Medical Image Segmentation

Geeta Hanji [1],M.V.Latte[2],Madhuri Deshak[3]

[1]Electronics and Communication Engg. Dept. PDA College of Engg, Gulbarga ,Karnataka, India.

geetanjalipatil123@gmail.com

[2]JSS Institute for Technical Education, Bangalore, Karnataka, India.

mvlatte@radiffmail.com

[3]M.Tech, Communication Systems, PDA College of Engineering, Gulbarga, Karnataka., India.

deshakmadhu@gmail.com

***Abstract*- The main concept of medical image segmentation is to extract and characterize the anatomical structures with respect to some input features or expert knowledge. The main objective of our work is image segmentation. Prior to segmentation we subject the medical image to preprocessing. Image preprocessing involves noise detection & histogram based identification of the type of noise present followed by smoothing with the suitable filters to get the good quality of image. Later edge detection using multi-dimensional (M-D) filtering and segmentation by region growing and contour extraction are performed to get the desired results.**

***Keywords* -- Image segmentation, Image smoothing Edge detection, Impulsive noise, Gaussian noise, Median filter, Gaussian Filter, Frost Filter, Region Growing, Active Contour.**

I.INTRODUCTION

Medical imaging applications play important role in the anatomical structures the human body. Image segmentation is a challenging task due to the various characteristics of the images, which leads to the complexity of segmentation. Image segmentation has been a powerful tool in analyzing the content of an image so as to know the information it stores. At present, image data visualization, especially visualization of medical image (such as X-ray, Computer Tomography (CT), Magnetic Resonance Image (MRI) and Position Emission Tomography (PET)), has become one of the hotspots of image processing research after 20 years development [1].

Image segmentation is the most intuitive method for medical image visualization. By extracting the edge of the interested template and pathological area the purpose of adjuvant therapy, surgical planning, teaching model, prosthetic design and etc is served.

Partitioning of an image into several constituent components is called Image segmentation. Prior to segmentation it is necessary to subject the image to filtering [3]. The goal of the filtering action is to cancel noise while preserving the integrity of edge and detail information. Several filtering schemes [11],[12] are available in the literature to restore the images. These schemes differ in their basic methodologies applied to suppress the noise. Since most of the medical images are corrupted by impulsive, Gaussian and speckle noise, identification and smoothing of the noise using suitable filters becomes the important pre-processing step prior to segmentation. Further, the edge detection of the pre-processed image helps in improving the valuable information for segmentation of the image.

This work deals with an algorithm to account for the above mentioned tasks: Image pre-processing followed by edge detection and segmentation. In this work we have considered the segmentation of the brain MRI images. Performance of the Median, Gaussian and the Frost filters is validated by adding impulsive, additive and speckle noise to the brain MRI image in the image pre-processing stage. Further to improve the valuable information of the pre-processed image, edge detection is performed using multi-dimensional (M-D) filtering. Finally image segmentation is carried out using Region Growing and Active Contour methods.

The present paper is organized as follows: Section II describes the histogram based noise identification. Section III describes smoothing of the noisy images. Section IV and V explains the edge detection and the image segmentation methods used in our work. Section VI presents the simulation results and discussions. Finally conclusions are drawn in section VII.

II. NOISE IDENTIFICATION

Digital images are often corrupted by different types of noise, namely Additive, Impulsive and Speckle. Causes of noise may be transmission errors, faulty memory locations or timing errors in A to D conversations. Most of the medical images are often corrupted by impulsive, Gaussian and speckle noise. Hence identification and removal of these noises is an important pre-processing in medical image segmentation. In our work, noise identification primarily consists of identifying the homogenous regions in the image based on roughly segmenting and labeling the noisy image. The image of labels is then used for the selection of homogeneous regions. The Peak detection and valley extraction method is used to analyze the noisy image histogram and finally extract the valleys required for computing the threshold value for the purpose of segmentation of the homogenous regions. A typical histogram analysis is carried out as follows:

Step1: Identify the dominating peaks of the histogram.

Step2: Find the valleys between different peaks.

Step3: Apply the threshold to the image for segmentation of the homogenous regions

Each of the local homogeneous regions must have at least 128 pixels. This value varies from image to image based on its size.

The identification of type of noise in the medical image is carried out in two stages. In the first stage, a criterion is used to detect the presence of the impulsive noise. If the result of this criterion is negative, the image is then submitted to second stage in order to identify either the additive or multiplicative nature of the noise.

A. Detection of Impulsive Noise:

If P_{avg} / P_{max} > Threshold , then the noise affecting the image is declared to be an impulsive noise, where P_{avg} is the average of the grey pixel values of the homogeneous regions and P_{max} is the maximum grey level pixel value in the homogeneous regions.

