Implementation of Image Processing Techniques for Identifying Different Stages of Lung Cancer

Anjali Sevani[1], Hardik Modi[1]

[1]*Charotar University of Science and Technology,
Changa - 388421, Gujarat, India.*

Sagar Patel[2], Himanshu Patel[2]

[2]*Charotar University of Science and Technology,
Changa - 388421, Gujarat, India.*

Abstract

Lung cancer is the most dangerous & widespread disease in the world. Lung cancer is the most common cause of the death. 90% of lung cancers are arising due to the consumption of the long time tobacco, cigarette smoking. About 10 to 15% of causes occur who have never smoked. Worldwide in 2012, lung cancer occurred in 1.8 million people and resulted in 1.6 million deaths. The lung cancer can be minimized, if the disease is to detect in initial stage. Although the process of detection of the cancer takes too much time, Hence lung cancer detection system using several image processing techniques to detect whether tumor is present or not and also shows that, in which stage the cancer is present in nodes of the lungs in CT-scan(Computed tomography) image. In this study the software MATLAB is used. Here, we discussed about which techniques are used to detect the tumor and the staging of the cancer and results of that.

Keywords: MATLAB, Image Pre-Processing, Image Enhancement, Binary Image Processing, Feature Extraction, Lung Cancer

INTRODUCTION

Lung cancer is also called lung carcinoma. It is an uncontrolled cell growth tumor in the tissues of the lungs. There are two types of lung cancer: 1.Small Cell Lung cancer (SCLC). 2. Non-Small Cell Lung Cancer (NSCLS) [10]. The size of tumor shows the staging of the cancer in the lung nodes. There are total four stages of the lung cancer in which, if the tumor is in the first or in the second stage, it can be recovered. If the tumor is in the third stage of the cancer it is difficult to recover. Very dangerous stage is fourth stage, in which there is no any chances to remove the lung tumor because the cells of the cancer are spread all the part of the body which is very difficult to recover. As a treatment of the lung cancer, CT(Computed tomogram)-scan, biopsy, radiotherapy, surgery, chemotherapy processes should be done. So In this case Image processing techniques are very useful to detect the tumor or the staging of the cancer and hence we can give the best solution to recover the lung tumor immediately. In our work the whole process is shows to detect the lung tumor and the stages of the tumor. Overall total four

processes are used to detect the tumor. Here the methodology section shows that, which processes are used in our entire work. Image pre-processing, Image enhancement, Binary image processing, Feature extractions are the main processes. Image pre-processing consists resizing the image & grayscale image. For Image enhancement we use Median filter & Morphology methods. In feature extraction we show the Extracted tumor, Boundary detection, Circularity of the tumor, Diameter of the tumor & Stage of the tumor. Results section represents the Experimental results and analysis of whole work, which shows the image of lung cancer, is passes on different processes and also shows the stage of the tumor and different images in different stage. At last the conclusion and references of this work is shown. [1-25]

There are different stages of the lung cancer which are,

Stage I: The cells of cancer are present only in the lungs and have not spread to any lymph nodes. The size of tumor is < 3 cm.

Stage II: The cells of cancer are presents in the lung and nearby lymph nodes. The size of tumor in this stage is between 3 cm to 7 cm.

Stage III: In this stage, cancer cells are occurred in the lung and in the lymph nodes in the middle of the chest. In this stage, the size of tumor is > 7 cm.

Stage IV: This stage of cancer is very dangerous and impossible to recover. In this stage, cancer cells are spread into both lungs or to another part of the body, such as the liver or other organs [11].

METHODS

The whole process of lung cancer detection is divided into four parts:

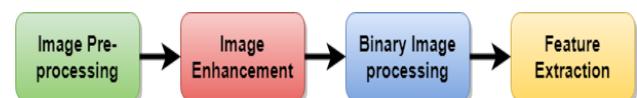Figure-1 shows the flow diagram to detect the lung tumor.

