cluster the features. This method is more effective for diagnosis of pulmonary nodules risk classification in adenocarcinoma in early-stage. This method failed to give accurate results for non-uniform distribution of pulmonary nodules and also affects classification accuracy.Xie, Y., Xia, Y., Zhang, describes about multi-view knowledge-based collaborative (MV-KBC) algorithm and how it works. The aim of this method is to detect the malignant nodules on chest CT in early stage. The proposed model has 3-D lung nodule characteristics by decomposing a 3-D nodule into nine fixed views. The author also introduced Computer Vision Technology. This method has high accurate rate but failed in to achieve the same performance has ImageNet Challenge on routine lung nodules.

Zhang, Q., & Kong, X describes about Multi-Scene Deep Learning Framework for Design of Automatic Lung Nodule Detection. The main aim this method is for increasing the accuracy and significantly reducing false positives in an enormous amount of image data in the detection of lung nodules. This proposed model has 2D CT multi-scene images for the identification of nodules. But this fails to obtain accuracy results while detecting the nodules.Ali, I., Hart, G. R., GunabushanamIn this paper the author describes the detection of nodules by Deep Reinforcement Learning. In this algorithm it takes a raw CT image as input and views it as a collection of states, and output a classification of whether a nodule is present or not. By Using Reinforcement Learning it can approach to address lung nodule function. The purposed model is always in learning state with every new subject, the model expands its learning by providing the new information and memory of historical information from previous subjects. It may help to save unwanted follow-up tests and cost. Cristin and Daniya et al describes the various application like forgery detection, Text recognition,Cancer detection in the field of Machine Learning.

Sahu, P., Yu, D., Dasari describes about the shape and size of the nodule as they are the essential indicators of malignancy in lung cancer diagnosis. CNN is used to view the sampling of lung nodule in cross sections from different angles. The aim of the paper is to classify the lung nodules and estimate the probability of malignancy using CNN. Proposed a lightweight, multiple view sampling based multi-section CNN architecture and encodes the nodules volumetric information into a compact representation by aggregating information from its different cross section via a view pooling layer.Li, Y., Zhang, L., Chen, H., & Yang describes about to detect the lung nodules using MR images. As the size of lung nodule differs, cropping each region with a fixed size may be not reasonable. To solve this problem, the author proposed Faster R-CNN is designed for lung nodule detection in this paper. It is the first attempt to detect lung nodules in thoracic MR images. Different from nodule detection methods in CT, the proposed method takes the whole image as input and no candidate extraction is needed. It can detect nodules with different sizes and types.

