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Detection of Lung Tumor in MR Images using Modified Pillar K-Means Algorithm with Gabor Filter and Color Mapping

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Abstract: ***This paper presents an approach to image segmentation using Modified Pillar K-Means algorithm. This segmentation method includes a new mechanism for distance metric and grouping the elements of high resolution images in order to improve accuracy. The system uses modified Pillar K-means algorithm for optimized image segmentation. The Pillar algorithm considers the placement of pillars that should be located as far from each other to resist the pressure distribution of a roof same as the number of centroids between the data distribution. This algorithm is able to optimize the K-Means clustering for image segmentation in the aspects of accuracy. This algorithm distributes all initial centroids according to the Accumulated Distance Metric (ADM) & the distance is calculated by Chessboard distance measure. This paper evaluates the proposed approach for image segmentation with Gabor filter, Modified Pillar K-Means clustering algorithm and Marker controlled Watershed Transform with different samples of MR Images for Accuracy, Precision, Sensitivity Factor, Specificity Factor F-Factor & Success rate. Experimental results clarify the effectiveness of our approach to improve the segmentation quality.***

Keywords: Tumor, Segmentation, Detection, Centroids, Gabor filter, Marker Controlled Watershed Transform

1. Introduction

Medical image processing is exciting and active fields of research, where disciplines such as Engineering, Computer Science, Physics, Biology and Medicine inter disciplinarily cooperate in order to improve health care. Most frequently, medical images are the basis of diagnostics, treatment planning, and treatment, but medical images are likewise important for medical education, research and epidemiology. Since the discovery of X-rays more than 100 years ago, several imaging modalities have been developed to visualize anatomy, tissue morphology, as well as muscular-skeletal and nervous functionality of the human body. Computed tomography (CT), magnet resonance imaging (MRI) and Ultrasound (US) are commonly known, but others, such as magnetic resonance spectroscopy imaging (MRSI), fluorescence endoscopy, CT angiography or optical surface scanning (OSS) are also applied in clinical routine. The discipline of medical image processing deals with: The generation & reconstruction, pre-processing & improvement, analysis & quantification, as well as visualization and management of all kinds of medical images. Frequently used steps in the image processing pipeline are image registration, which aims at aligning image data from different modalities, subjects, or points of time, as well as image segmentation, which aims at localization and delineation of relevant objects in two-dimensional (2D) projections and three-dimensional (3D) visualization.

Lung cancer is a disease of abnormal cells multiplying and growing into a tumor. Lung cancer is the most dangerous and widespread cancer in the world according to stage of discovery of the cancer cells in the lungs, so the process early detection of the disease plays a very important and essential role to avoid serious advanced stages to reduce its percentage of distribution.

General description of lung cancer detection system contains four basic stages. The first stage starts with taking a collection of CT images (normal and abnormal).The second stage applies several techniques of image enhancement, to get best level of quality and clearness. The third stage applies image segmentation algorithms which play an effective rule in image processing stages, and the fourth stage obtains the general features from enhanced segmented image which gives indicators of normality or abnormality of images.

2. Lung Cancer

Lung cancer is the most common cancer which occurs for both men and women. According to the report submitted by the American Cancer Society in 2013, lung cancer would report for about 13% of all cancer diagnoses and 28% for all cancer deaths. The survival rate for lung cancer analyzed in 5 years is just 15%. If the disease is identified while it is still localized, this rate increases to 49%.However, only 15% of diagnosed lung cancers are at this early stage [5]. The human lungs are the organs of respiration in humans. The main function of the lungs is to allow oxygen from the air to enter the bloodstream for delivery to the rest of the body [6].

Lung cancer is caused by uncontrolled cell growth in tissues of the lung. If left untreated, this growth can spread beyond the lung in a process called metastasis into nearby tissue and eventually, into other parts of the body [7]. Lung cancer is of two types: NSCLC and SCLC. The NSCLC accounts for about 80% of lung cancers. There are different types of NSCLC. And SCLC accounts for about 20% of all lung cancers. Although the cells are small, they multiply quickly and form large tumors that can spread throughout the body. Smoking is almost always the cause of SCLC. It was formerly referred to as "oat-cell" carcinoma [7].

2.1 Causes of Lung Cancer

Some of the main causes of lung cancer are:

- Smoking: It is the main cause of Lung cancer.
- Radon Gas: Radon is a colorless and odorless gas generated by the breakdown of radioactive radium, which in turn is the decay product of uranium found in the Earth's crust. The radiation decay products ionize genetic material, causing mutations that sometimes turn cancerous.
- Asbestos: Asbestos can cause a variety of lung diseases, including lung cancer. Tobacco smoking and asbestos have a synergistic effect on the formation of lung cancer. In smokers who work with asbestos, the risk of lung cancer is increased 45-fold compared to the general population.
- Air pollution: Outdoor air pollution has a small effect on increasing the risk of lung cancer.
- Genetics: About 8% of lung cancer is due to inherited factors. In relatives of people with lung cancer, the risk is increased 2.4 times. This is likely due to a combination of genes. Polymorphisms on chromosomes 5, 6 and 15 are known to affect the risk of lung cancer.