Figure 1: Lung cancer detection diagram

Image Pre-processing

Here, first we resize the image because the sources of different images are different and to specify the stages of the cancer in image processing, image resizing is the most important factor. After resizing, the image is converted into the grayscale image. In Gray scale Image, The value of each pixel is single sample, which carries only intensity information of the pixel. Grayscale image consist exclusive shades of gray. This type of Images are the result of measuring the intensity of light at each pixel in a single band of the light spectrum such as infrared, ultraviolet, visible light etc [12].

Image Enhancement

To improve the quality of the image, Image enhancement is used. This technique can be performed in both domains, spatial domain and in Frequency domain. The objective of the Image Enhancement is to make Image better, improving the quality of the Image. An Enhancement algorithm is used for the purpose of some particular application, which can be done either increasing or the suppressing the noise or contrast of the image. In Image enhancement we can increase or decrease the brightness of the image as per our application. This technique improves the visual perception of the image. Basically, this technique can be classified into two categories [13-15].

1. Spatial domain method.

2. Transform domain method

Spatial domain method are operates directly on the image, while Transform domain method operates on Fourier transform of the image and then again it back into the spatial domain. Enhancement techniques are basically, based on the histograms, because it is very simple and fast. With them acceptable results, we can achieve some application which we want.

This technique accentuates and sharp the image features such as edges, boundaries and contrast, hence we can easily visualize the graphical data inside of the image. For Enhancement we used Median filter.

Median filter

Median filter is a very useful and effective technique to reduce the noise in the image. This filter detects the edges, first noise should be removed in image and then, edge removal is performed. The main use of the median filter is to remove the noise without removing edges. Average filter is also used for noise remove but, in average filter the mid pixel intensity is replaced by the average of pixels in the window hence, some data will be lose. So here we used the Median filter for noise remove. Median filter is one kind of smoothing technique as linear Gaussian filter. All smoothing techniques are very effective to remove the noise, but adversely affect the edges. So it is very important to remove noise as a time preserves the edges in the image.

The main idea of the median filter is to run, replacing each entry with the median of neighboring pixels intensity entries. This pattern of neighbors is called the "window". For 1D signal, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) images, more complex window patterns are possible [16-17].

 These window sizes are commonly used in median filtering:

$$3 \times 3, 5 \times 5, 7 \times 7$$

Example of median filtering application:

3×3 original image:

18	65	80
75	88	55
110	158	230

Median filter uses the full 3×3 neighborhood: 18, 65, 80, 75, 88, 55, 110, 158, 230

Now make this series in ascending series: 18, 55, 65, 75, 80, 88, 110, 158, 230

Hence, the median value of this image is now 80. The original image becomes;

18	65	80
75	80	55
110	158	230

Binary image processing

This step of our research involves some binary operations, for that we use morphology operations. Morphology is used to find the shape and size or structure of the object. We use the concept of structuring element. The structuring element is a mask or window which is placed in original image to find desired output and basically smaller in size compared to original image. The basic morphological operations are dilation, erosion, opening & closing. Here, we used opening and closing, for that first we need to understand dilation and erosion morphology operations.

Dilation

In this operation, the image is expanded from its original shape. It is similar to the convolution process, and it reflected and shifted from top to bottom and left to right. The way the binary image is expanded is determined by the structuring element.

Erosion

Erosion is the opposite of the dilation. In erosion the area of the foreground pixels is shrinks in size, and holes within that area become larger. Erosion is basically used to remove the foreground pixel which is not completely surrounded by other white pixels.

Opening

Opening is based on dilation and erosion. It is simply defined as erosion followed by dilation. It removes some of foreground (white) pixels from the edges of the foreground pixels. In general, it is less destructive than erosion. Somewhat it is similar to erosion. It smoothes the inside of the object contours and eliminate thin parts of the image and breaks narrow isthmuses.

The mathematical representation of the opening is denoted by;

$$I \circ B = (I-B) + B \qquad (1)$$

Where, I = Original Image

B = Structuring element

Closing

Closing is just opposite to opening. It is based on dilation & erosion. Closing is simply defined as dilation followed by the erosion. Closing enlarges the boundaries of the foreground (white) pixels in the image and it shrinks and fills the holes in background region. It is less destructive of the original boundary shape. Closing is somewhat similar to dilation. It also smoothes sections of contours but, as opposed to the opening, it fuses narrow breaks, long thin gulfs, and fills the gap in the contours [18-19].

