IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 12, December 2019, ||Series -III|| PP 18-25

Lung Cancer Analysis Using Digital Image Processing With Machine Learning Algorithms

[1]Dr. R Kumar,[2] MR. R Ramesh Kumar, [3]MS.V Umashankari
[1]Associate Professor, [2] Assistant Professor [3] Assistant Professor
Department of Computer Science and Engineering
CMS College of Engineering and Technology,
Coimbatore, Tamil Nadu, India

ABSTRACT *- The human body is made up of various fundamental organs, one of which is the lung. The lungs are divided into two halves, right lung and left lung, and its job is to exchange gas, which is referred to as breathing or respiration. The issue of human lungs is colossally expanding as a result of modern lifestyle and environmental contamination. Furthermore, several Image processing techniques are concocting a fantastic solution for the Medical industry to discover and assess lung diseases. This article considers and investigates a couple of those Image Processing methods. Preprocessing and highlight extraction from X-rays, as well as a Computer Tomography (CT) scan, are required by the Computer Aided Diagnosis (CAD) frameworks in order to analyse lung illnesses..*

Key words: *Computer Aided Diagnosis (CAD), X-rays, Computer Tomography (CT), Lung Disease Diagnosis (LDD), Image Processing Technique, Lung Cancer, Classification.*

I. INTRODUCTION

Lung cancer, also known as lung carcinoma, is a malignant tumor characterized by uncontrolled growth of the cell in tissues of the lung. It is mandatory to treat this to avoid spreading its growth by metastasis to other parts of the body. Most cancers that start in the lung are carcinomas.

The two main types are small-cell lung carcinoma and non-small-cell lung carcinoma. Long-period tobacco smoking is the primary factor for 85% of lung cancers. About 10–15% of cases occur in people who have never smoked but due to air pollution, secondhand smoking, asbestos, and radon gas. Computer tomography (CT) and radiographs are the methods to detect the presence of lung cancer. The diagnosis is confirmed by biopsy which is usually performed by bronchoscopy or CT scan. The cause of cancer-related death among men is mainly due to lung cancer. Hence, it is essential to determine a new method to diagnose the lung cancer at an earlier stage. Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Image Acquisition is a process of getting an input image for the process of automatic detection of lung cancer using Digital Image

Image processing performs some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Early evaluation takes place when a patient participates in a screening program before symptoms occur.In this paper we access cancer image into MATLAB collected from different hospitals where present work is going on and this available image was colour image we have access that image into MATLAB and followed conversion.

In clinical practice, nodules are usually observed over time to check any visible change has occurred. It helps to identify, quantify and visualize the density changes from indeterminate nodules or lesions after treatment. Physicians can take decisions with the help of numerical information and visuals.

II. LITERATURE SURVEY

2.1 LUNG CANCER DETECTION USING IMAGE PROCESSING TECHNIQUES

Recently, image processing techniques are widely used in several medical areas for image improvement in earlier detection and treatment stages, where the time factor is very important to discover the abnormality issues in target images, especially in various cancer tumors such as lung cancer, breast cancer, etc. Image quality and accuracy is the core factors of this research, image quality assessment as well as improvement are depending on the enhancement stage where low pre-processing techniques is used based on Gabor filter within Gaussian rules. Relying on general features, a normality comparison is made. In this research, the main detected features for accurate images comparison are pixels percentage and mask-labeling.

An image improvement technique is developing for earlier disease detection and treatment stages; the time factor was taken in account to discover the abnormality issues in target images. Image quality and accuracy is the core factors of this research, image quality assessment as well as enhancement stage where were adopted on low pre-processing techniques based on Gabor filter within Gaussian rules. The proposed technique is efficient for segmentation principles to be a region of interest foundation for feature extraction obtaining. The proposed technique gives very promising results comparing with other used techniques. Relying on general features, a normality comparison is made. The main detected features for accurate images comparison are pixels percentage and mask-labeling with high accuracy and robust operation.