B. Detection of Additive or Multiplicative Noise:

If P_{avg} is nearer to the value zero than we can say it as additive noise else it is multiplicative noise.

III. IMAGE SMOOTHING

Medical image smoothing is the process of removing the noise from the observed noisy image to render the original image. However, this is a difficult problem in any image processing system because the restoration filter must not distort the useful information in the image and preserve image details and texture while removing the noise [3].

The smoothing of the medical image is carried out in two stages. In the first stage, a criterion is used to suppress the presence of the impulsive noise using a suitable filter. If the type of noise in the medical image is either additive or multiplicative, the image is then submitted to second stage in which a mask Gaussian filter or Frost filter [5] are used for suppressing the Gaussian and Speckle noise respectively. The details of the filtering are given as follows:

A. Impulsive Noise Smoothing:

Median filtering which is basically a non-linear filter is used to achieve good results in image restoration. All the 2-stage median based filters are very effective in detection and suppression of the impulsive noise. In our work we have used a 2-stage switching threshold based median filter. In the first stage Min-Max strategy is used for impulse noise detection and “A Switching Threshold based Median Filter” [ ] is used for impulsive noise reduction, where median $\{x_k\}$ is the noise exclusive median.

$$y_{median} = \begin{cases} median\ \{x_k\}; & if\ \left|median\ \{x_k\} - x\right| > threshold \\ x & ;\ otherwise \end{cases} \quad (1)$$

B. Additive Noise Smoothing

The additive noise smoothing of the medical image is carried out by using a Gaussian filter. The Gaussian linear filter is a simple rank selection filter that attempts to remove Gaussian noise by convolving the given image with the Gaussian mask. Since the image is stored in discrete pixels, the Gaussian mask will be a discrete approximation of the 2-D Gaussian function g(x) as given below:

$$g(x) = \frac{1}{\sqrt{2\cdot\pi}\cdot\sigma}\cdot e^{-\frac{x^2}{2\sigma^2}} \quad (2)$$

C. Multiplicative Noise Smoothing:

The multiplicative noise smoothing of the medical image is carried out by using a Frost filter. The Frost filter replaces the pixel of interest with a weighted sum of the values within the mxn moving window. The weighting factors decrease with distance from the pixel of interest. The weighting factors increase for the central pixels as variance within the window increases [5].

D. Performance of the filtered image

Performance of the resultant filtered medical image is calculated by using mean square error and PSNR.

MSE measures the average of the squares of the errors. PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise. A higher PSNR would normally indicate that the reconstruction is of higher quality.

It is most easily defined via the mean squared error (**MSE**) which for two $m\times n$ monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-K(i,j)]^2 \quad (3)$$

$$\begin{aligned} PSNR &= 10\cdot\log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20\cdot\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20\cdot\log_{10}(MAX_I) - 10\cdot\log_{10}(MSE) \end{aligned} \quad (4)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.

IV. EDGE DETECTION

Edge detection is a process of identifying image edge. The sharp change in image pixel intensity is identified as the edge of the image. Edge detection of an image significantly reduces the amount of data and filters out the redundant information, while preserving the vital structural properties in an image. Sound edge detection will provide valuable information for further processing of an image such as image segmentation, image enhancement, image registration, identifying object in scene etc. In our work we have used multidimensional filtering technique for edge detection.

V. IMAGE SEGMENTATION

The main goal of image segmentation is domain independent partitioning of an image into a set of disjoint regions that are visually different, homogeneous and meaningful with respect to some characteristics or computed property such as grey level, texture or color to enable easy image analysis. In our work we have attempted to segment the given medical image using the following approaches:

Merge-Split Blocking Using Region growing and Active contour methods.

A. Merge-Split Blocking Using Region growing method

a) Region growing method

The first step in region growing is to select a set of seed points. Seed point selection is based on some user criterion. The initial region begins as the exact location of these seeds. The regions are then grown from these seed points to adjacent points depending on a region membership criterion. The criterion could be, for example, pixel intensity, gray level texture, or color.

The region is iteratively grown by comparing all unallocated neighboring pixels to the region. The difference between a pixel's intensity value and the region's mean is used as a measure of similarity. The pixel with the smallest difference measured this way is allocated to the respective region. This process stops when the intensity difference between region mean and new pixel become larger than a certain threshold. Then segmentation is carried out by using Merge-Split Blocking.

b) Merge-Split Blocking

The merge-split routine is an optional stage of our region growing based segmentation scheme. It requires a threshold as an input. This threshold determines which blocks can be merged into a single block and which blocks can be split into smaller blocks based on the difference between the maximum and minimum intensities in each block. If the max-min difference of a block is close to the max-min difference of its neighbors (i.e., difference between blocks is within the threshold), then the blocks are merged into a single block. A block is split in half if the max-min difference of the block exceeds the threshold. This process is done recursively until no blocks satisfy the criteria to be split or merged [8].