3. Literature Survey

In this section those references that are most relevant are presented.

Lung cancer was not known before the advent of cigarette smoking. It was not even recognized as a disease until 1761. Different aspects of lung cancer were described further in 1810. In Germany in 1929, physician Fritz Lickint recognized the link between smoking and lung cancer. Bhadauria and Dewal described that with the advancement in Computed Tomography technology it is widely used in diagnosing different diseases. The expanding volume of thoracic CT studies along with the increase of image data, supplements the need for CAD schemes to assist the radiologists. Mathematical morphology is a new mathematical theory which can be used to process and analyze the images [7]. Yamomoto et al., described LSCT technique which was mobile-type CT scanner mainly for the purpose of mass screening of lung cancer. With LSCT technique, one main complexity was raise in the image information to around 30 slices per person from1 X-ray film [9]. Yeny Yim et al., described about Hybrid lung segmentation in chest CT images for computer aided diagnosis. The author proposed a system which consists of three phases to obtain lung region borders [11]. Zhi-Hua Zhou et al. described that Lung cancer is one of the most common and deadly diseases in the world. Detection of lung cancer in its early stage is the key of its cure [12].

Lin et al. described the method to diagnose lung cancer nodules on digitized chest radiographs, which was based on a parameterized two-level convolution artificial neural network and on a special multi-label output encoding procedure. Kanazawa and Kubo described a system to detect the tumor candidates from helical CT images that extracted and analyzed features of the lung and pulmonary blood vessel regions and then utilized defined rules to perform diagnosis. Armato et al., described fully automated computerized technique based on two-dimensional and three-dimensional analyses of the image data obtained during diagnostic CT scans for the identification of lung nodules in helical computed tomography scans of the thorax. Penedo et al. developed a system that employed an artificial neural network to detect suspicious regions in a low-resolution image and employed another artificial neural network to deal with the curvature peaks of the suspicious regions, which was used in the detection of lung nodules found on digitized chest radiographs.

Yamomoto et al., proposed image processing for computer aided diagnosis of lung cancer by CT (LSCT) [9]. LSCT is the newly built mobile-type CT scanner mainly for the purpose of mass screening of lung cancer. In this new LSCT technique, one main complexity is the raise in the image information to around 30 slices per person from 1 X-ray film. In the process detection of edge is needed to display image information to the doctor for identify abnormalities.

In 2010, M.Gomathi and Dr. P. Thangaraj used the idea of basic image processing techniques such as Bit-Plane Slicing, Erosion, Median Filter, Dilation, Outlining, Lung Border Extraction and Flood-Fill algorithms are applied to the CT scan image in order to detect the lung region. Then the segmentation algorithm is applied in order to detect the cancer nodules from the extracted Lung image and proposed the idea of Fuzzy Possibility C Mean (FPCM) algorithm for segmentation because of its accuracy. After segmentation, rule based technique is applied to classify the cancer nodules. Finally, a set of diagnosis rules are generated from the extracted features. From these rules, the occurrences of cancer nodules are identified clearly. In 2011 Disha Sharma and Gagandeep Jindal proposed the system generally first segments the area of interest (lung) and then analyzes the separately obtained area for nodule detection in order to diagnosis the disease.

4. Problem Statement

Despite the advances in oncological care over the last decades lung cancer remains the largest cause of cancer deaths worldwide with an overall 5-yr survival rate of only 15% .Early detection of the lung increases significantly the chances of survival. For this purpose, Physicians use variety of techniques imaging modalities which include Xrays, Bronchoscopy, Computerized tomography (CT) Scan and sputum cytology.

Early Detection and Accuracy of detection are the main problems. Small tumors should be detected and identified easily. If a tumor is small and it is not detected then it could expand in a few days and could become very difficult to treat. Early Detection and early treatment are the necessary things for saving the lives. Lung cancer is considered to be the main cause of cancer death worldwide, and in its early stages it is difficult to detect because only in the advanced stage symptoms appear causing the mortality rate to be the highest among all other types of cancer. If lung nodules can be identified accurately at an early stage, the patient’s survival rate can be increased by a significant percentage.

4.1 Lung Cancer

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5. Technical Approach

In the following paper, we are proposing an effective scheme to detect abnormal formation of cells in the lungs. Here we present an approach that detects the tumor from the lung image. In this proposed approach we first collect MR Images of cancer affected lungs and then we apply a series of operations.