2.2 LUNG CANCER DETECTION USING IMAGE SEGMENTATION BY MEANS OF VARIOUS EVOLUTIONARY ALGORITHMS

The objective of this paper is to explore an expedient image segmentation algorithm for medical images to curtail the physicians interpretation of computer tomography (CT) scan images. Modern medical imaging modalities generate large images that are extremely grim to analyze manually. The consequences of segmentation algorithms rely on the exactitude and convergence time. At this moment, there is a compelling necessity to explore and implement new evolutionary algorithms to solve the problems associated with medical image segmentation. Lung cancer is the frequently diagnosed cancer across the world among men. Early detection of lung cancer navigates towards apposite treatment to save human lives. CT is one of the modest medical imaging methods to diagnose the lung cancer. In the present study, the performance of five optimization algorithms, namely, k-means clustering, k-median clustering, particle swarm optimization, inertia-weighted particle swarm optimization, and guaranteed convergence particle swarm optimization (GCPSO), to extract the tumor from the lung image has been implemented and analyzed. The performance of median, adaptive median, and average filters in the preprocessing stage was compared, and it was proved that the adaptive median filter is most suitable for medical CT images. The results are verified for 20 sample images of the lung using MATLAB.

2.3 LUNG CANCER DETECTION USING GAUSSIAN RULES

As per the technical evolution and latest trend taken into consideration, we have decided to make research over biomedical term i.e. Lungs cancer detection. Recently, image processing techniques are widely used in several medical areas for image improvement in earlier detection and treatment stages. There are various types of cancers i.e. lungs cancer, Breast cancer, blood cancer, throat cancer, brain cancer, tongs cancer, mouth cancer etc. Lung cancer is a disease of abnormal cells multiplying and growing into a tumor. Cancer cells can be carried away from the lungs in blood, or lymph fluid that surrounds lung tissue.

In this project we access cancer image into MATLAB collected from different hospitals where present work is going on and this available image was color image we have access that image into MATLAB and followed conversion. Image quality and accuracy is the core factors of this research, image quality assessment as well as improvement are depending on the enhancement stage where low pre-processing techniques is used based on Gabor filter within Gaussian rules. The segmentation and enhancement procedure is used to obtain the feature extraction of normal and abnormal image. Relying on general features, a normality comparison is made. In this research, the main detected features for accurate images comparison are pixels percentage and mask-labeling.

2.4 IMAGE PROCESSING BASED DETECTION OF LUNG CANCER USING GABOR FILTER

In this paper, we implement and analyze the image processing method for detection of lung cancer. Image processing techniques are widely used in several medical problems for picture enhancement in the detection phase to support the early medical treatment. In this research we proposed a detection method of lung cancer based on image segmentation. Image segmentation is one of intermediate level in image processing. Marker control watershed and region growing approach are used to segment of CT scan image. Detection phases are followed by image enhancement using Gabor filter, image segmentation, and features extraction. From the experimental results, we found the effectiveness of our approach.

The results show that the best approach for main features detection is watershed with masking method which has high accuracy and robust. In this study we implement and evaluate three image segmentation methods for analyzing lung cancer, such as Region Growing, Marker Controlled Watershed, and Marker Controlled Watershed with Masking. The results show that Marker Controlled Watershed with Masking give us the best performance in term of segmentation result and running time. Therefore, we select Marker Controlled Watershed with Masking method in image segmentation stage. Furthermore, in the feature extraction stage, we use color attribute for the analysis of lung cancer using binarization. Finally, the binarization method was successfully determined condition of lung (normal or cancer) from the CT scan image.

2.5 LUNG CANCER DETECTION USING CT SCAN IMAGES

Lung cancer is one of the dangerous and life taking disease in the world. However, early diagnosis and treatment can save life. Although, CT scan imaging is best imaging technique in medical field, it is difficult for doctors to interpret and identify the cancer from CT scan images. Therefore computer aided diagnosis can be helpful for doctors to identify the cancerous cells accurately. Many computer aided techniques using image processing and machine learning has been researched and implemented. The main aim of this research is to evaluate the various computer-aided techniques, analyzing the current best technique and finding out their limitation and drawbacks and finally proposing the new model with improvements in the current best model. The method used was that lung cancer detection techniques were sorted and listed on the basis of their detection accuracy.

III. EXISTING SYSTEM

Previous methodology uses a modified version of the quality threshold clustering algorithm to associate each voxel of the lesion to a cluster, and changes in the lesion over time are defined in terms of voxel moves to another cluster. In addition, statistical features are extracted for classification of the lesion as benign or malignant. To develop the proposed methodology, two databases of pulmonary lesions

- malignantlesions in treatment (public)
- indeterminate cases (private)

Inter-cluster density change measures were obtained.It indicates the degree of change in the clusters and how each of them is abundant in relation to volume.

DISADVANTAGE:

- In this method accuracy of detection is merely low.
- Possibilities of detection are comparatively less.
- Slow process and precision.

