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Segmentation of Lung cancer using Deep learning

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Abstract: ***Lung cancer is one among the deadliest and dangerous widespread diseases that create a major public health problem. The main aim of this paper is to basically segment the image or to identify the nodule present in the image and provide the accuracy of that segmented image. In this concern, proper segmentation of lung tumor present in the X-ray scans or Magnetic Resonance Imaging (MRI) or Computed Tomography (CT scan) is the first stone towards achieving completely automated diagnosis system for lung cancer detection of the patient. With the advanced technology and availability of dataset, the time required for a radiologist can be saved using CAD tools for tumor segmentation. In this work, we use an approach called data driven for lung tumor segmentation from CT scans by using UNet. In our approach we will train the network by using CT image with tumor having the slices of size (512 × 512 × 1). Our model has been trained and tested on the LUNA16 dataset considering 10 patients, provided by or used by Lung image database consortium (LIDC) and the image database resources initiative (IDRI). In this dataset, our proposed technique will achieve an average dice score of 0.8507. This can further be analyzed or used for other medical images to find the nodule or with other applications such as in brain image segmentation and liver image segmentation.***

Index Terms**: *Lung cancer; deep learning; segmentation using U-Net.***

I. INTRODUCTION

Lung cancer is one among the most common cancers, with over 225,000 cases diagnosed, and 150,000 deaths due to it, and 12 billion dollars spent yearly on medical health care centers in the U.S to curtail the deaths of cancer patients. It is also one of the fatal cancers; taking every disease into an account in U.S[1] 17% of people are getting diagnosed with lung cancer. Trained radiologists or the most experienced radiologist doctors are required for detecting the various types of cancer at the early stage itself and detecting the cancer in the starting stage requires that it should be more accurate. The premature detection of the lung cancer leads to cure of the disease at the early stages and the case of the patient doesn't get complicated in any of the perspective. The main task of the radiologist is to recognize or detect the cancer on premature stage with more accuracy so that millions of lives could be saved across the world. The CT Scanned or the MRI images are used for the detection and segmentation of the cancer is shown in Fig.1. The stages of the cancer are the process of metastasis; there are four stages in the cancer - Stage 1 and Stage 2 refers to the cancers at the early stage and the later stages like Stage 3 and Stage 4 refers to the stages that the cancer has been outspread over the other tissues or parts of the body organs [2]. The present generation, the cancer is diagnosed by using the CT scans or the MRI Images of the patient lungs. The detection of the lung cancer is mainly done using computer aided methods for more accuracy and cost reduction so that leads to curing of the disease easier and successful. Deep learning methods are capable of tackling a variety of problems

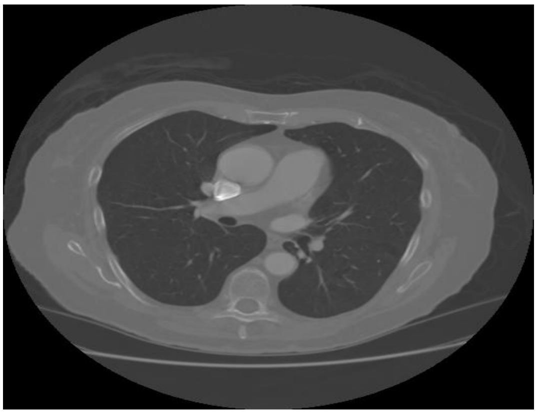

Fig.1: CT Scan Image of Lung

such as object recognition, speech recognition and natural language processing. Deep learning mainly CNN is used for extraction, this is widely used because it extracts features by using multilayer convolution and max pooling methods. CNN allows us to extract multiple features which are present at the hidden layer as well. We have to use a convolution neural network which consists of mainly some layers in the network they are two convolutional layers i.e. pooling layer and a drop out layer for segmentation [3]. Pooling is nothing but another building block of CNN; the main concept of pooling is to reduce the size of representation and also helps in reducing the estimation in the network. Predominantly max pooling is used and next layer is dropout layer which is used to prevent the neural network from over fitting; it means ignoring the neurons which are randomly selected during the training time. In this paper, our main aim is to build a computer aided diagnosis (CAD) system.

