Lung Cancer Detection from Medical Images via Quadratic-SVM Classifier

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***Abstract*—Cancer is a notable global health epidemic with death rates rising regularly. In the United States and internationally lung cancer is the leading cause of cancer mortality between women & men. About 90% of lung cancer cases are caused by smoke and tobacco use. Further factors though like asbestos, radon gas, exposures to air pollution, & chronic infections can contribute to lung cancer. Moreover, some inherited and acquired causes of lung cancer vulnerability were proposed. Medicine imaging means the procedure and method by which the inner part of the body is represented for medical study & intervention, and the role of certain bodies or tissues is represented visually (physiology). Here is the proposal for medical image detection by a computer-aided method for Lung Cancer with the aid of a support vector machine and image processing on CT scanning images. A common cause of death for people around the world tends to be lung cancer. The only thing that could boost people's chance of survival appears to be the early diagnosis of lung cancer. Here, we presented an SVM classifier with a Quardaractiv function. Also, a high pass filter and median filter have used to filter the images. These processes followed the reconstruction of the image then morph the given images and finally segment the images. Here, we compare different-different SVM classifier functions with the proposed SVM kernel Function. And, we obtained fruitful results in terms of accuracy, sensitivity, and specificity.**

Keywords*—Image processing, Cancer Detection, Lung Cancer, Medical Image, high-pass filter, Morphological Filtering, Morphological Opening & Closing, median filter, SVM.

I. INTRODUCTION

Image processing (IP) is any type of signal processing in which input is presented as an image (e.g. an image or a video frame), and an image processing output or a series of features and parameters relevant to the image. IP requires the desired processing or modification of a current image which also helps to get a readable file. Many image processing methods include the handling of the image as a 2D signal and the implementation of traditional signal processing technology. This article reflects on tools of medical IP. Medical imaging and processing methods play an important part in many applications in the medical field today. Such applications are carried out in the scientific path of events; hence the benefits & drawbacks of medical images influence the outcomes of doctor-patient diagnosis not only for diagnosis but also in the planning, carrying out and assessment fields before the operation [1,2].

Cancer is one of the most serious death-provoking diseases. A category of diseases is cancer. This includes abnormal cell growth. It extends to other areas of the body and impacts it very rapidly. Both types of tumors do not appear to be cancerous. Any tumors are not spread across the body. The symptoms of cancer include cancer, abnormal bleeding, increased weight loss, long-term cough. There are about 100 different types of human body cancer. Cancer research is one of the most demanding, attractive, and focused fields in the medical field. Adequate automated tumor and cancer prediction systems are needed to ensure the necessary care for patients [3].

A malignant tumor, that is the unregulated growth of cells in lung tissues, is lung cancer, called lung carcinoma. To prevent extending its development by metastasis to other areas of the organism, it is important to handle this. Carcinomas are the majority of cancers that begin in the lung. 2 major forms are lung carcinomas of small cells and lung carcinomas of non-small cells. Long-term smoking of tobacco is the main reason for 85% of lung cancers. Some 10% to 15% of people who never smoked except air pollution, second-hand smoking, asbestos, and radon gas. The standard techniques for detecting lung cancer are computer tomography (CT) and radiographs. Diagnosis is confirmed by biopsy normally done with a CT scan or bronchoscopy. The cause of death from cancer in men is attributed mostly to lung cancer. A new robust way of diagnosing lung cancer in the early stages is therefore important. 20 lung image samples & 4 algorithms were taken for processing for this study. Combination of adaptive equalization of histograms, adaptive median filter & GCPSO (Guaranteed Convergence Particle Swarm Optimization) depends upon algorithms has been shown, amongst other things, to produce better results [4].

Medical imaging is the most important tool in modern medicine; some kinds of imaging technologies like ultrasonography, X-ray imaging, CT, biopsy imaging, & optical coherence tomography have been generally used in clinical detection for several types of diseases. In helping diagnosis and therapy accurate medical images may also play an important part. They are helpful for health care students in the field of education by illustrating these images to them. Medical imaging includes a variety of procedures or techniques to produce a visual representation of the internal body parts such as tissues or organs for clinical purposes so that diseases and injuries can be tracked, diagnosed, and managed. It also helps to establish anatomical and physiological databases [5,6].