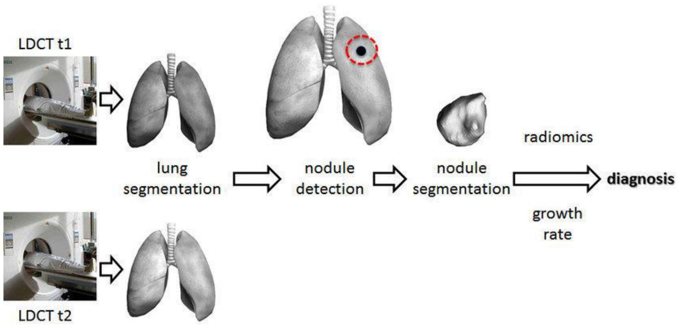
IV. PROPOSED SYSTEM

In this project a lung cancer detection system using image processing is used to classify the present of lung cancer in an CT- images. In this study, MATLAB have been used through every procedures made. In image processing procedures, process such as image pre-processing, segmentation and feature extraction have been used.

We are aiming to get the more accurate results by using efficient segmentation as Cascaded Expectation Maximization and Adaptive Neuro Fuzzy Interference System for classification techniques. The aim of this research is to detect normal and abnormal lung using accurate images comparison for medical assistance.

ADVANTAGES:

- Cancer detection using this methodology is highly improvised.
- Performance of this method is better than the existing method.
- Detecting accuracy is improved.



There are six modules in our project.They are given below

4.1 Image Acquisition

4.2 Pre processing

4.3Segmentation using Expectation Maximisation algorithm

4.4 Feature Extraction

4.4.1 Statistical feature

4.5Classification using ANFIS

Image Acquisition

Image Acquisition is a process of getting an input image for the process of automatic detection of lung cancer using Digital Image Processing.

Pre processing

Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing.

 Resizing Color conversion Noise removal

Noise Removal using Median Filter: The median filter is a nonlinear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise also having applications in signal processing. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries.

Segmentation: Segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity or texture. We use Expectation Maximization for segment the white blood cells. Digital image processing is the use of computer algorithms to perform image processing into digital images. Image segmentation is very important and challenging process of image processing. Image segmentation is the techniques are used to partition an image into meaningful parts have similar features and properties. The aim of segmentation is simplification i.e. representing an image into meaningful and easily analyzable way. Image segmentation is the first step in image analysis. The main goal of image segmentation is to divide an image into several parts/segments having similar features or attributes. The main applications of image segmentation are: Medical imaging, Content-based image retrieval, and Automatic traffic controlsystems, Object detection and Recognition Tasks, etc. The image segmentation can be classified into two basic types: Local segmentation (concerned with specific part or region of image) and Global segmentation (concerned with segmenting in whole image, consisting of large number of pixels). We useExpectation Maximization Segmentation for extraction of lung lesions.

Expectation Maximization: The EM algorithm proceeds from the observation that there is a way to solve these two sets of equations numerically. One can simply pick arbitrary values for one of the two sets of unknowns, use them to estimate the second set, then use these new values to find a better estimate of the first set, and then keep alternating between the two until the resulting values both converge to fixed points. It's not obvious that this will work, but it can be proven that in this context it does, and that the derivative of the likelihood is (arbitrarily close to) zero at that point, which in turn means that the point is either a maximum or a saddle point. In general, multiple maxima may occur, with no guarantee that the global maximum will be found. Some likelihoods also have singularities in them, i.e., nonsensical maxima.. The EM algorithm (and its faster variant ordered subset expectation maximization) is also widely used in medical image reconstruction, especially in positron emission tomography and single photon emission computed tomography.

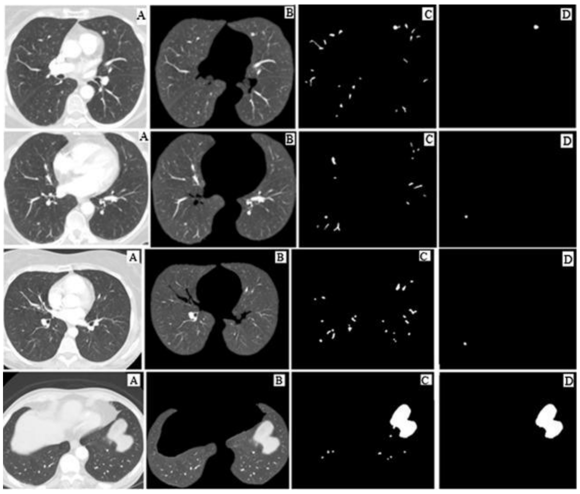


Figure 4.3: Segmentation

Feature extraction: In machine learning, pattern recognition and image processing feature extraction starts from an initial set of measured data and builds derived values (features) intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be redundant then it can be transformed into a reduced set of features (also named a feature vector). Determining a subset of the initial features is called feature selection. The selected features are expected to contain the relevant information from the input data, so that the desired task can be performed by using this reduced representation instead of the complete initial data. We extract Statistical and texture features for pap smear segmented images.