This is mainly divided into 4 stages. Initially we collect MR images and then we use suitable filters like Gabor filter to enhance the image, then we apply Modified Pillar K-Means Clustering Segmentation to the already enhanced image and then in the last stage i.e features extraction stage we clearly locate the tumor region by color mapping.

This can be shown in the form of block diagram as follows:

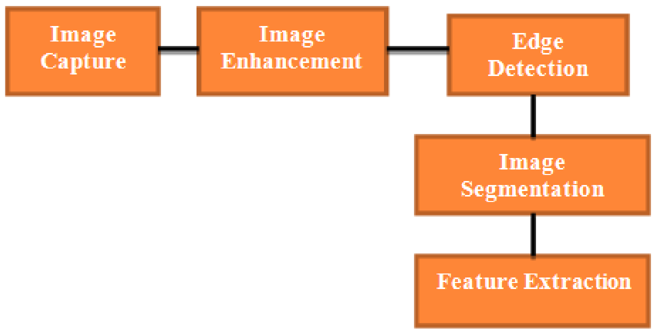


Figure 1: Block diagram of the proposed method

5.1 Image Enhancement

The image Pre-processing stage starts with image enhancement; the aim of image enhancement is to improve the interpretability or perception of information included in the image for human viewers, or to provide better input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories: Spatial domain methods and frequency domain methods. Unfortunately, there is no general theory for determining what "good" image enhancement is when it comes to human perception. If it looks good, it is good.

However, when image enhancement techniques are used as preprocessing tools for other image processing techniques, the quantitative measures can determine which techniques are most appropriate.

5.1.1 Gabor Filter

Image presentation based on Gabor function constitutes an excellent local and multi scale decomposition in terms of logons that are simultaneously (and optimally) localization in space and frequency domains. A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function.

$$\mathbf{F[IR(gabor\ filter)] = F[H]*F[G]} \qquad (1)$$

The Equation of Gabor filter is given as:

$$G_{x,y} = \exp\left(-\frac{(x\cos\theta + y\sin\theta)^2 + \gamma^2(-x\sin\theta + y\cos\theta)^2}{2\sigma^2}\right) X\cos\left(2\pi\frac{1}{\lambda}(x\cos\theta + y\sin\theta) + \phi\right) \qquad (2)$$

Where, γ is the aspect ratio, ϕ is the phase

θ is the orientation, λ is the wavelength

5.1.2 Gabor Filter Algorithm

The steps involved in Gabor Filter's Algorithm are as follows:

Step 1: Read the image
Step 2: Resize the image
Step 3: Show the input resized image
Step 4: Declare Gabor Filter Variables
Step 5: Assign value to aspect ratio, gamma, theta, orientation, bandwidth and lambda
Step 6: Implement Gabor filter equation which was shown above
Step 7: Show the filtered image

5.2 Image Segmentation

Image segmentation is an essential process for most image analysis subsequent tasks. In particular, many of the existing techniques for image description and recognition depend highly on the segmentation results [9].Segmentation divides the image into its constituent regions or objects. Segmentation of medical images in 2D, slice by slice has many useful applications for the medical professional such as: visualization and volume estimation of objects of interest, detection of abnormalities (e.g. tumors, polyps, etc.), tissue quantification and classification, and more [9]. The goal of segmentation is to simplify and/or change the representation of the image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics [9]. 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 (edge detection). All pixels in a given region are similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). Segmentation algorithms are based on one of two basic properties of intensity values: discontinuity and similarity. The first category is to partition the image based on abrupt changes in intensity, such as edges in an image. The second category is based on partitioning the image into regions that are similar according to a predefined criterion.

Image segmentation plays a major role in the field of biomedical applications. The segmentation technique is widely used by the radiologists to segment the input medical image into meaningful regions [1, 4, 5, 8]. The specific application of this technique is to detect the tumor region by segmenting the abnormal MR input image. The size of the tumor region can be tracked using these techniques which aid the radiologists in treatment planning. The primitive techniques are based on manual segmentation which is a time consuming process besides being susceptible to human errors. Several automated techniques have been developed which removes the drawbacks of manual segmentation.