The mathematical representation of the closing is denoted by;

$$I \bullet B = (I+B) - B \qquad (2)$$

Where, I = Original Image

B = Structuring element

Feature extraction

It represents the interested part of the image. It describes the information in the extracted region. Features of the image can be extracted by its content like colors, textures, shape, position, edges and the regions etc... The selected features are the expected information data from the Input data; hence we can perform the desired task [20-21].

In feature extraction we show the Extracted tumor, Boundary detection, Circularity of the tumor and the Diameter of the tumor. Hence, we can define the stages of the lung cancer.

For extraction of tumor, we use Region of interest (ROI) method. ROI is the samples within a dataset. Basically it is used to detect the area. Using ROI we defined the boundaries of the object and we can know the area of the object [22].

For boundary detection, first draw each boundary over the object and fill the different colors in object using MATLAB software.

For circularity of the object, we use the equation shown below [23];

$$If \ \frac{4\pi area}{Perimeter^2} = 1 \ then \ the \ object \ is \ circle \qquad (3)$$

&

$$If \ \frac{4\pi area}{Perimeter^2} < 1 \ then \ the \ object \ is \ not \ circle \qquad (4)$$

This way, we can find the circularity of the tumor and once object is defined as a circle, then we can find the diameter of the object using region props function of MATLAB. The diameter of the tumor shows the area of the tumor and hence, we can define the staging of the lung cancer.

RESULTS & DISCUSSION

A CT-scanned image of the lungs which is affected by the cancer tumor is shows in figure-2[24].
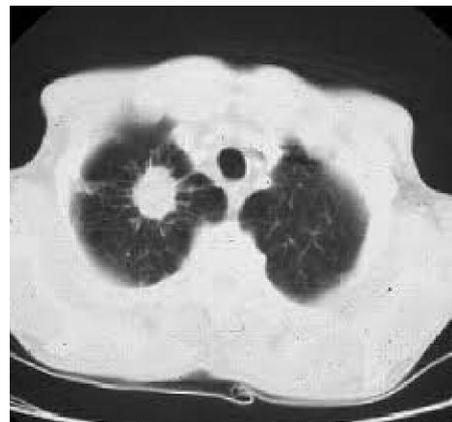

Figure 2: CT-scanned image of lungs affected by cancer tumor

Now this figure-2 is resized to define the stages of the cancer and converted into grayscale image, hence we can easily see the shades of gray. Figure-3 shows the grayscale image of lungs affected by cancer.


Figure 3: Grayscale Image

Now for Image enhancement we used median filter to remove noise from the image without affecting the edges of the tumor. We can use different odd window sizes like 3×3,5×5,7×7 but, here we use 3×3 median filter because it is more effective than other window sizes. figure-4 shows 3×3 median filter is applied on grayscale image.
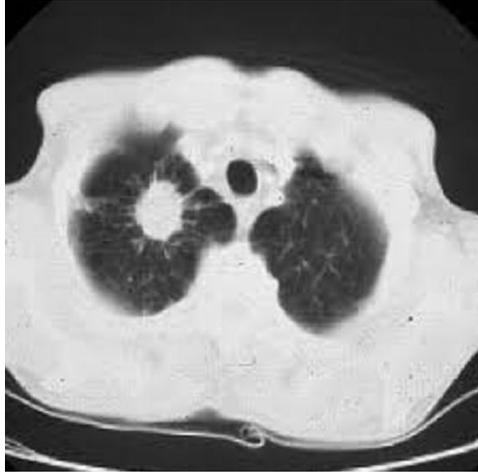