A. MEDICAL IMAGING SYSTEMS

This system uses the patient's signals to produce images. The systems of medical imaging use non-ionizing and ionizing sources.

1. X-ray imaging systems

X-rays were utilized to image body parts for medical purposes from the invention of X-rays by German scientist Roentgen. The electrons in the x-ray tube are created by thermal emissions in the cathode and accelerated by a potential difference of 50 to 150 KV. Anode has been struck by electrons to create X-rays. Just one percent of energy is transferred to X-rays & the rest is changed to heat.

2. **Computed tomography (CT)**

In this modality, rather than traditional radiography, images are created in several dimensions. In various directions, the CT scanner makes different slices of tissues of the body. The patient is located inside its opening with a CT scanner and screened in both directions with a rotating X-ray tube [7].

II. LITERATURE REVIEW

N. S. Nadkarni & S. Borkar [2019] Presents an automatic diagnostic method for lung cancer in images of computed tomography scan. Methods like median filtering for IP, accompanied by lung field segmentation using mathematical morphology operations are suggested for lung cancer detection. Geometric characteristics are determined from the field of interest derived also are utilized by support vector machine to identify CT images as normal and abnormal [8].

Toğaçar, M., [2019] The research uses LeNet, AlexNet & VGG-16 Deep Learning models for diagnosis of lung cancer. An open data set consisting of CT images were used to perform the experiments. Convolutional Neural Networks (CNNs) for feature extraction and classification purposes were used in this experiment. The most effective classification accuracy of 98.74% was obtained with a combination of NN and AlexNet. Then deep feature collection was implemented to select the most effective features by MRMR (Minimum Redundancy Maximum Relevance). Thus, the success rate was reported at 99.51 percent, with chosen characteristics & the kNN model being reclassified. The suggested model is a consistent diagnostic model for the diagnosis of lung cancer via chest CT images [9].

ALzubi, J. A., [2019] The proposed approach is divided into two steps, collection of features and classification of an ensemble. In the first point, an integrated Newton Raphsons MLMR (Maximum Likelihood & Minimum Redundancy) preprocessing model is utilized to pick necessary attributes to minimize classification time. The second step is used to identify patients with chosen attributes, which increase their accuracy of cancer diagnoses and also decrease their false-positive rates. The second phase is an integrated neural network ensemble Classification algorithm. Experimental findings suggest that the proposed method accomplishes a higher false-positive rate, predictability accuracy & decreased delay compared to traditional methods [10].

Ü. Özsandıkcıoğlu et al. [2018] In this research, an Electronic Nose method has been built to examine the breathing of human beings to diagnose whether or not they suffer from lung cancer. S Metal Oxide Semiconductor gas sensors & 14 Quartz Crystal Microbalance sensors have been utilized in this Electronic Noses system. Both sensors utilized in this system are vulnerable to lung cancer-related reactive organic composites. First preprocessing of data collected from this method. Features for optimizing classification success were then extracted from results. Principal Component Analysis was used to eliminate redundant features. Finally, features extracted have been defined using the nearest k neighbors and support vector machines methods [11].

T. Patel and V. Nayak [2018] Image processing techniques have recently been commonly used in different medical fields to enhance the image at an earlier stage of diagnosis & treatment, where the time factor is most critical in detecting problems of abnormality in target images, mainly in many cancers like breast cancer, lung cancer, etc. Image consistency and precision are the main factors of this study. Recently, the Local Energy-based Shape Histogram (LESH) technology of feature extraction was designed for the diagnosis of lung cancer. They make bigger our work to application of lung cancer LESH and sensitivity analysis (SA). For research studies, JSRT & clinical dataset is chosen. This method can lead to a broader data set process, which can produce better outcomes than the earlier one [12].

M. Vas and A. Dessai [2017] A diagnosis of lung cancer algorithm are proposed in the present paper using morphological mathematical operation for segmenting lung area of interest, that extracts Haralick features from & uses artificial neural networks (ANN) for cancer classification. A significant number of deaths worldwide have been caused by cancer, which is the source of the highest mortality rates of lung cancer. The radiologists use a CT scan to diagnose and monitor cancer of the body. Visual data processing can be used in the later stages for cancer diagnosis, culminating in late cancer treatment, which further raises cancer mortality rates [13].