5.2.1 Modified Pillar K-Means Clustering

The Modified Pillar algorithm [1] is described as follows. Let X={xi |i=1,…,n} be data, k be number of clusters, C={ci | i=1,…,k} be initial centroids, SX be identification for X which are already selected in the sequence of process, DM={xi |i=1,…,n} be accumulated distance metric, D={xi | i=1,…,n} be distance metric for each iteration, and m be the grand mean of X. The following execution steps of the proposed algorithm are described as:

5.2.2 Modified Pillar Algorithm:

1. Set C=Ø, SX=Ø, and DM=[ ]
2. Calculate D← dis(X,m) ; Hear We have used Chessboard distance instead of Euclidian distance method i.e.,
D ← max[abs(x+s), abs(x-s)]
3. Set number of neighbors nmin = α. n / k
4. Assign dmax← argmax(D)
5. Set neighborhood boundary nbdis = β . dmax
6. Set i=1 as counter to determine the i-th initial centroid
7. DM = DM + D; Hear it is Accumulated Distance Metric (ADM)
8. Select ж ← xargmax(DM) as the candidate for i-th initial centroids
9. SX=SX U ж
10. Set D as the distance metric between X to ж.
11. Set no← number of data points fulfilling D ≤ nbdis
12. Assign DM(ж)=0
13. If no < nmin, go to step 8
14. Assign D(SX)=0
15. C = C U ж
16. i = i + 1
17. If i ≤ k, go back to step 7
18. Finish in which C is the solution as optimized initial centroids

5.3 Feature Extraction

Image features Extraction stage is an important stage that uses algorithms and techniques to detect and isolate various desired portions or shapes (features) of a given image.

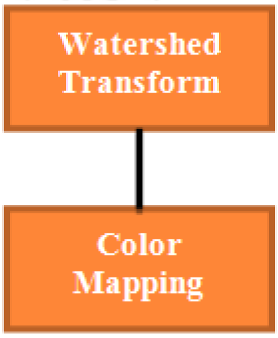


Figure 2: Block diagram from Feature Extraction

5.3.1 Marker Controlled Watershed Transform (MCWT)

The watershed transform is a tool morphological based for image segmentation. It is proposed by Digabel and Lantuejoul which consider a grey level image as a topographic relief. If one combines the grey level of each point at an altitude. It is then possible to define the watershed transform as the ridge forming the boundary between two watersheds. This is to compute the watershed of the said relief. Watersheds thus obtained correspond to regions of the image. Watershed represents the boundaries between adjacent catchments. The minimum can be interpreted as markers of watershed regions and the watershed can be interpreted as contours.

5.4 Color Mapping

It applies different colors to the various clusters of the Image. After applying all the Visualization steps, the tumor region can easily be spotted.

6. Experimental Results

The practical results for the proposed method for the set of MR Images are shown below:

True positive value, Tp = [a(i,j)==1 || m(i,j)==1]
True negative value, Tn = [a(i,j)==0 || m(i,j)==0]
False positive value, Fp = [a(i,j)==1 || m(i,j)==0]
False negative value, Fn = [a(i,j)==0 || m(i,j)==1]

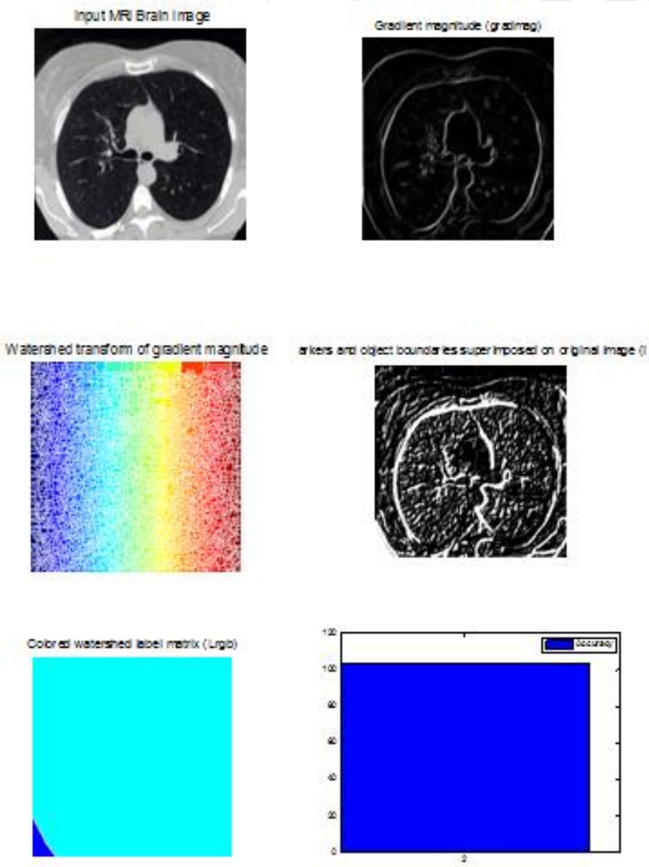
The formulae used to calculate Accuracy, Precision, Sensitivity Factor, Specificity Factor, F-Factor & Success Rate are:

Accuracy= ((Tp+Tn)/(Fp+Fn))*100

Precision = (Tp/(Tp+Fp))
Sensitivity Factor SF = [tp/(tp+fn)]
Specificity =(Tn/(Tn+Fp))
F = (2*Precision*Sensitivity)/(Precision+Sensitivity)
SR = Sensitivity/(Sensitivity+F)