Figure 4: 3×3 median filtered image

Now, we use the morphology methods to get our desired output. To perform morphology operation, image should be binary. Dilation and erosion are the basic functions of the morphology. Here we apply Opening and Closing functions using dilation and erosion morphology functions. Basically dilation expands the objects boundary and erosion shrinks the object. Opening used to eliminate the thin parts of the object, while closing fills the gap of the object. figure-5 shows the opening of the image and figure-6 shows the closing of the image.
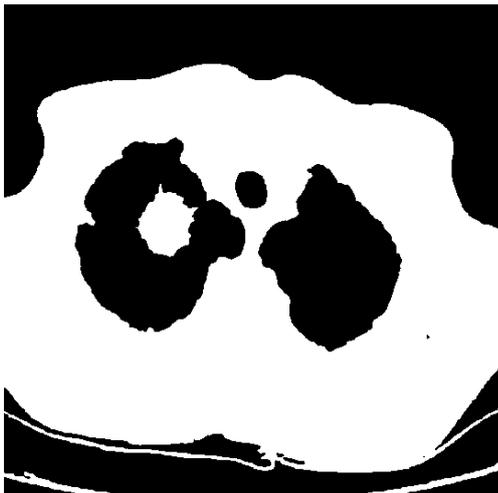
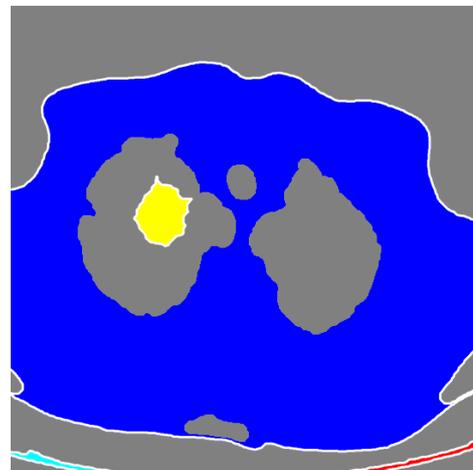**Figure 5:** Opening of the image
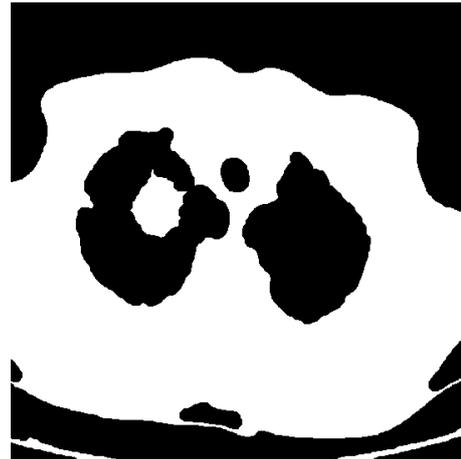
Figure 6: closing of the image

In feature extraction the region of interest is applied to the image hence, we can visualize only the shape of tumor. figure-7 shows the extracted tumor.

Figure 7: Extracted tumor

We can also shows the tumor as a different color which is shown in the figure-8.

Figure 8: tumor shows in a different color

Now to define the stages of the cancer, first we identify the circularity of the tumor, for that we use in equation-(3),

Using equation-(3), we can find the circularity of the tumor and hence we can find the diameter of the tumor which identifies the stages of the tumor. In this image the circularity of the tumor is 0.66 and the diameter of the tumor is 144.13 pixels which shown in the figure-9. Now these pixels are converted into centimeter.

1 pixel = 0.026458333 centimeter [25]

Here, in this image tumor consists 144.13 pixels which is 3.813439583 centimeter, defines the tumor is present in the second stage of the cancer.
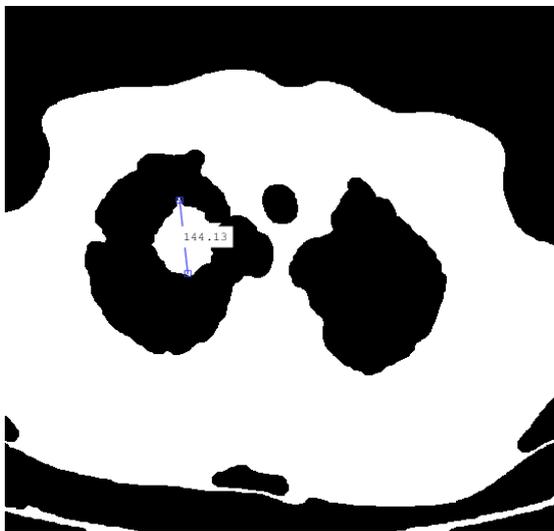

Figure 9: Diameter of the tumor

Stages of cancer

This section shows the pictorial representation of different CT-scanned images of lungs which is affected by the cancer tumor. Total four images are taken which are in different stages of the cancer, from left to right ,flow of the images shows the image is   passes on the different techniques of image processing, which are deeply discussed in this section.