Q. Wu and W. Zhao [2017] To identify Small Cell Lung Cancer (SCLC) from computed tomography images, propose a new algo depends upon neural-networks, that is referred to as EDM (Entropy Degradation process). This analysis could help to diagnose lung cancer at an early age. Training data & research data are lung CT scans conducted by the National Cancer Institute in high resolution. 12 lung CT scans, six of which are for healthy lungs and six of which are scans for SCLC patients, were chosen from the library. They take 5 scans of every group randomly to train the model, also use the other 2 scans to test. The accuracy of their algorithms is 77.8% [14].

R. Sammouda [2016] This paper proposes to segment regions of lung extracted from human chest CT images improved process of the Hopfield Artificial Neural Network Model. The images are obtained from normal subjects and those with Computed Tomography imaging tools as candidates for the detection of lung cancer. To improve the lung region lobes detection at the edge a mixture of bit-planes of every pixel is utilized. Three diagnostic regulations and well-defined filters from the candidate status to the true or false positive status of the candidate cancer area are checked [15].

III. RESEARCH METHODOLOGY

A. PROBLEM DOMAIN

With the great demand for CAD (computer-aided diagnosis) in the medical field, automatic medical image classification is highly required. Lung cancer diagnosis from CT scan image is generally done by a human expert but the automated system can be applied for this kind of diagnosis by a machine.

1. **To detect cancer in the early stage**

Lung cancer is considered the leading cause of cancer death globally, and in early stages is impossible to find because it only happens in gradual stages, and causes the highest mortality rates in all other cancer forms.

2. **To improve the accuracy of lung cancer detection**

There are very minute points that come across while analysis of CT scan images for lung cancer diagnosis human with a lot of workloads can easily skip these points which affects the overall accuracy in cancer detection.

B. PROPOSED METHODOLOGY

We are going to use the morphological opening and closing operation and skull stripping to segment and detect the tumor which is faster than the base and the 4- kernel based SVM which will increase our accuracy our proposed method is faster than the other. The image is being loaded and preprocessed with the morphological operation and then the image Is going to be segmented and loaded into different SVM kernels and finally detect cancer and show the final accuracy.

The following techniques are given below which is used in the Proposed:

1. Support Vector Machines

It is one of the greatest machine learning Algorithms. SVM contracts with pattern classification. SVM algo is utilized generally for several pattern classification. There are two different types of pattern, linear & non-linear patterns. Linear patterns are those which can be effortlessly separable in a smaller dimension. Non-Linear patterns are those which cannot be easily separable or which have to be altered further thus required a higher dimensional system.SVM takes data as i/p & o/p hyperplane, which simple line in a 2-D system that separates the best two different datasets. This line is the decision boundary. SVM is a good data separation tool.

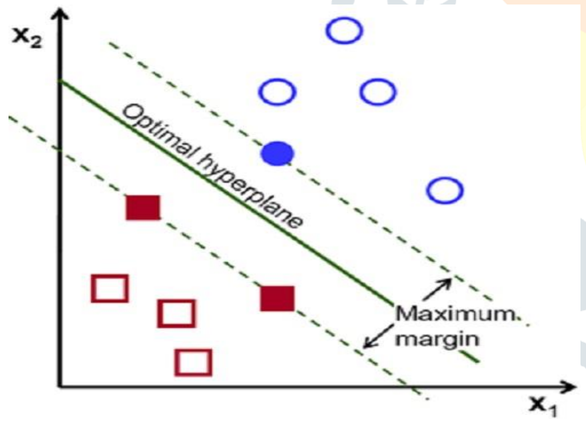

Figure 1: SVM

Fig. 1 shows the general idea of SVM, how the pattern classification appears when two distinct sets of data points are separated using a hyperplane. Also, it shows a decision boundary approach. The decision boundary is that which to put a straight line such that it separates between the positive and negative examples that street as wide as possible.

The figure contains 3 different lines. Line w.x-b = 0 is named margin of separation or marginal line. w.x-b=1 & w.x-b=-1 are positively and negatively affected lines on the plane. The three lines together construct the hyperplane dividing the defined patterns and the pattern on the edges of the hyperplanes is called vectors of support [16].