Different sample of Lung MR Images are taken and simulated in MATLAB 7.5 version & results of modified Pillar K-Means clustering algorithm is shown below:

For Test Image 1



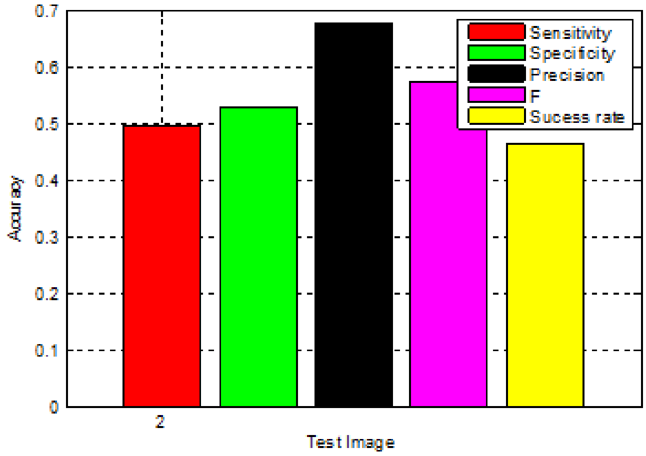
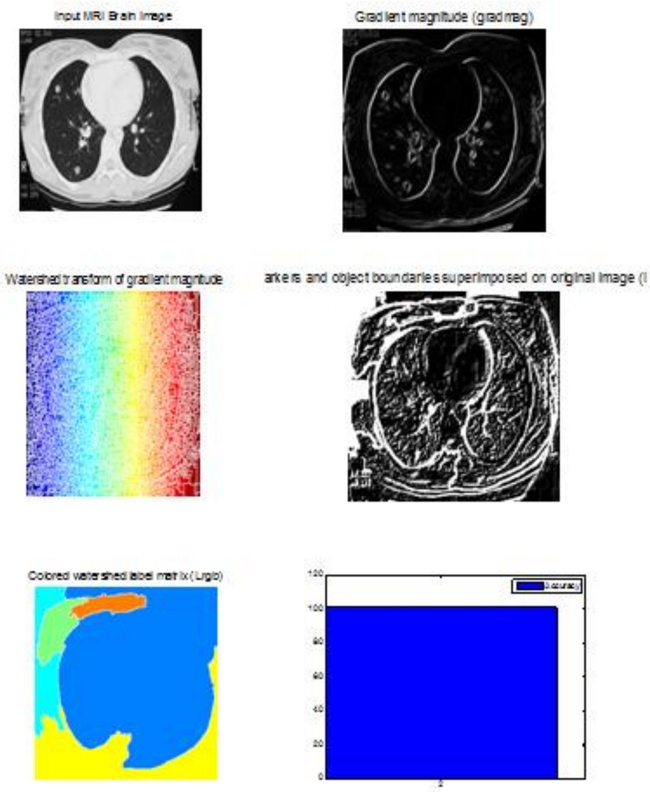