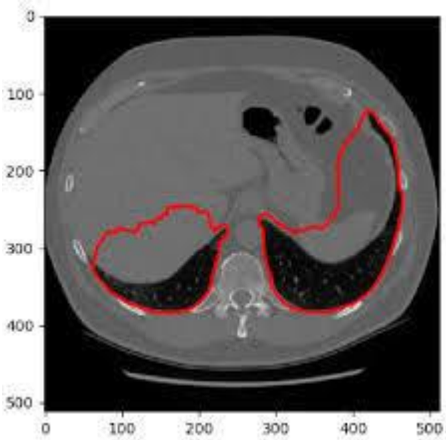
Statistical Features:

Mean: For a data set the arithmetic mean, also called the mathematical expectation or average is the central value of a discrete set of numbers: specifically, the sum of the values divided by the number of values. If the data set were based on a series of observations obtained by sampling from a statistical population, the arithmetic mean is the sample mean to distinguish it from the mean of the underlying distribution, the population mean .In probability and statistics,the population mean, or expected value are a measure of the central tendency either of a probability distribution of the random variable characterized by that distribution.

Variance: In probability theory and statistics variance is the expectation of the squared deviation of a random variable from its mean. Informally, it measures how far a set of (random) numbers are spread out from their average value. Variance has a central role in statistics, where some ideas that use it include descriptive statistics, statistical inference, hypothesis testing and Monte Carlo sampling. Variance is an important tool in the sciences, where statistical analysis of data is common. The variance is the square of the standard deviation, the second central moment of a distribution, and the covariance of the random variable with itself.

GLCM Feature:

The Gray Level Co-occurrence Matrix (GLCM) and associated texture feature calculations are image analysis techniques. Given an image composed of pixels each with an intensity (a specific gray level), the GLCM is a tabulation of how often different combinations of gray levels co-occur in an image or image section. Texture feature calculations use the contents of the GLCM to give a measure of the variation in intensity at the pixel of interest. Echoview offers a GLCM Texture Feature operator that produces a virtual variable which represents a specified texture calculation on a single beam echogram



V. ALGORITHM

1) Quantize the image data. Each sample on the echogram is treated as a single image pixel and the value of the sample is the intensity of that pixel. These intensities are then further quantized into a specified number of discrete gray levels as specified under Quantization.

2)Create the GLCM. It will be a square matrix N x N in size where N is the Number of levels specified under Quantization. The matrix is created as follows:

a) Let s be the sample under consideration for the calculation.

b) Let W be the set of samples surrounding sample s which fall within a window centered upon sample s of the size specified under Window Size.

c) Considering only the samples in the set W, define each element i,j of the GLCM as the number of times two samples of intensities i and j occur in specified Spatial relationship . . The sum of all the elements i, j of the GLCM will be the total number of times the specified spatial relationship occurs in W.

d) Make the GLCM symmetric:

i) Make a transposed copy of the GLCM

ii) Add this copy to the GLCM itself This produces a symmetric matrix in which the relationship i to j is indistinguishable for the relationship j to i (for any two intensities i and j). As a consequence the sum of all the elements i, j of the GLCM will now be twice the total number of times the specified spatial relationship occurs in W (once where the sample with intensity i is the reference sample and once where the sample with intensity j is the reference sample), and for any given i, the sum of all the elements i, j with the given i will be the total number of times a sample of intensity i appears in the specified spatial relationship with another sample.

e) Normalize the GLCM:

i) Divide each element by the sum of all elements The elements of the GLCM may now be considered probabilities of finding the relationship i, j (or j, i) in W.

Calculate the selected Feature. This calculation uses only the values in the GLCM. See:

- Energy
- Entropy
- Contrast
- Homogeneity
- Correlation
- Shade
- Prominence

The sample s in the resulting virtual variable is replaced by the value of this calculated feature.