- **Hyperplane:** The hyperplane is chosen from a collection of hyperplanes that optimize the margins, i.e. the distance from the hyperplanes to the closest point in each pattern. The main objective pf SVM is to optimize margin means the distance of 2 different data points is to be maximum.
- **Linear SVM:** That is the best way to use SVM. It is used for the linear isolation of the training dataset. This utilizes hyperplane or line graphically that classifies dataset.
- **Non-linear SVM:** The non-linear SVM was used for classification when the training dataset is linearly non-separable. SVMs use a nonlinear kernel function to divide data set in high dimensional feature space into 2 groups. In 2D feature space non-linear SVMs generates quadratic or polynomial curve to spate datasets into 2 classes, Curve divides datasets in feature space.

a. **Quadratic kernel SVM (QSVM)**

A new quadratic kernel is added to distinguish the data nonlinearly from the support vector machine. A quadratic decision of separating nonlinearly date is utilized. The quadratic kernel eq. is

$$K(x, y)\ (x^T y + 1)^2 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

2. Median Filter (MF)

Filtering is a significant part of any processing system for the signal that consists of signal degraded estimation in maximum cases through impulse noise that is generally caused by error generated when converting analog to a digital signal via Analog-to-Digital Converter (ADC).

MF is a digital filtering method that is not linear and is usually used for dramatically reducing noise in the image. It is one of the better window operators from a variety of window operators, including the mean, min, max, and mode filter. A sample value of the input signal is clearly to be evaluated and calculated if the signal is representative. Due to this, it is always easier for the median filter to retain useful information in an image than the Boxcar filtering approach [17,18]

3. High-Pass Filter (HPF)

It is an electronic filter that passes signals that are more frequently than those cut-off frequencies and slows down signal at frequencies below the cut-off frequency. The attenuation rate depends on the filter configuration for each frequency. Usually, an HPF is constructed as a linear time-invariant system. In audio engineering, it is also named bass-cut filter or low cut filter [19].

An HPF can be used to make an image look clearer. These filters highlight fine information in the image – precisely the reverse of the LPF. HPFs High-pass filters operate similarly to low-pass filtering; it simply uses a particular kernel for convolution. Note the minus sign for the neighboring pixels in the example below. Nothing occurs when there is no change in intensity. But if one pixel is brighter than the next, it is boosted [20].

4. Morphological Filtering

It consists primarily of non-linear operations linked to morphology or structure of image attributes, like borders, skeletons, etc. In morphology strategies, the image is tested by masking a small template or shape named element in the structure, as well as this element is the basis for activities that identify the interest area or area approximately a pixel.

Mathematical morphology depends upon established theory operation b/w points of an object named image and kernel known as a structuring factor.

a) Morphological Closing

Closing is similar in many respects to dilation in that it tends to increase foreground (bright) boundaries regions in the image (also shrink background color holes in certain regions), however, it's less destructive of novel boundary shape [21].

This is helpful when closing small holes within the objects in the foreground or small black points. For mathematical morphology, set closure A by structuring element B is the expansion of the set, the morphological closure of the image is defined as the dilation from I to B followed by the expanded image erosion from B. It can be written mathematically as:

$$[I * B] = (I \oplus B) \ominus \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where $\oplus$ & $\ominus$represent dilation & erosion, correspondingly.

In IP, closing is the essential workhorse for the reduction of morphological noise along with opening. Opening removes small objects and removes small holes by closing.

With the Closing operation, all internal noise in the object area is eliminated and the background is not affected [22].

b) Morphological Opening and Closing

Opening and closing are 2 main mathematical morphology operators. Both derive from simple erosion & dilation operations. As for such operators the gray-level versions are usually extended to binary images. An opening's fundamental effect is rather like erosion in that it appears to remove certain (bright) foreground pixels from edges of foreground pixel regions. However, it's less destructive than typical erosion. Exact operation is defined by a structural feature, as with other morphologic operators. The operator's effect is to retain foreground parts that are identical to or may contain the structuring aspect entirely while removing all other foreground pixel regions [23].