Stage: 1

Diameter: 2.223029167cm

Figure-10 shows the process, in which CT-scanned image of lung cancer is passes on different techniques of image processing. Left most image of Figure 10 is an input image and Right most image of Figure 10 is an output image. The roundness of the tumor is 0.63 and the diameter of this tumor is 2.2230 cm. So, stage 1 of Lung cancer is detected.
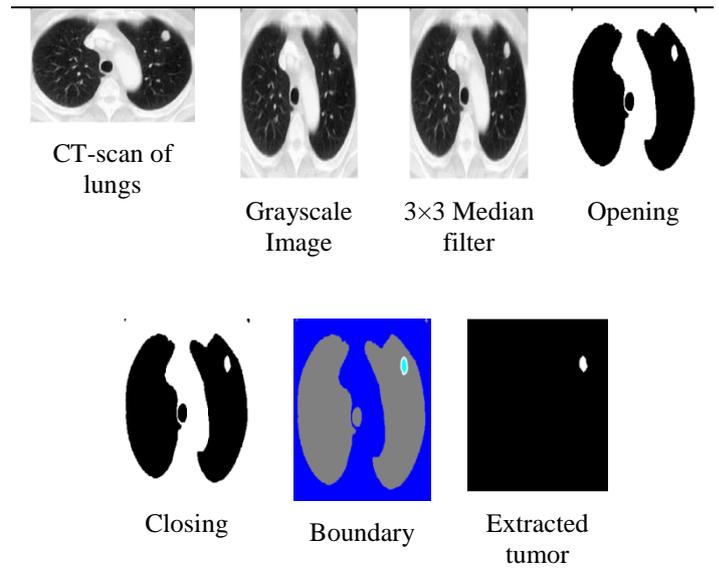

Figure 10: Stage 1 detection

Stage: 2

Diameter: 3.751791667cm

Figure-11 shows the process, in which CT-scanned image of lung cancer is passes on different techniques of image processing. Left most image of Figure-11 is an input image and Right most image of Figure-11 is an output image. The roundness of the tumor is 0.66 and the diameter of this tumor is 3.7517 cm. So, stage 2 of Lung cancer is detected.
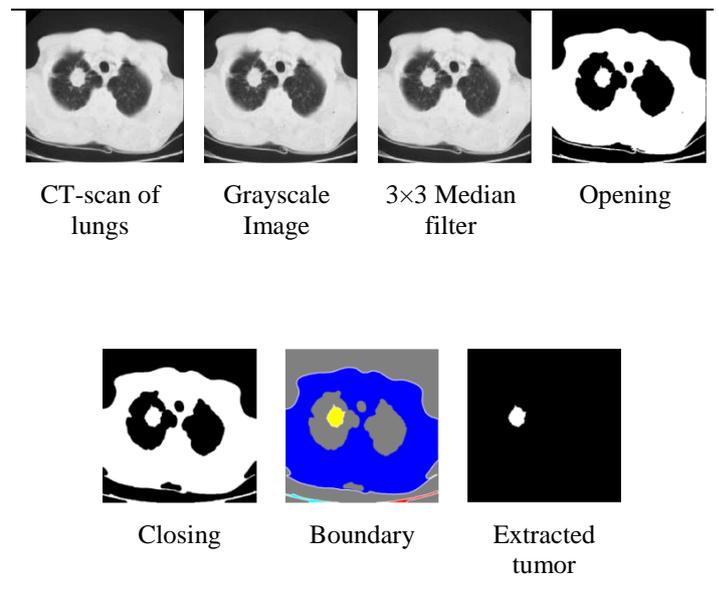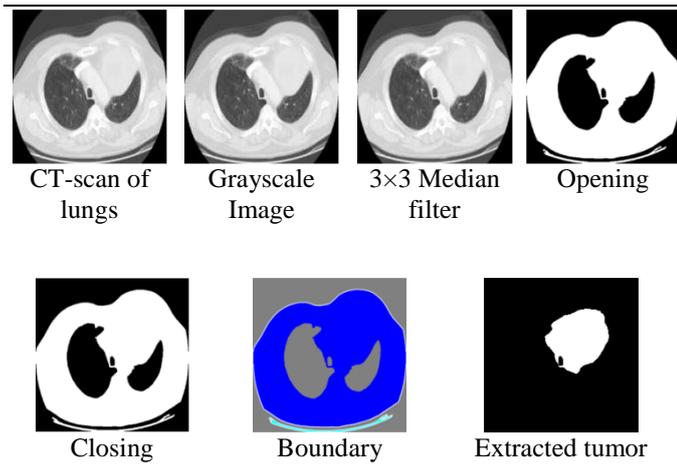