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This system takes input as the CT scanned image of the patient chest and provides the result whether the patient affected by the disease or not. As the task looks like simple kind of job but it's too difficult to diagnose the cancer at the premature stages, because the CAD system which we build should be able to detect the tiny part of the lung which is affected with cancer cells,

if it fails to detect then it leads to less percent of survival as the cells spread over the body organs So the pipe lining of our project would be, Image preprocessing → Segmentation of lung using CNN

1.1. Lung cancer Description:

The Lung cancer is normally found or present in the lung part or at the lower part of the lung tissue. The cancer will spread all over the body organs within a short time. Lung cancer is the major and fatal cancer where death rates are high around the world in human beings. Because of the lung cancer percentage of deaths are more year by year w.r.t various cancers like colon cancer, prostate cancer, ovarian cancer and breast cancers. The most and various types of cancers among lungs are Small cell lung cancer i.e. (SCLC) and the second will be Non-small cell lung cancer(NSCLC) [4]. Small cell lung cancer normally occurs in a person irrespective of gender who is a heavy smoker. NSCLC is a particular term among various types of lung cancers and most common cancer among all types. NSCLC will mainly include squamous cell carcinoma, adenocarcinoma and large cell carcinoma.

1.2. CNN description:

The CNN is basically built based on the neurons present in our body which is the connectivity pattern between the neurons. It includes an input layer and an output layer, along with these it also include multiple hidden layers as well . The hidden layers of the network in the CNN include the convolutional layers, pooling layers and RELU layer. Pooling layers is used for representing the data by combining both the outputs of neuron clusters of one layer into a single neuron of the next layer to reduce the size. Fully connected layers is used to connect each neuron of one layer to each and every neuron in another layer.

1.3. Symptoms:

Symptoms are nothing but falling down or downfall from normal condition to an abnormal condition. Lung cancer does not cause any of the signs or symptoms at premature stage of the patient. The symptoms of the lung cancer are seen when is it in the later stages i.e. at the 3rd or 4th stage of the cancer [5]

- Cough that will not get cured easily
- Coughing with blood
- Breathing problem
- Weight loss
- Headache
- Bone pain
- Chest pain

1.4. *Causes*:

The main cause for the lung cancer is due to smoking. Lung cancers occurs for smokers as well as for passive smokers as well who inhale the smoke. Smoking with second handed also lead to lung cancer. Even if someone does not smoke, the risk of causing the lung cancer increases if they are exposed to 'shake hand' smoke. It means that when some person has smoked, the cancer spreads when one shakes hand with that person. Chances of disease getting outspread can be occurred by Family history as well or the hierarchy; i.e. if someone in family might have suffered with this type of lung cancer may occur to his or her family members [5].

1.5. Complications:

Lung cancer may lead to some of the complications [5], i.e.

- Coughing with blood from mouth
- Breathing problem
- Cancer that spreads to other tissues or other parts of the body, the spreading process is called as metastasis.

1.6. Preventions:

There's no precise or exact way or the path to prevent [5] lung cancer, we can reduce the risk of the lung cancer by following the below activities:

- Don't try to smoke or reduce smoking
- Avoid shake hand smoke
- Eat healthy foods.
- Do Exercise more in a day or do yoga.

II. LITERATURE SURVEY

The standard American Cancer Society is so far estimated that the number of lung cancer cases for the year 2019 with 228,150 new cases and 142,670 death cases. In the previously published journals, survey papers & conferences held around the world, we reviewed and highlighted their works for lung cancer diagnosis. Among all the papers, we noticed in a few papers that preprocessing and lung segmentation was the main step, but in some others, thresholding [6] was the main step along with preprocessing. Different datasets were used by researcher and reviewed; Lung Image Database Consortium (LIDC) provided large dataset with more number of CT images with required information. Some survey papers used kaggle dataset. As far as our literature overview or the survey, we found that among all only few or some researchers have used deep learning algorithms in lung cancer diagnosis. We will do segmentation using CNN because when compared to threshold, the corner nodule will not be detected and hence, we will get less accuracy. The literature survey tells about the previous papers what the process is used by the different researchers in detecting the lung nodule present in the cancer patient. The most used method is filters for the preprocessing and the thresholding is used mainly in almost all the surveys for segmentation.