5. Semantic Image Segmentation

Semantic segmentation of the image is a wide area of interest for computer vision & machine learning researchers. Several implementations require detailed & effective image segmentation & segment grading frameworks to analyze visual content and make decisions in real-time. The application field consists of autonomous driving, remote sensing, video surveillance, indoor navigation, augmented or virtual reality systems, etc. Object segmentation & classification produce specific parameters of performance for different purposes involving comprehensive domain analysis. There are a wide variety of applications in which the classification of remote sensing image scenarios is critical and has received significant attention [24]. For segmentation of the medical image, detailed treatment of human life is of the utmost importance. Before an examination, the frequency of noise content should be eradicated and the image quality increased. This part of the work is called preprocessing [25].

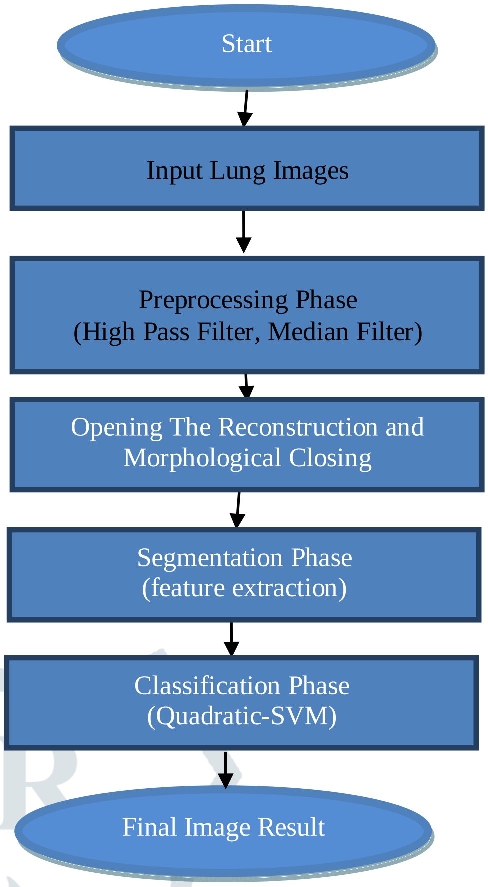

Figure 2: Flow Chart of the Propose Method

Fig. 2 shows the flowchart for the proposed model that consists of all the required number of steps

IV. RESULTS AND DISCUSSION

A. DESCRIPTION

The analysis methods selected for this study will be presented by MATLAB 2018. For scientific computing, it is a highly skilled language. This involves a basic environment in which. Math terminology defines problems and responses in programming, visualization, or computation.

B. SCREENSHOTS OF SIMULATED RESULT

This section demonstrated all screenshots of results. First of all, it includes the GUI window to start the program and to run displayed in fig. 3.

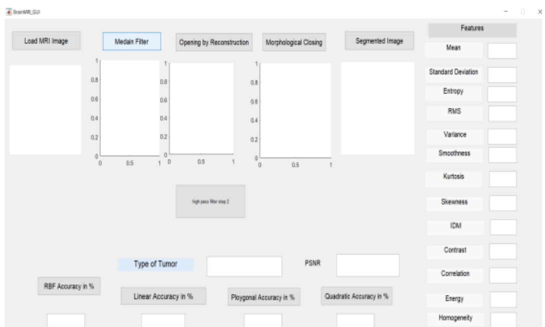

Figure 3: GUI

Secondly, we upload the lung image dataset to simulate the experiments that are displayed in fig.4.

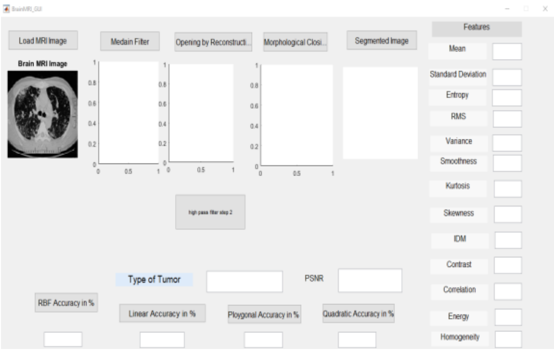

Figure 4: Load the lung Images

Once all lung image dataset uploaded then apply a high pass filter to make an image appear sharper shown in fig. 5.