Classification using ANFIS:

The ANFIS can be viewed either as a fuzzy system, a neural network or fuzzy neural network (FNN). This paper is integrating the learning capabilities of neural network to the robustness of fuzzy logic systems in the sense that fuzzy logic concepts are embedded in the network structure. It also provides a natural framework for combining both numerical information in the form of input/output pairs and linguistic information in the form of IF–THEN rules in a uniform fashion.

The proposed algorithm is achieved by the intelligent scheme ANFIS. This intelligent scheme is used to classify the fault type and deduce if it is single phase to ground, phase to phase, double phase to ground, or three phases. The input data of the ANFIS are firstly derived from the fundamental values of the voltage and current measurements after making. ANFIS and Artificial Neural Network (ANN) can model qualitative aspects of human knowledge.

VI. IMPLEMENTATION

Implementation of the system refers to the final installing of the package in its real environment, to the satisfaction of the indeed users and the operation of the system. It is the process of converting a new or revised system design to operation. It is the key stage in achieving successful new system. The process of putting the developed system in actual use is called system implementation. This includes all those activities that take place to convert from the old system to new system. It must therefore be carefully planned and controlled. Proper guidance should be imparted to the physicians so that he is comfortable in using the application.

VII. IMPLEMENTATION PLAN

The transformation from theoretical designs to working system is done in this stage. Developed package of system is tested with simple data, accurate error identification and then through proposed change from the user etc. a dress rehearsal working of system is done, so as the system is scrutinized, for pointing out errors and modifications required if any keeping in mind the expectations and specifications from the system.

EDUCATION AND TRAINING

The expectations from the system are made achieved by the people who will be involved to be confident of their role in the new system. The complexity of the system is directly proportional to the amount of training and education given for the user.

MAINTAINENCE

Maintenance is making adaptation of the software for external changes (requirements changes or enhancements) and internal changes (fixing bugs). When changes are made during the maintenance phase all preceding steps of the model must be revisited.

The maintenance activity occurs since it is unreasonable to assume that software testing will uncover all in a large system. The second activity that contributes the definition of maintenance occurs since rapid changes are encountered in every aspects of computing. The third activity involves recommendation for new capabilities, modification to the existing functions and general enhancements when the software is used. The fourth maintenance activity occurs when software is changed to improve future maintainability or reliability.

VIII. CONCLUSION

Lung cancer is the most fatal and widespread cancer in the world, measured by the stage at which cancer cells are discovered in the lungs. As a result, early detection of the disease is critical in avoiding serious advanced stages and lowering the percentage of people who have it. The time factor was taken into account to identify the abnormality concerns in target images in an image improvement procedure being developed for early disease identification and treatment stages. The proposed method is effective for getting feature extraction by using segmentation principles as a region of interest basis. In comparison to existing methods, the proposed strategy yields very promising outcomes. Texture and mathematical properties with high precision are the major features discovered for accurate picture comparison.

With the advancement of large-scale image processing, this field has a lot of room for future research. We have a vision for the future and speculate on prospective trends. The details of implementation detection with updated architecture are presented in this study. To combine a depiction of all density changes in a single image with a density change analysis based on location to diagnose lesions and a change forecast. The region level analysis will be added to this study in the future.

REFERENCES

[1]. American Cancer Society, "Cancer Statistics, 2005", CA: A Cancer Journal for Clinicians, 55: 10-30, 2005, "http://caonline.amcancersoc.org/cgi/content/full/55/1/10".

[2]. D. Lin and C. Yan, "Lung nodules identification rules extraction with neural fuzzy network", IEEE, Neural Information Processing, vol. 4, (2002).

[3]. A. El-Baz, A. A. Farag, PH.D., R. Falk, M.D. and R.L. Rocco, M.D., "detection, visualization, and identification of lung abnormalities in chest spiral CT scans: phase I", Information Conference on Biomedical Engineering, Egypt (2002).

[4]. B.V. Ginneken, B. M. Romeny and M. A. Viergever, "Computer-aided diagnosis in chest radiography: a survey", IEEE, transactions on medical imaging, vol. 20, no. 12 (2001).

[5]. Beucher, S. and Meyer, F., “The Morphological Approach of Segmentation: The Watershed Transformation,” Mathematical Morphology in Image Processing, E. Dougherty, ed., pp. 43-481, New York: Marcel Dekker, 1992.

[6]. Nguyen, H. T., et al “Watersnakes: Energy-Driven Watershed Segmentation”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume 25, Number 3, pp.330-342, March 2003.