III. DATASET

Dataset for diagnosing the cancer is mainly obtained from Lung Image Database Consortium (LIDC) and Image Database Resource Initiative (IDRI). LIDC and IDRI consist of 1000 CT scans of both small & large tumors which are saved in Digital Imaging and Communications in Medicine (DICOM) format [7] [8].

IV. METHODOLOGY

In our methodology, we will use patient CT scanned images of lung cancer for segmentation and along with segmentation we will use normalization, down sampling and zero-centering. The initial approach and the first step is to simplify the input image and process the CT scanned images of patient to CNN's but the results what we expected was almost unpredictable. It means the results were poor, so considering the poor results we used an additional preprocessing of the images to identify the region of interest and then convert it to CNN's. To identify the ROI's, we used and trained a U-Net for nodule detection This paper presents the detection of lung cancer based on chest CT images using CNN. In the early first stage, lung regions are extracted from CT image using the morphological operations in the preprocessing step and after this, each slices are segmented to extract the tumors. The segmented tumor regions are input to the CNN architecture. Then, CNN is the method used for segmentation. The main purpose of the case study is to diagnose whether the tumor is present in a patient's lung or not. The Fig. 2 demonstrates the block diagram or the pictorial representation of the proposed system.

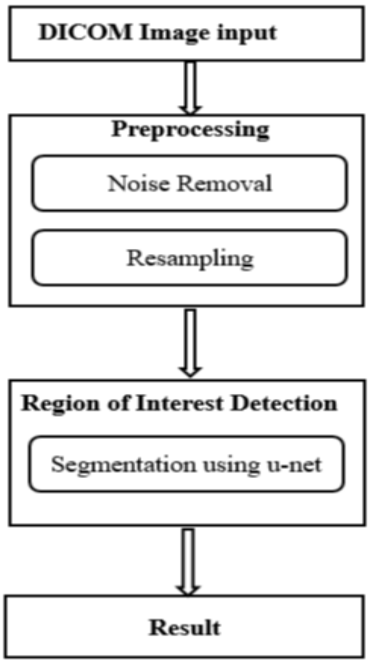

Fig.2: Proposed Methodology

2.1. Preprocessing:

Preprocessing is applying some transformations to our data before providing the image to any of the algorithm. Basically data preprocessing is a technique used to convert the raw Image data into clean data to identify the image for further steps. In other words, the data which us collected from different source is a raw data which cannot be used for analysis, so hence preprocessing is done by using morphological operations. In our proposed methodology we use morphological operations for removing the noise and other obstacles. The mainly used morphological operations [9] are the dilation, the erosion, the closing, the opening and hit-or-miss transform. Among all of the we mainly apply morphological closing i.e. (dilation and erosion) on the image. The dilation mainly fills the pixels which are caused by the lung or the pulmonary vessels of the lung. The main effect of dilation is to "grow" or "widen" objects present in the binary images whereas, in the erosion the outcome is to "shrink" or "Compress" the objects. The thickening and thinning of the image are controlled by the shape and size of the nodule element. We use the erosion as well; the main objective of the erosion is to erode away the boundaries of the region. For every patient, at the first step we mainly convert the pixels of each image to a Hounsfield units (HU) values, the measurement of radio density values and based on these values we remove out the slices into a single image we use segmentation to mask out the particles present in the CT scanned image i.e. bone, outside air present while fetching out the image, and other obstacles that makes our image noisy, and left out only lung tissue information for the classification. The distinctive radio densities values of various organs or parts of a CT scanned images are provided in Table 1. Firstly, the values of Air are around −1000 HU units, secondly values of the lung tissue will be around −500 units, third the values of water or blood and along with other tissues will be around 0 HU units, and finally the value of bone is around 700 HU units, by this values we mask out pixels of the image that are above−320 HU units or close to −1000 HU units, these are mainly used to extract lung cancerous tissues as the one and only segment from the lung image. Pixels thresholder at 400 HU units, and the masking that are used to make an account for the possibility of some occurrence in cancerous growth within the bronchioles (air pathways) inside the lung, we choose to include this air to create the finalized mask.