Figure 11: Stage 2 detection

Stage: 3

Diameter: 9.776089583cm

Figure-12 shows the process, in which CT-scanned image of lung cancer is passes on different techniques of image processing. Left most image of Figure-12 is an input image and Right most image of Figure 12 is an output image. The diameter of this tumor is 9.7760 cm. So, stage 3 of Lung cancer is detected.
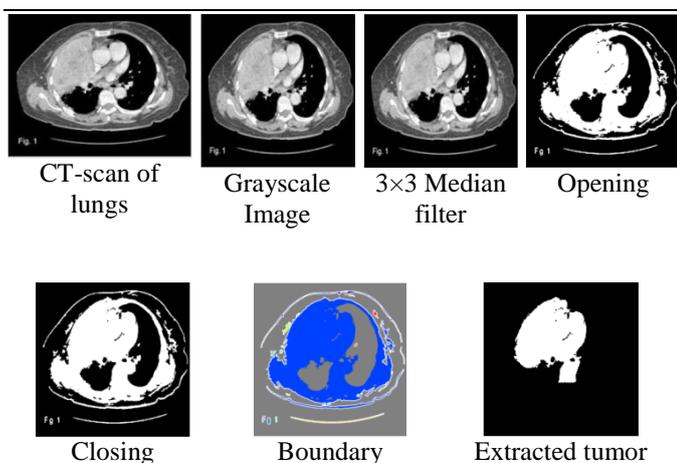

Figure 12: Stage 3 detection

Stage: 4

Diameter: 13.043958333cm

Figure-13 shows the process, in which CT-scanned image of lung cancer is passes on different techniques of image

processing. Left most image of Figure-13 is an input image and Right most image of Figure-13 is an output image. The diameter of this tumor is 13.0439cm. So, stage 4 of Lung cancer is detected.

Figure 13: Stage 4 detection

From above results, our techniques have identified different stages of lung cancer.

CONCLUSION

Lung cancer is one of the most dangerous disease in the world. The expert physicians diagnose the disease by experience. As a treatment of cancer, surgery, chemotherapy, radiation, and targeted therapy are included. These treatments are lengthy, costly, and painful. Hence an attempt is made to atomize this procedure to detect the lung cancer using image processing techniques. Median filter is used to make image sharp and noise free. Binary image processing, which includes morphology method: dilation, erosion, opening and closing. Using this method we can expand and shrink the image as per our desire output. In feature extraction we shown extracted tumor, diameter of the tumor and staging of the cancer. For future work, the proposed methods can also be applied to some other cancer types like brain tumor, skin cancer, stomach cancer, breast cancer etc.

REFERENCES

[1]   Introduction of lung cancer is available: https://en.wikipedia.org/wiki/Lung_cancer

[2]   Makaju, Suren, P. W. C. Prasad, Abeer Alsadoon, A. K. Singh, and A. Elchouemi. "Lung Cancer Detection using CT Scan Images." *Procedia Computer Science* 125 (2018): 107-114.