B. Active contour (Snake) method

Snake is an energy minimizing, deformable spline influenced by constraint and image forces that pull it towards object contours. Snakes are greatly used in applications like object tracking, shape recognition, segmentation, edge detection, stereo matching. Snakes may be understood as a special case of general technique of matching a deformable model to an image by means of energy minimization. Snake is an “active” model as it always minimizes its energy functional and therefore exhibits dynamic behavior. One may visualize the snake as a rubber band of arbitrary shape that is deforming with time trying to get as close as possible to the object contour.

The energy functional consists of two components: the first component is the potential energy, and it is small when the contour is aligned to the image edge, and the second component is the internal deformation energy, and it is small when the contour is smooth. The termination functional can be implemented with a gradient direction calculus in a slightly smoothed version of the image.

a) Active contours models.

An Active contour can be parametrically represented by v(*s*) = (*x*(*s*), *y*(s)) and its energy functional can be written as:

$$E = \int_0^1 E_{int}(v(s))ds + \int_0^1 E_{image}(v(s))ds + \int_0^1 E_{ext}(v(s))ds \quad (5)$$

where E_{int} represents the internal energy of the spline due to bending. Internal spline energy can be written as:

$$E_{int} = \frac{(a(s)|v_s(s)|^2 + B(s)|v_{ss}(s)|^2)}{2} \quad (6)$$

The generic total image energy can be expressed as a weighted combination of the three energy Functions.

$$E_{image} = w_{line}E_{line} + w_{edge}E_{edge} + w_{term}E_{term} \quad (7)$$

The main advantage of active contour models is the ability of the method to give a piece wise linear description of the shape of the object at the time of convergence, without extra processing.

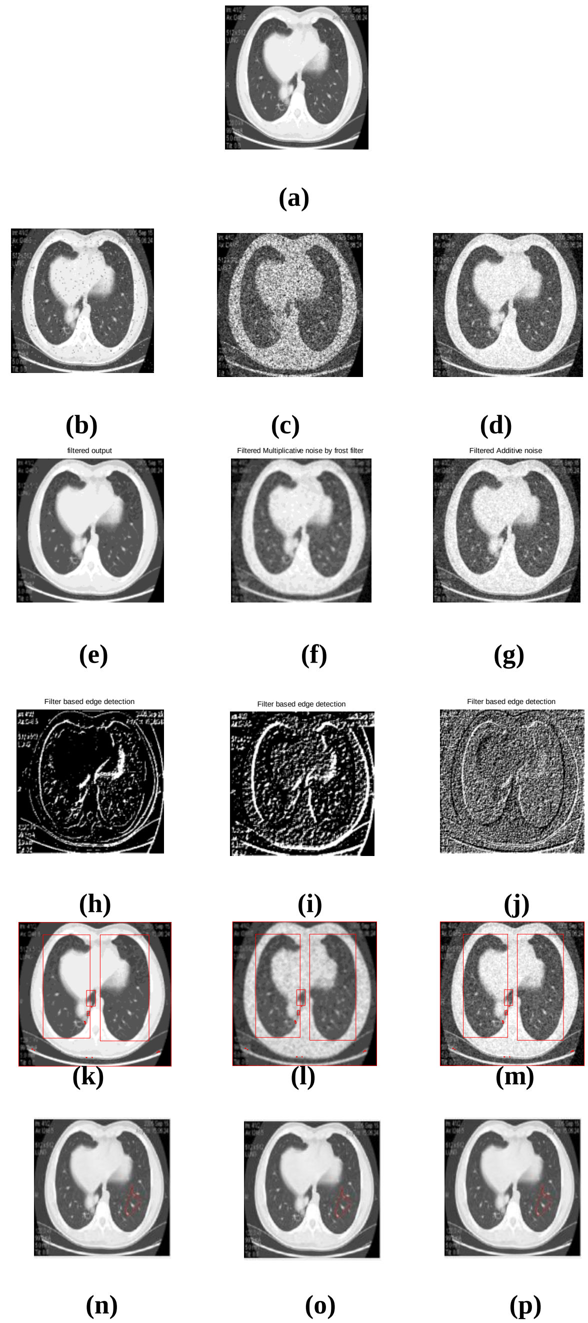

Fig 1. (a) Original Image (b) Image with impulse noise (c) Image with of multiplicative noise (d) Image with additive noise,(e) Impulse noise filtered image (f) Filtered multiplicative noise (g)Filtered additive noise, (h),(i),(j) Edge detected output of (e) ,(f),(g) using M-D filtering Technique (k),(l),(m) Region growing segmentation outputs of (h),(i),(j) and (n),(o),(p) Active counter(Snake) segmentation output (a)

VI. SIMULATION RESULTS AND DISCUSSION

Image segmentation is typically used to locate objects of interest and boundaries like lines, curves in an image. Our work (algorithm) developed in this direction is validated by implementing a program on MATLAB platform and the simulated results are as shown in fig1.