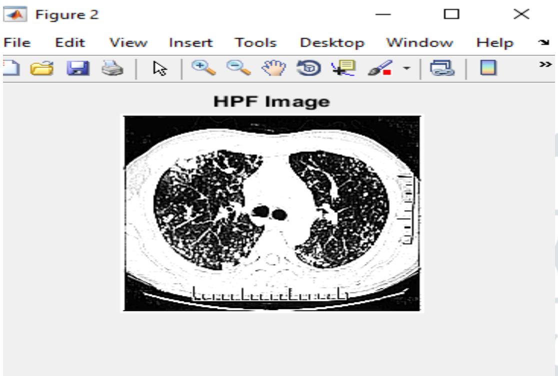

Figure 5: Apply high pass filter

When the image gets sharpen then net step is to apply a median filter to remove noise from images displayed in fig. 6. Such a noise reduction is a standard pre-processing phase to boost later processing performance (for example, edge detection on an image). The median filter is a non-linear digital filtering technique.

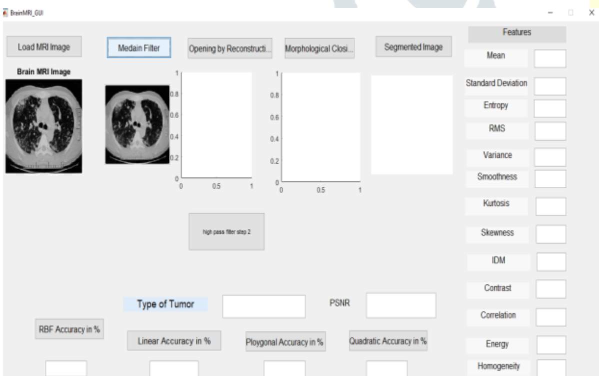

Figure 6: apply a median filter

After removing the noise from the given lung image dataset images need to reconstruct. For this purpose apply the reconstruction process illustrated in fig. 7.

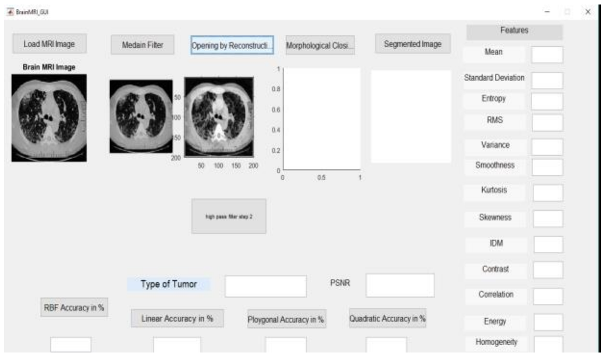

Figure 7: opening by reconstruction

Once the reconstruction step has been done then performs morphing on the lung image dataset shown in fig. 8. Morphing is a specific effect in motion pictures & animations that alter (or morph) a picture or render another image through a seamless transformation.

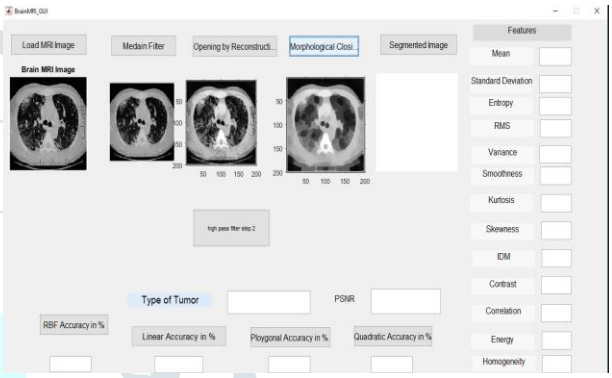

Figure 8: morphological closing

After morphs the image we got a different shape of images. Then perform the segmentation step to semi-automatic or automatic detection of boundaries within the two-dimensional or three-dimensional image on morphed images as displayed in fig.9. Image segmentation is commonly used in images to find objects and boundaries (lines, curves, etc.).

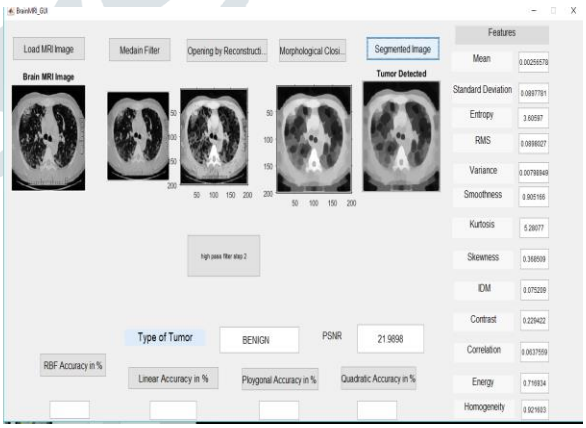

Figure 9: Segmented image

After performing the segmentation step, we achieved the final lung images illustrated in fig. 10.