Figure 3: Experimental Results for Test Image 1

For Test Image 2



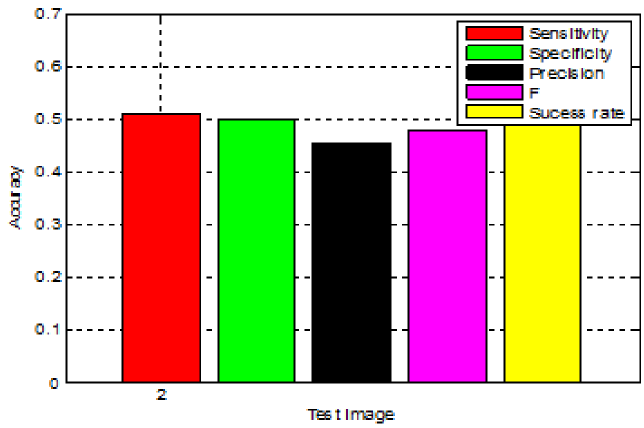


Figure 4: Experimental Results for Test Image 2

For Test Image 3

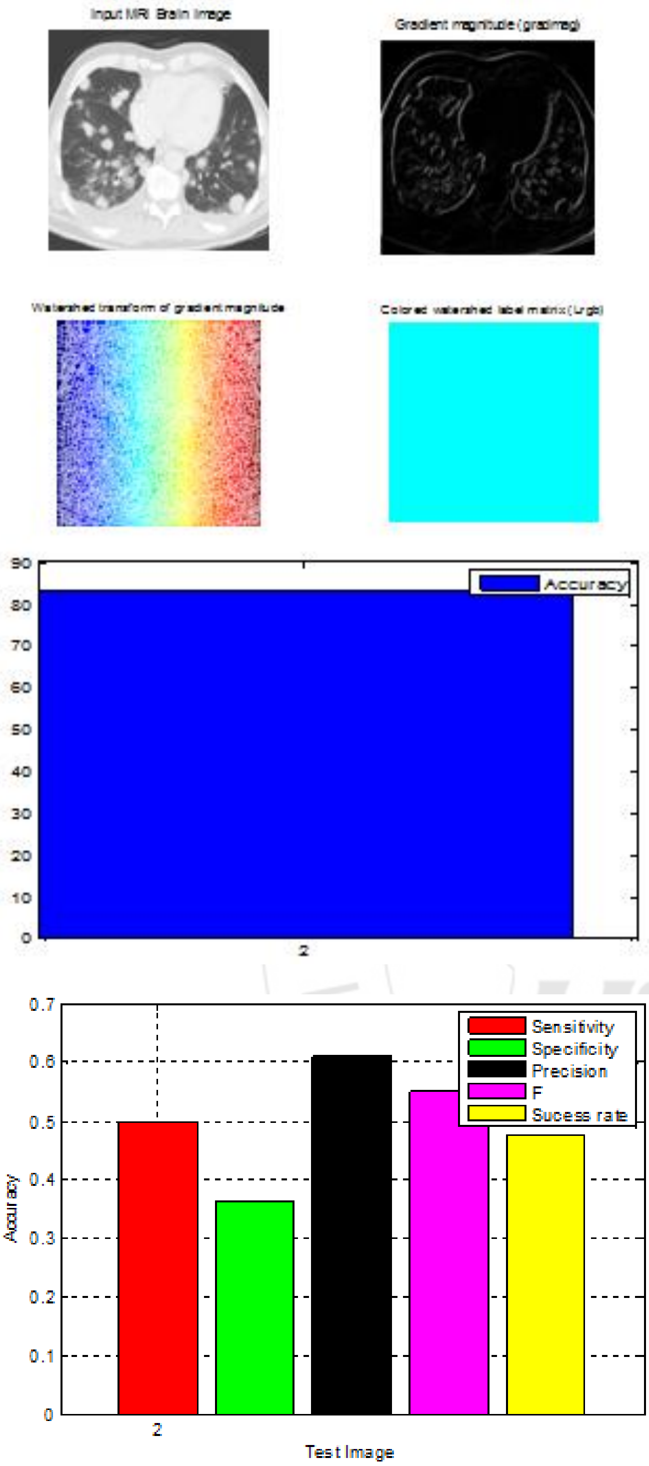