Figure (a) is original brain MRI image. Fig (b) is an image with 0.02% impulse noise density. Fig (c) and (d) are images with multiplicative and additive noise. Impulse noise filtered image using our proposed threshold based median filtering technique in which the noise content is suppressed to the highest extent is shown in Fig (e). Figures (f) and (g) demonstrate the performance of Frost and Gaussian filters in suppressing the speckle and additive noise respectively. Visual analysis shows that the results are pleasing. PSNR and MSE values obtained are also much encouraging Figures (h),(i) and (j) are the edge detected images of figures (e),(f) and (g) respectively. Figures (k),(l),(m) demonstrate the segmentation results obtained using Region growing method where as figures (n),(o),(p) show results of segmentation using Active contour method. Active contour, can locate the object boundaries dynamically and automatically from an initial contour as seen from the results.

VII. CONCLUSION

In this paper we have attempted to segment the underlying brain MRI image. Prior to segmentation type of the noise present in the image is identified and are filtered using suitable noise removal filters. Edge detection is performed to obtain the edge details of the image M-D filtering approach. Using Merge-split algorithm due to its use of the criteria based on the difference between the maximum and minimum pixel values within the region tends to act like an edge detection algorithm. So for medical images, merge-splitting is an effective first stage in segmentation, so that region growing takes place faster. Use of Active contour method has located the object boundaries dynamically and automatically from an initial contour due to ability to give a piece wise linear description of the shape of the object without extra processing.

REFERENCES

[1] Jagadish H. Pujar, Pallavi S. Gurjal, Shambhavi D. S, Kiran S. Kunnur," Medical Image Segmentation based on Vigorous Smoothing and Edge Detection Ideology", International Journal of Electrical and Computer Engineering, 2 May 2010.

[2] Prof. Geeta Hanji, Dr. M.V.Latte, "A New Threshold Based Median Filtering Technique for salt and Pepper Noise removal", 2nd International Conference on Digital Image Processing-ICDIP 2009, Proceedings of SPIE, vol.7546,PP754639-754649-10(2010) DOI:10.1117/12.856333

[3] Reginald L. Lagendijk and Jan Biemond ,"Basic methods for Image Rrestoration and Identification*",* 15 February, 1999.

[4]]Prof.Geeta Hanji, Dr. M.V.Latte,"Detail Preserving Fast Median based Filtering",Journal of Advanced Computer science and Technology,1(4)(2012)195-206

[5] Frost, V.S., Stiles, J.A., Josephine, A., Shanmugan, K. S., and Holtzman, J.C., 1982. A Model for Radar Images and Its Application to Adaptive Digital Filtering of Multiplicative Noise. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. PAMI-4, No. 2, March 1982.

[6] Kevin Liu." An Implementation of the Median Filter and Its Effectiveness on Different Kinds of Images", Computer Systems Lab, 2006-2007.

[7] Minh N. Do and Yue M. Lu"Multidimensional Filter Banks and Multiscale Geometric Representations", Foundations and Trends in Signal Processing, Vol. xx, No 1–96

[8] Shilpa Kamdi, R.K.Krishna "Image Segmentation and Region Growing Algorithm" , International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 1.

[9] Ashraf A. Aly, Safaai Bin Deris and Nazar Zaki "A Novel Image Segmentation Enhancement Technique Based On Active Contour And Topological Alignment",Advanced Computing: An International Journal (ACIJ), Vol.2, No.3, May 2011.

[10] Michael Kass, Andrew Witkin and Demetri Terzopoulos "Snakes: Active Contour Models", International Journal of Computer Vision, 321-331 (1988).

[11] X.Z.Sun and Anastasios N. Venetsanopoulos, "Adaptive Schemes for Noise Filtering and Edge Detection by Use of Local Statistics*",* IEEE transactions on circuits and systems,vol 35, no. 1, January 1988.

[12] Kevin Liu." An Implementation of the Median Filter and Its Effectiveness on Different Kinds of Images", Computer Systems Lab, 2006-2007.

[13]Prof.Geeta Hanji, Dr. M.V.Latte,"A New Impulse Noise Detection and Filtering Technique", International Journal Scientific and Research Publications (IJSRP), vol.2, Issue 1, January 2012.ISSN 2250-3153