Figure 10: The final result

C. COMPARISON GRAPHS PROPOSED & BASE RESULT

This section described the comparison among various kernel functions of SVM. The obtained results of sensitivity, specificity, and accuracy have shown in table I. There is five different SVM kernel function have compared. These are RBF, Linear, Polynomial, Hybrid (i,e. existing method), and Quadratic (i.e. proposed method).

Table I. Comparative results for SVM kernels

Sr. no.	SVM's Kernel function	Sensitivity	Specificity	Accuracy
1.	RBF	55.94	76.92	70
2.	Linear	64	79.37	56
3.	Polynomial	60.61	69.44	58.33
4.	Hybrid (Existing)	62.70	59.97	81.82
5.	Quadratic (Proposed)	76.92	96.15	90

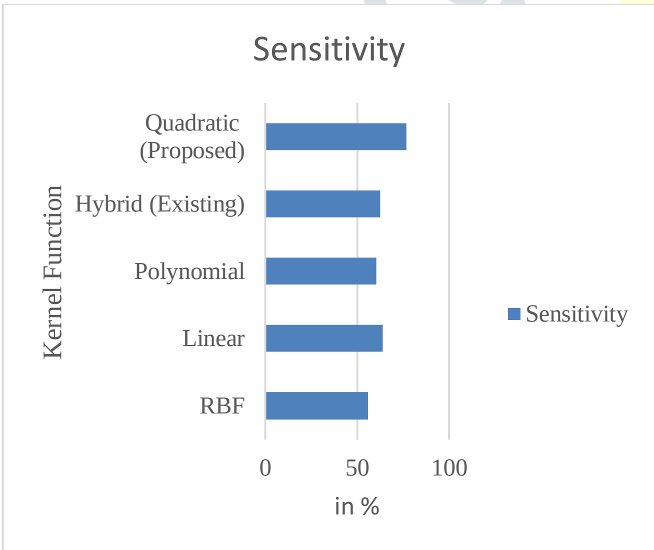

Figure 11: Sensitivity comparison of Propose Quadratic-SVM with existing hybrid-SVM kernel functions including RBF-SVM, Linear-SVM, & Polygonal-SVM.

Fig. 11 indicates the sensitivity value for all kernel functions. Here we can see that the quadratic-SVM gives a higher sensitivity value i.e. 76.92% in comparison to other SVMkernels.

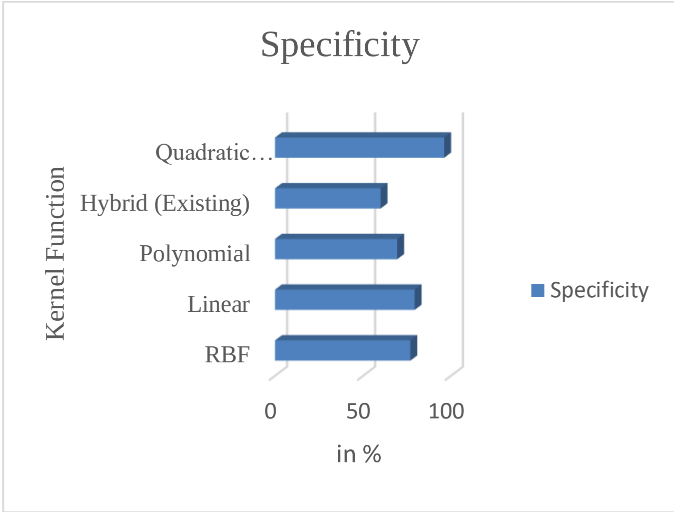

Figure 12: Specificity comparison of Propose Quadratic-SVM kernel function with the existing hybrid-SVM kernel, RBF-SVM, Linear-SVM, Polygonal-SVM.

Fig. 12 indicates the specificity value for all kernel functions. Here we can see that the quadratic-SVM gives a higher specificity value i.e. 96.15% in comparison to other SVMkernels.