[3]   El-Regaily, Salsabil A., Mohammed A. Salem, Mohammed H. Abdel Aziz, and Mohammed I. Roushdy. "Survey of Computer Aided Detection Systems for Lung Cancer in Computed Tomography." *Current Medical Imaging Reviews* 14, no. 1 (2018): 3-18.

[4]   Kalaivani, S., Pramit Chatterjee, Shikhar Juyal, and Rishi Gupta. "Lung cancer detection using digital image processing and artificial neural networks." In *Electronics, Communication and Aerospace Technology (ICECA), 2017 International conference of*, vol. 2, IEEE, (2017):100-103.

[5]   Kumar, S. Logesh, M. Swathy, S. Sathish, J. Sivaraman, and M. Rajasekar. "Identification of lung cancer cell using watershed segmentation on CT images." *Indian Journal of Science and Technology* 9, (2016)

[6]   Dimililer, Kamil, Buse UGUR, and K. Yoney. "Tumor detection on CT lung images using image enhancement." In *International Science and Technology Conference (ISTEC 2016)*. (2017).

[7]   Kumar, Devinder, Alexander Wong, and David A. Clausi. "Lung nodule classification using deep features in CT images." In *Computer and Robot Vision (CRV), 2015 12th Conference on*, IEEE, (2015): 133-138.

[8]   Hua, Kai-Lung, Che-Hao Hsu, Shintami Chusnul Hidayati, Wen-Huang Cheng, and Yu-Jen Chen. "Computer-aided classification of lung nodules on computed tomography images via deep learning technique." *OncoTargets and therapy* 8 (2015).

[9]   Gajdhane, M. V. A., & Deshpande, L. M. (2014). Detection of Lung Cancer Stages on CT scan Images by Using Various Image Processing Techniques. IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN, 2278-0661.

[10]   Introduction of lung cancer available: https://www.medicinenet.com/lung_cancer/article.ht m#lung_cancer_facts

[11]   Stages of lung cancer is available: https:// www.healthline.com/health/lung-cancer#back-pain

[12]   Grayscale Image available: https://en.wikipedia.org /wiki/Grayscale

[13]   Chaudhary, Anita, and Sonit Sukhraj Singh. "Lung cancer detection on CT images by using image processing." In Computing Sciences (ICCS), 2012 International Conference on, IEEE, (2012): 142-146.

[14]   Gonzalez, Rafael C., and Richard E. Woods. "Digital image processing prentice hall." Upper Saddle River, NJ (2002).

[15]   Van Ginneken, Bram, BM Ter Haar Romeny, and Max A. Viergever. "Computeraided diagnosis in chest radiography: a survey." IEEE Transactions on medical imaging 20, no. 12 (2001):1228-1241.

[16]   Median filter available: https://en.wikipedia.org /wiki/Median_filter

[17]   Pratap, Gawade Prathamesh, and R. P. Chauhan. "Detection of Lung cancer cells using image processing techniques." In Power Electronics, Intelligent Control and Energy Systems (ICPEICES), IEEE International Conference on, IEEE, (2016):1-6.

[18]   Jayaraman, S., and S. Esakkirajan. "Digital image processing." (2009).

[19]   Gonzalez, Rafael C., and Richard E. Woods. "Digital image processing prentice hall." Upper Saddle River, NJ (2002).

[20]   Armato, Samuel G., Maryellen L. Giger, and Heber MacMahon. "Automated detection of lung nodules in CT scans: preliminary results." Medical physics 28, no. 8 (2001):1552-1561.

[21]   Mokhled, S. "Lung Cancer Detection Using Image Processing Techniques." Leonardo Electronic Journal of Practices and Technologies 11, no. 20 (2012): 147-158.

[22]   ROI is available: https://en.wikipedia.org/wiki/ Region_of_interest

[23]   https://angeljohnsy.blogspot.com/2012/05/find-area-perimeter-centroid.html

[24]   Figure2 is available: https:// www.emedicinehealth. com/lung_cancer/article_em.htm

[25]   Pixel to Cm conversion available :http://www.unitconversion.org/typography/pixels-x-to-centimeters-conversion.html