Performance Comparison on Various Bio-Electrical Signals of MRI, CT and HSI in Human Abnormal conditions Using Hyperspectral Signal Analysis based 3D Visualization

Dr.T.Arumuga Maria Devi, AP/CITE, M.S.University, Tirunelveli, India, deviececit@gmail.com

Mr.D.Muthukumar, AP/SS,KCET, Virudhunagar, India, dmkumarvnr@gmail.com

Abstract: In the current days, the human bodies anatomical study highlights the treatment planning medical science depend on the medical imaging technology and bioelectrical medical images. Exactly the human body, MRI, CT and HSI widely prefers and using for the imaging. But by nature medical images are complex and noise. This leads to the necessity of processes that decreases difficulties in analysis and increases quality of output. Bioelectrical medical image processing is the most inspiring and emerging field today. This paper defines the methodology of detection & extraction of disease from patient's MRI, CT & HSI scan images of the human body. In this paper, a technique for segmentation of capturing images has been developed on three dimensional MRI, CT & HSI data which permits the identification of unnatural tissue with high accuracy and reproducibility compared to manual methods. This method combines with some noise removal functions, segmentation and morphological operations which are the basic ideas of image processing. Detection and extraction of tumor from MRI scan images of the brain is done by using MATLAB software. The aim of this work is to performance comparison on various Bio-Electrical Signals in Human Abnormal conditions using Hyperspectral Signal Analysis using MRI,CT & HSI image data sets.

Keywords* — *Bio-electrical signal, Grey scale imaging, MRI, CT, HSI, MATLAB, Morphology, Noise removal, Segmentation.

I. INTRODUCTION

Now a day's medical diagnosis is mostly supported by the imaging techniques. Many imaging modalities such as magnetic resonance imaging (MRI)[5], computed tomography (CT), ultrasonography, Doppler scanning, and nuclear imaging have entirely extended medical imaging field. Computed Tomography (CT)[7] and Magnetic Resonance Imaging (MRI)[22] have been customarily used for clinical analysis. MRI yielded well results in clinical diagnosis. Modern spectral imaging techniques have showed their significance in medical imaging by providing added potential to medical experts at higher speed and accuracy. The optical characteristics of tissues offer valuable diagnostic information. Hyperspectral image analysis[12] is being broadly used for medical diagnosis due to its ability to provide real time images of biomarker information and spectral information of tissues. Recently Hyperspectral imaging (HSI) [17][18] has emerged as a new member of the family of the medical imaging modalities. HSI offers a powerful tool for non-invasive tissue analyses. HSI systems are also used in image guided surgery. HIS can visualize invisible wavelength regions and bring them to the human vision range. In fact, Hyperspecral imaging has already been used in the medical field. Hyperspectral imaging captures bioelectrical such as reliable data and it shows a superior sensitivity for detecting a residual tumor tissue than current surgical tissue sampling techniques. Figure.1 shows a schematic view of a Hyperspectral image.

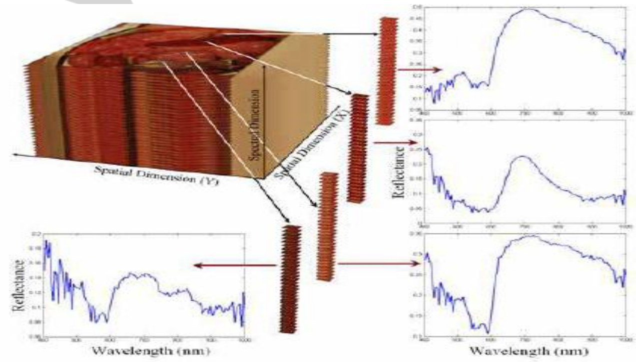


Figure 1. A schematic view of a Hyperspectral image.

The spectral graphs of the average spectrum from different parts of the body are shown in the four graphs. The graph shows the reflectance for each wavelength in that region. Bioelectrical (electrophysiological) signals: Electrical and chemical transmissions form the electrophysiological communication between neural and muscle cells. Signal transmission between cells takes place as every cell becomes depolarized relative to its resting membrane potential. These changes are recorded by electrodes in contact with the physiological tissue that conducts electricity. Although surface electrodes capture bioelectric signals of groups of correlated nerve or muscle cell potentials, intracellular electrodes display the difference in electric potential through an individual cell membrane.