Figure 5: Experimental Results for Test Image 3

For Test Image 4

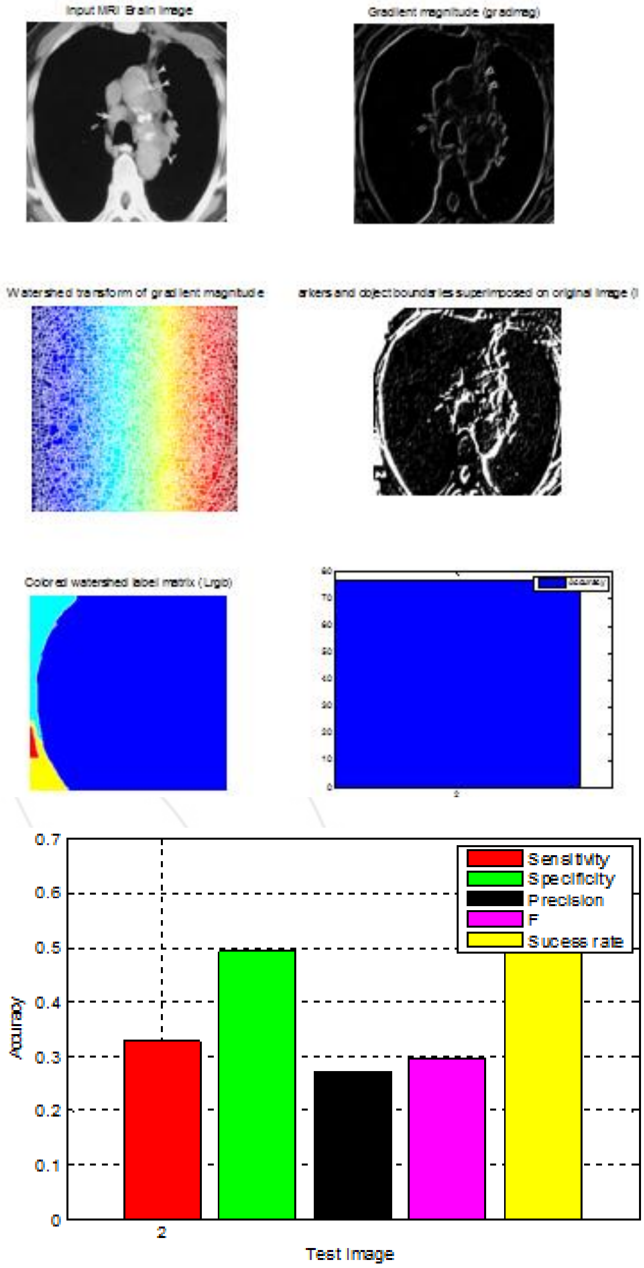


Figure 6: Experimental Results for Test Image 4

For Test Image 5

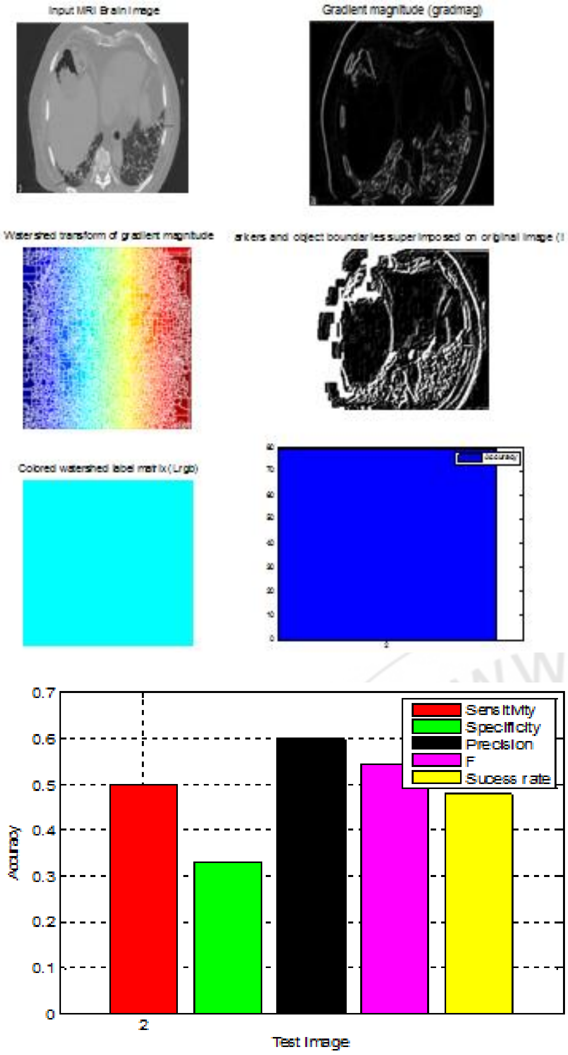
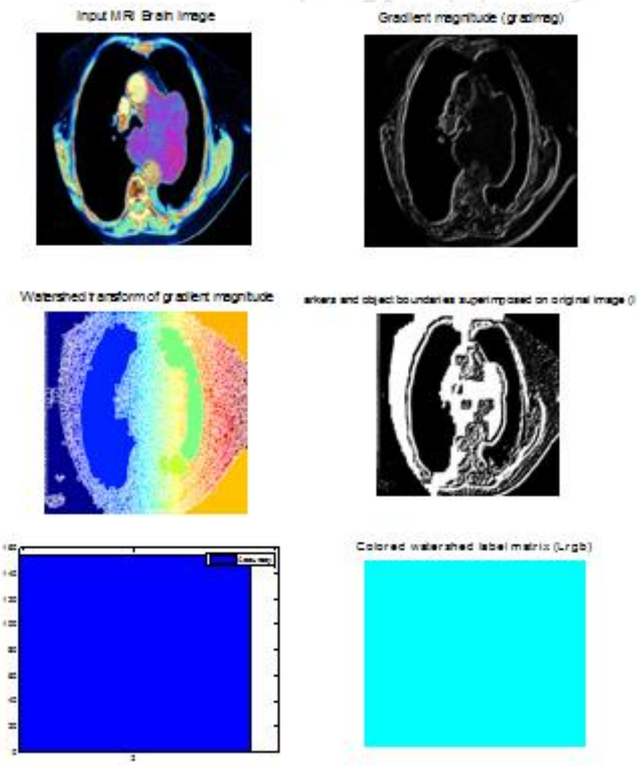