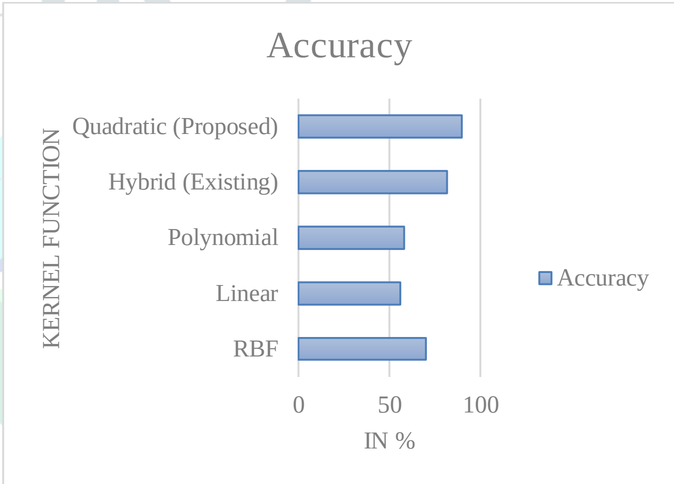

Figure 13: Accuracy comparison of Propose Quadratic-SVM kernel function with the existing hybrid-SVM kernel, RBF-SVM, Linear-SVM, Polygonal-SVM.

Fig. 13 indicates the accuracy value for all kernel functions. Here we can see that the quadratic-SVM gives a higher accuracy value i.e. 90% in comparison to other SVMkernels.

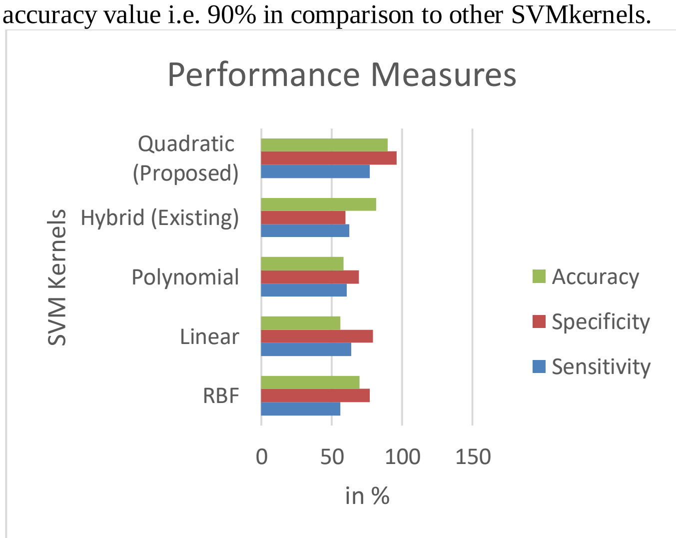

Figure 14: Performance measurement of different SVM kernel functions.

Fig. 14 illustrated the overall performance measurements for all kernel functions. It includes all three parameters for comparison and the quadratic-SVM achieved a higher value in comparison to other SVMkernels.

V. CONCLUSION

Lung cancer is the most prevalent death cancer of all cancers and CT scans are the perfect way to image cancer of the Lung. Cancer is detected in multiple forms as a symptom, such as a tumor, abnormal coughing, long-term cough, accelerated weight loss, etc. Lung cancer, also recognized as carcinoma, is the development of malignant lung tumors (cancerous nodules) due to uncontrollable cell growth in lung tissues. The major issue with lung cancer is that most of these cancer cases are detected in later stages of cancer making treatments very difficult & considerably decreasing survival chances. To resolve this issue, the SVM classifier has been used with the Quardaractiv function. Also, a high pass filter and median filter have used to filter the images. These processes followed the reconstruction of the image then morph the given images and finally segment the images. From the experimental results and analysis, we achieved higher performance in comparison to other SVM kernel functions. Proposed model performance is measured as inaccuracy, sensitivity & specificity term, which are 90%, 96.15%, and 76.92% respectively. This is 9% faster than the existing hybrid SVM kernel function.

This work is future enhance in the field of disease detection using MRI images or another real image dataset. This will also useful to detect protest cancer via morphing the images and by applying Random forest classifier or any other best classifier

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