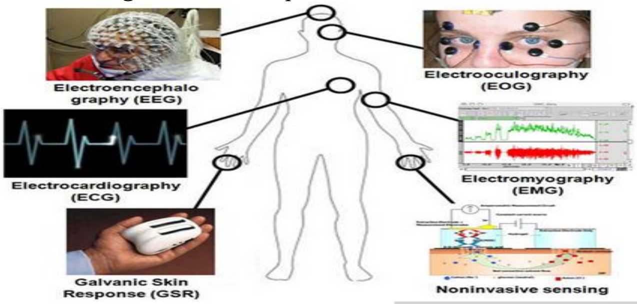
II OBJECTIVES

The first purpose of this work is to study bio-electrical signal recording, scope of Hyperspectral imaging and develop a framework for a robust and exact segmentation of a large class of brain tumors[8][9] in CT, MRI and HSI images. The second one is to detection and comparing abnormal conditions of human brain DICOM image such as CT, MRI with HSI medical images. The image analysis is implemented through Matlab code.

 DOI : 10.18231/2454-9150.2018.0567

A) BIO-ELECTRICAL SIGNAL RECORDING

Bio-electrical signals denote space-time records with one or multiple independent or dependent variables that capture some aspect of a biological event. They can be either deterministic or random in nature. Deterministic signals very frequently can be compact, described by syntactic techniques, while random signals are mainly described by statistical techniques. Figure 2.a shows bio-electrical signal recording and 2.b shows spatial and spectral view[24] of various image view techniques.



(a)

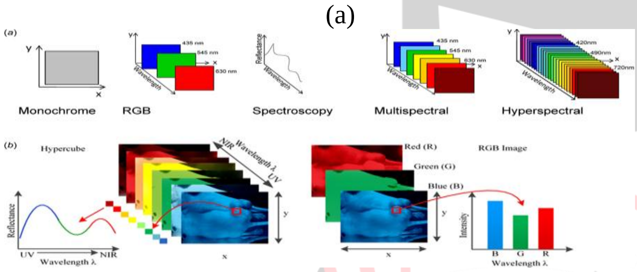


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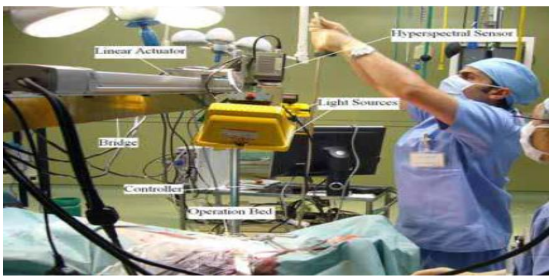
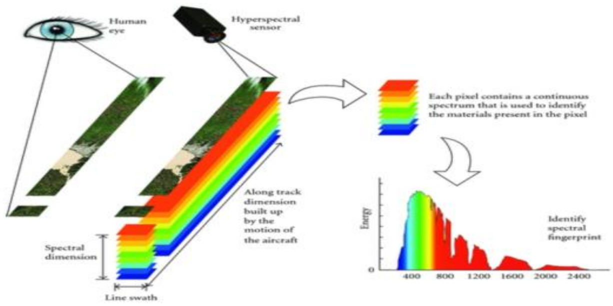
Figure 2.a) Bio-electrical signal recording. b) Spatial and Spectral view of various image view techniques.

B) HYPERSPECTRAL IMAGING

Hyperspectral Imaging (HSI) is a form of imaging spectroscopy that captures spectral and spatial data beyond the limited three electromagnetic bands of the human eye. It produces a three-dimensional image with each pixel containing spectral information of the captured scene. The spectral information of each pixel correlates to the chemical composition of the scene. In the field of early detection of tumor, HSI is shown as a hopeful technology due to its non-invasive interaction with tissue and its ability to rapidly acquire and analyze data, obtaining beneficial information for diagnosis purposes. Hyperspectral images are captured by one sensor that captures a set of adjacent bands.



(a)



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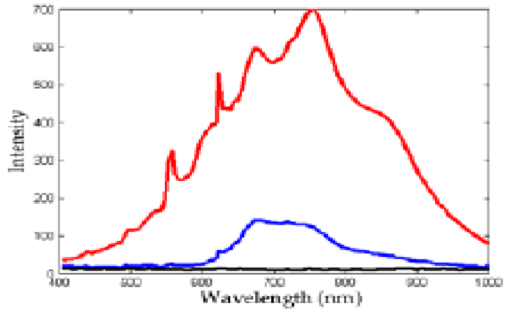


(c)

Figure 3.a) Hyperspectral image recording setup
b) Wavelength of spectral bands
c) Visual system of spectral signature in blue and corresponding white reference in red and dark current in black.

Figure 3. shows HS Image recording setup, spectral view of HS image and visual system of spectral signature in blue and corresponding white reference in red and dark current in black.