Table 1: Intensity HU units for CT scans [10]

Substance	Radiodensity (HU)
Air	-1000
Lung tissue	-500
water and blood	0
bone	700

2.2. Region of interest:

The segmentation contains a lot of obstacles or the noise obtained from threshold that have many pixels which were part of lung tissue, due to CT scans, the noise is present or most of the pixels are identified at the image edges which tends to fall outside of the range. Just because of this most of the classifiers will not classify the images accurately which are located at the edges of the lung. We use convolutional neural network for this type of edge detection, to filter out the noise and various particles which includes the pixels of the edges.

2.3. Nodule detection by using U-net:

The CT scanned images of the patient generally contains a detailed pattern of data or dots of an object, the object will be taken out from the image (e.g., brain tumor), and the object edges would be a variable. To have more scope with segmenting these objects we use more specific and detailed patterns, the proposed CAD system uses the skip level architecture that combines with the quality representation of the decoding layers resembles the appearance as exactly the same representations from the shallow encoding layers which is used to produce a detailed structured segmentation. [11] Basically this method has tremendously demonstrated results when applied on the natural images and it is also applicable for biomedical images, the network U-Net, which basically describes the skip level architecture is used to resolve the problem of the cell tracking. The network architecture U-Net mainly consists of one down-sampling i.e. (encoding) path and one up-sampling i.e.(decoding) path. The down-sampling path will have 5 convolutional blocks. Each convolutional block will have two convolutional layers with the size of filter would be 3×3 which is placed at the strides of each 1 in both directions and the activations of the rectifiers, which actually increases the feature maps i.e. from 1 to 1024. For down-sampling of the network we use max pooling with a filter sized stride of 2×2 matrix which is applied to the last or the end of each and every blocks except the last one convolutional block, by doing this the size of feature maps obviously decreases. In the up-sampling path, each block begins with a deconvolutional layer with size of filer would be 3×3 and a stride of 2×2, which is used increase the size by two times of feature maps in either ways or in both the directions but which leads to decreasing in the number of feature maps by 2 numbers, so the size of feature maps increases. In each of the up-sampling block, two convolutional layers are used which actually reduces the number of feature maps by concatenating the deconvolutional feature maps and often some of the other feature maps as well from the encoding path. Apart from all these i.e. the unmodified U-Net architecture, we use a separate method or process called zero padding, mainly used to place the dimension of the output of all the convolutional layers i.e. of both the down sampling as well as the up-sampling paths. Finally, a sized matrix of 1×1 convolutional layer is used, which reduces the number of feature maps to two, the main or the basic function is to reflect the foreground and background segmentation respectively. We do not use any of the fully connected layers in the network

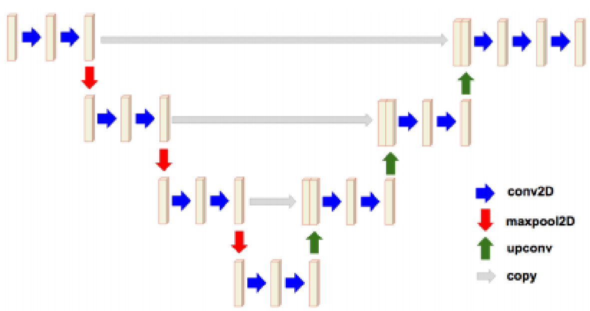

Fig.3: U-Net architecture

The visualization or the architecture of the U-Net is been included here which is shown in Fig.3. During training of the architecture, the altered or the modified U-Net takes an input of 512 × 512 2D CT image scanned slices, and labels them as provided (512× 512 mask where nodule pixels are 1, rest other are 0).