3. METHODOLOGY

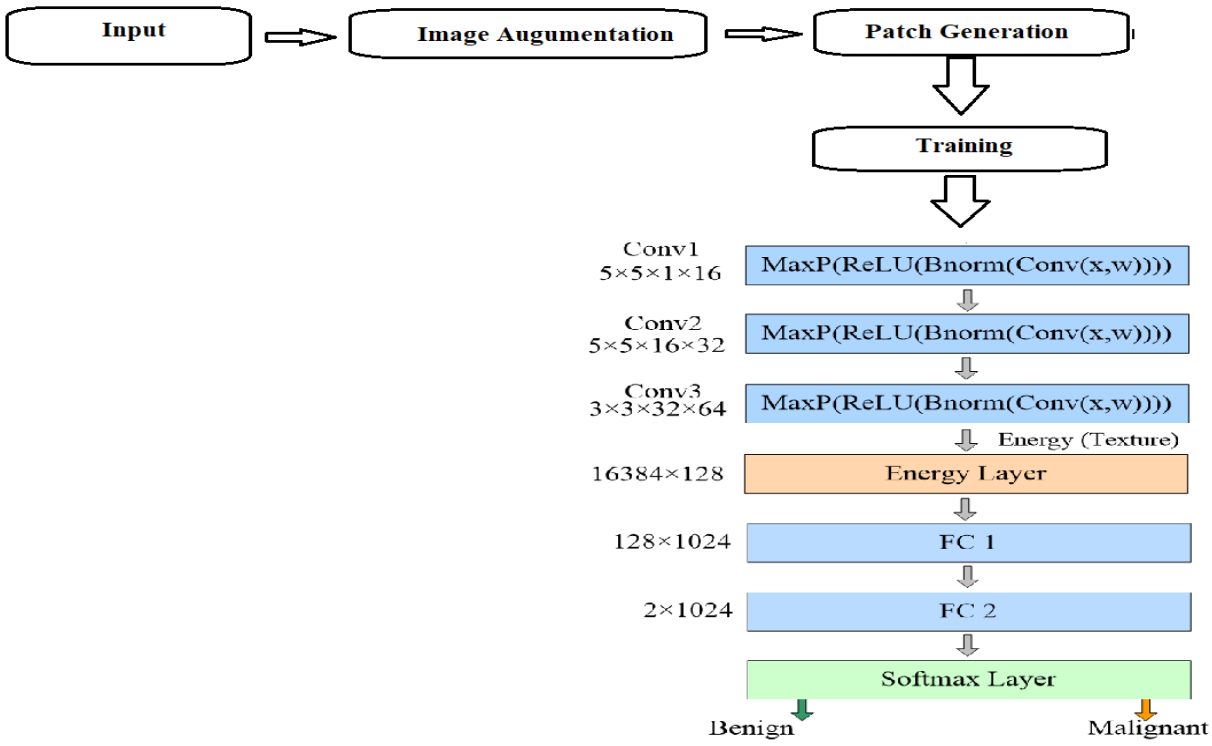

Figure 2: Flow chart of lung nodule detection process

Image Augmentation: -

More amount of sample data can effectively improve the deep CNN training and testing accuracy by reducing the loss function, and will improve the robustness of networks. Image augmentation is a technique to increase the performance of a deep network with small training data. Image augmentation unnaturally will increase training pictures by generating changed copies of the initial images by victimization numerous image process operations, such as; translation, resize, random rotation, flips and shear, and so on. The size of the dataset is increased using random rotation for training the deep CNN.

Patch Generation Technique: -

The path generation is done in two phases. In the first phase, Region of Interest (ROI) around the nodule is extracted by acquiring the central coordinates (x, y, z) and slice number of malignant and benign nodules. Then voxel coordinates are acquired by taking some pixels around the central coordinates. In the second phase, all the patches are extracted by using voxel coordinates which were extracted in the first phase. The same central coordinates (x, y) for each slice during the extraction of every patch.

Convolutional Layers

The kernel size for the primary 2 layers is five x 5, whereas, the output channels are sixteen and 32, respectively. The third convolutional layer is taken into account as intermediate layer to extract the feel features. it's 64 output channels and 3 x 3 kernel size.

Pooling Layer

A pooling layer reduces the feature map size and conjointly reduces the computations and weights that ends up in management over fitting the network. during this model, each feature map from consecutive convolutional layers is directly pooled by computing the utmost of its ReLU (Rectified Linear Unit).

Energy layer

The energy layer that consists of energy descriptor is unbroken at the last convolutional layer. it's wont to learn the feel features. It enhances learning capability of network additionally to reduction of vector size for next absolutely connected layer. This additionally reduces the quality of the projected network while not compromising the accuracy.

Fully Connected Layer

Dense Layer is another name for Fully Connected Layer. These provide learning features based on all possible combinations of the preceding layer's features. It keeps a mapping between input and output.

SoftMax Layer

The SoftMax is used as a classifier. The objective of the classifier is to narrow down the difference between the probabilities of the actual label and predicted label. It distinguishes the benign nodule, malignant nodule from the given input data.

Back Propagation Algorithm

The Back propagation algorithm is a neural network algorithm which computes the gradient of the loss function for a single weight by the chain rule. It with efficiency computes one layer at a time. It computes the gradient; however, it doesn't outline however the gradient is used. The model is trained using the back propagation algorithm with 2D -parameters which are updated by stochastic gradient after the calculation of cost function in iterative manner. In this algorithm the weight is decayed nearly to zero for every iteration, which improves the learning efficiency of the input parameters.

4. CONCLUSION

In this paper, we have done image augmentation, patch generation techniques. We also performed training and testing on the datasets. We have taken the datasets of lung CT scans of LUNA16 from online. In this we use CNN for classification of the lung nodules. We particularly focused on Layers in the CNN. We mainly introduced Energy layer for texture features extraction. We make use of the Back propagation algorithm. Finally, we have successfully separated the Benign and Malignant Nodules and identify the lung nodules with 79% accuracy. But we faced issues while pre-processing the datasets.

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