Figure 7: Experimental Results for Test Image 5

For Test Image 6



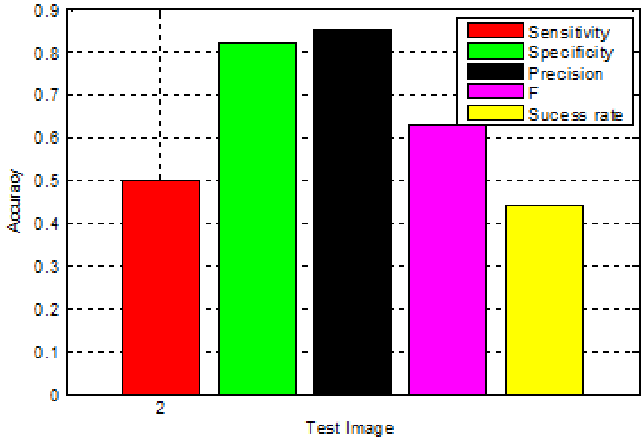
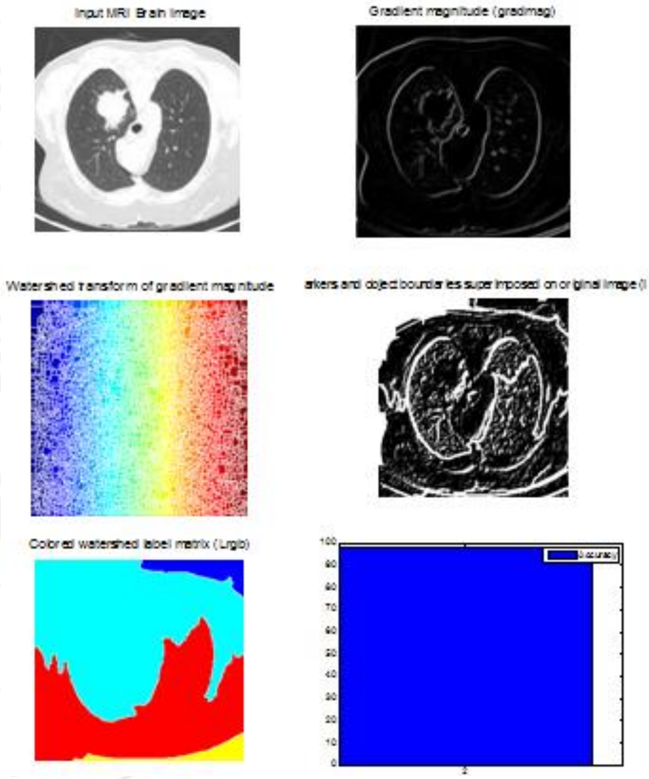


Figure 8: Experimental Results for Test Image 6

For Test Image 7



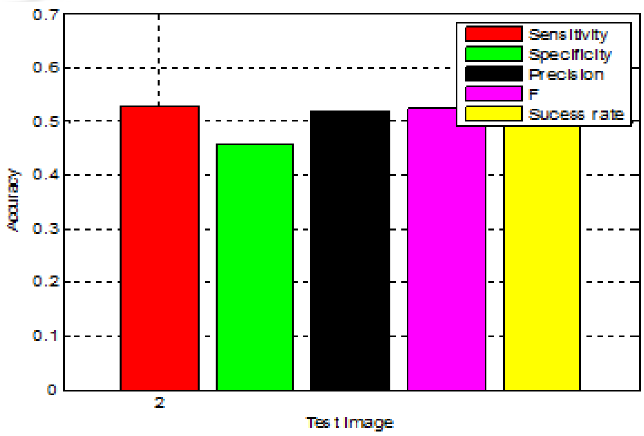


Figure 9: Experimental Results for Test Image 7

7. Conclusion

In this Paper, we proposed an approach to image segmentation using Modified Pillar K-Means algorithm with Gabor filter & color mapping for Lung MR Images. The system applies the modified Pillar K-Means algorithm for optimized segmentation. Pillar algorithm considers the placement of pillars should be located as far from each other to resist the pressure distribution of a roof, as same as the number of centroids between the data distribution. This algorithm is able to optimize the K-Means clustering for image segmentation in the aspects of accuracy, precision, sensitivity, specificity, F-factor & success rate. A series of experiments with different Lung MR Images was conducted and executed. The experimental results show that our proposed approach for image segmentation using Modified Pillar K-Means algorithm is able to improve the accuracy and enhance the quality of image segmentation.

The Code Has Been Successfully Simulated in Matlab 7.5 version. The proposed technique has spotted the tumor region in the affected Lungs and the code has been verified on different healthy and cancer affected lung Images and got good results.

8. Future Scopes

Future research in the segmentation of medical images will lead towards improving the accuracy, exactness, and computational speed of segmentation approaches, as well as minimizing the amount of manual interaction. These can be improved by incorporating discrete and continuous-based segmentation methods. Computational effectiveness will be crucial in real-time processing applications. Segmentation methods have proved their utility in research areas and are now emphasizing increased use for automated diagnosis and radiotherapy. These will be particularly important in applications such as computer integrated surgery, where envision of the anatomy is a significant component.

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