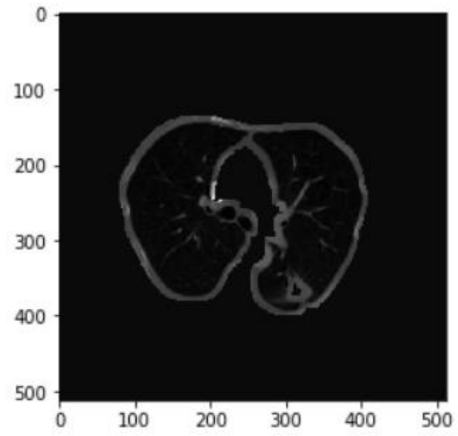

Fig.4: U-Net Input

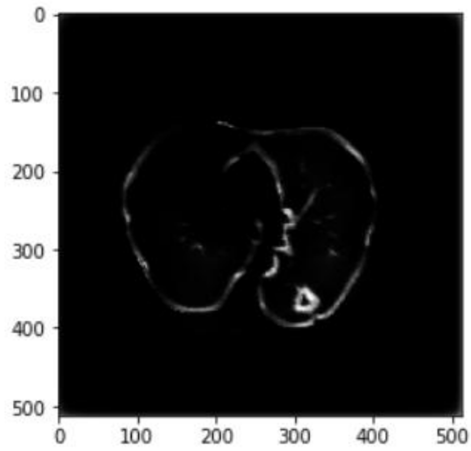

Fig.5: Predicted Image

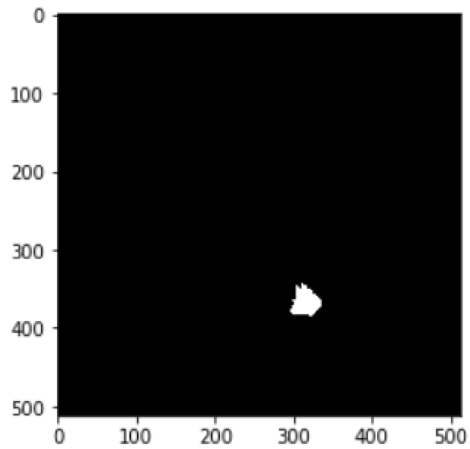

Fig.6: Ground truth Image

The model is trained on to provide an output image with the size of shape 512 × 512 where each pixels of the shape or the output contains a value which is in between 0 and 1 which indicates the probability of the pixel which belongs to a nodule.

This is repeatedly done by taking out the slices corresponding to the labeled one of the final U-Net layered architecture. Corresponding U-Net inputs, labels, and predictions on a patient from the LUNA16 validation set.

Once the U-network architecture receives the processed image as shown in Fig.4, the network architecture will go ahead and performs certain operation according to the image and provides the predicted image which is shown in Fig.5 along with that we receive a ground truth image as well which is shown in Fig.6.

V. RESULTS

In our proposed work, the generated images of the segmented contours are compared over the manual contours for all the test scanned images using evaluation metrics. Dice Coefficient is a measure of relative overlap, in which the co-efficient 1 represents perfect agreement and the co-efficient 0 represents no overlap [12].

$$D=\frac{2|P\cap Q|}{|P|+|Q|}$$

where ∩ denotes the intersection operator, P and Q are the ground truth and test regions of the images. Please note that dice coefficient (D) has a restricted range of [0, 1]. We will run our code on a GPU in order to get the greater acceleration for the execution, with Tensor flow backend. The network parameters were set to Batch size of 4 and Number of epochs is set to 10. In order to evaluate the performance of our network, we will dice co-efficient for the index. With our proposed U-net network, the average dice coefficient index has reached to 0.8407

VI. CONCLUSION AND FUTURE WORK

The deep 3D CNN models such as the Google net-based models, perform the best and provides more precisely on the test set. We process the data using with less labeled data than most of the other CAD systems. As a fascinating thing that the older models labeled as positive feed for cancerous images using first activation layer. The bright pixels normally respond to locate the cancerous nodules, our current U-Net model has a possibility of extension to ascertain the exact location of the cancerous nodules present in the Scanned CT image of the patient. The future work related is classify the detected nodule whether the scanned image of the patient has tumor or not (basically it is to sort whether the image has lung cancer or not). Other opportunities for improvement or the future work is to include by making the network still better or use more layers for better performance, and more extensive parameters can be used for tuning.

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