[7]. Suzuki K., et al., “False-positive Reduction in Computer-aided Diagnostic Scheme for Detecting Nodules in Chest Radiographs by Means of Massive Training Artificial Neural Network”, Academic Radiology, 12, No 2, February 2005, pp. 191-201.

[8]. D. Jiang, C. Tang, and A. Zhang, “Cluster analysis for gene expression data: A survey,” IEEE Trans. Knowl. Data Eng., vol. 16, no. 11, pp. 1370–1386, Nov. 2004.

[9]. C. A. Sugar and G. M. James, “Finding the number of clusters in a dataset,” J. Amer. Statist. Assoc., vol. 98, no. 463, pp. 750–763, 2003.

[10]. R. Kohavi, “A study of cross-validation and bootstrap for accuracy estimation and model selection,” in Proc. 14th Int. Joint Conf. Artif. Intell., vol. 2. San Francisco, CA, USA: Morgan Kaufmann, 1995, pp. 1137–1143.

[11]. V. N. Vapnik, Statistical Learning Theory. New York, NY, USA: Wiley, 1998.

[12]. S. M. B. Netto, A. C. Silva, H. Lopes, A. C. de Paiva, R. A. Nunes, and M. Gattass, “Statistical tools for the temporal analysis and classification of lung lesions,” Comput. Methods Programs Biomed., vol. 142, pp. 55–72, Apr. 2017.

[13]. S. M. B. Netto, A. C. Silva, A. C. de Paiva, R. A. Nunes, and M. Gattass, “Unsupervised detection of density changes through principal component analysis for lung lesion classification,” Multimedia Tools Appl., vol. 76, no. 18, pp. 18929–18954, Sep. 2017.

[14]. R. K. Jain et al., “Change in tumor size by RECIST correlates linearly with overall survival in phase I oncology studies,” J. Clin. Oncol., vol. 30, no. 21, pp. 2684–2690, 2012.

[15]. J. Dinkel et al., “Inter-observer reproducibility of semi-automatic tumor diameter measurement and volumetric analysis in patients with lung cancer,” Lung Cancer, vol. 82, no. 1, pp. 76–82, 2013.

[16]. A. M. Wulff et al., “Volumetric response classification in metastatic solid tumors on MSCT: Initial results in a whole-body setting,” Eur. J. Radiol., vol. 82, no. 10, pp. e567–e573, 2013.

[17]. L. Hadjiiski et al., “Computer-aided diagnosis for interval change analysis of lung nodule features in serial CT examinations,” Proc. SPIE, vol. 6514, pp. 651411-1–651411-7, Mar. 2007.

[18]. J. Parikh et al., “Changes in primary breast cancer heterogeneity may augment midtreatment MR imaging assessment of response to neoadjuvant chemotherapy,” Radiology, vol. 272, no. 1, pp. 100–112, 2014

[19]. V. Rajkumar et al., “Texture analysis of 125I-A5B7 anti-CEA antibody SPECT differentiates metastatic colorectal cancer model phenotypes and anti-vascular therapy response,” Brit. J. Cancer, vol. 112, pp. 1882–1887, May 2015.

[20]. J. Böttcher et al., “Response to neoadjuvant treatment of invasive ductal breast carcinomas including outcome evaluation: MRI analysis by an automatic CAD system in comparison to visual evaluation,” ActaOncol., vol. 53, no. 6, pp. 759–768, 2014.

[21]. C. Yip et al., “Imaging tumor response and tumoral heterogeneity in non–small cell lung cancer treated with antiangiogenic therapy,” J. Thoracic Imag., vol. 30, no. 5, pp. 300–307, 2015.

[22]. Y. Zheng, X. Zhang, B. Hou, and G. Liu, “Using combined difference image and k-means clustering for SAR image change detection,” IEEE Geosci. Remote Sens. Lett., vol. 11, no. 3, pp. 691–695, Mar. 2014.

[23]. C. Adak, “Rough clustering based unsupervised image change detection,” CoRR, vol. abs/1404.6071, pp. 1–4, Aug. 2014.

[24]. N. Li, F. Liu, and Z. Chen, “An unsupervised approach based on Riemannian metric to change detection on multi-temporal SAR images,” Proc. SPIE, vol. 9244, pp. 924418-1–924418-6, Oct. 2014.

[25]. A. M. Lal and S. M. Anouncia, “Semi-supervised change detection approach combining sparse fusion and constrained k means for multitemporal remote sensing images,” Egyptian J. Remote Sens. Space Sci., vol. 18, no. 2, pp. 279–288, 2015.