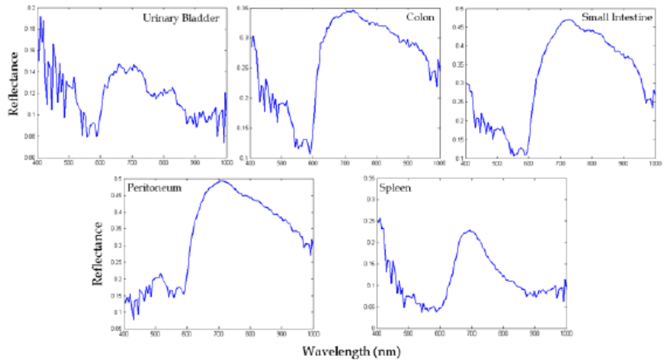


Figure 4. Reflectance spectra using visible and near infrared.

Figure 4 shows Reflectance spectra using visible and near infrared camera: the horizontal axis displays different wavelengths in nonometers, and the vertical axis shows the reflectance[14]. The raw data are corrected to reflectance using the following equation:

$$R(\lambda) = \frac{I_{raw}(\lambda) - I_{dark}(\lambda)}{I_{white}(\lambda) - I_{dark}(\lambda)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where $R(\lambda)$ is the calculated reflectance value for each wavelength, $I_{raw}(\lambda)$ is the raw data radiance value of a given pixel, and $I_{dark}(\lambda)$ and $I_{white}(\lambda)$ are, correspondingly, the dark current and the white board radiance acquired for each line and spectral band of the sensor. MR image is collected by explicitly designed image sequences, it can be considered

 DOI : 10.18231/2454-9150.2018.0567

ISSN : 2454-9150 Vol-04, Issue-04, July 2018

as a multispectral image[4]. Figure.5 shows image sequences.

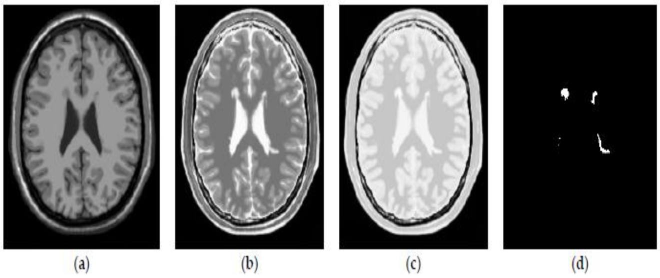


Figure 5. Three MR images containing MS lesions (a) T1W; (b) T2W; (c) PD; (d) ground truth (lesions)

III. METHODOLOGY

Image segmentation[2] algorithms broadly used as a crucial technique for high-level image understanding, and it significantly reducing the complexity of content analysis of images. This usage of segmentation can be widely applicable for medical image processing and this commonly used by doctors.

A. Region Growing Method

Region growing is a standard segmentation method. This method tries to extracting an image region that is connected based on some predefined criteria. These criteria can be based on intensity information and edges in the image. It works on the assumption that, the intensity values in each region/object conforms to Gaussian distribution; the mean intensity value for each region/object is different. The procedure for the same as follows:

l. This method takes a set of seeds as input along with the image.

2. The regions are grown by comparing all unallocated neighboring pixels to the regions.

3. The variance between a pixel's intensity value and the region's mean is used as a measure of similarity.

4. The pixel with the smallest dissimilarity measured this way is allocated to the respective region.

5. This process continues till all pixels are allotted to a region.

B. Thresholding

This is the simple method of image segmentation is named thresholding method. In this method is fully based on the clip-level or a thresholding value of the pixel to turn a gray scale image into a binary image value of the pixel. The main aim of this method is to select the thresholding value or the values of multiple levels are selected. The many popular methods are used in industry the maximum entropy method, maximum variance and k-means clustering[20]. The latest method have been developed for the thresholding is Computed Tomography (CT) images[21]. The main method is to reconstruct the original image.

C. ROI Selection

ROI stands for Region of Interest selection. ROI selection helps the end user to extract or cut the needed region. Because medical images more commonly have identical regions which will have same gray level, intensity level and same shapes for example scanned image of brain. The ROI selection will helps to extract the abnormal region alone. It will avoid the unwanted region of the medical images and reduce complexity.

D) De-noising

Medical images are more used by the doctors, because it has major applications like anatomical structure study, for treatment planning, to identify the tissues and glands and also for its volume measurements. Medical images are the output of the medical imaging technology like MRI, CT, HSI, etc. But the medical images are generally complex in nature and also noisy. For the denoising process, considered rank and median filtered. The placement of the value or position within this order set is referred as the rank.

E) Image Enhancement

Image enhancement technology plays a very important role in image processing[19]. By enhancing some information and restraining other information selectively, it can improve visual effect. Here histogram equalization method is used, which enhance the image and normalize the intensity throughout the image. The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function, $h(r_k) = n_k$ where $r_k$is the k^{th} intensity value and nk is the number of pixels in the image with intensity r_k. Histograms are frequently normalized by the total number of pixels in the image.

F) Morphology Process

The field of mathematical morphology contributes a wide range of operators to image processing, all based around a few simple mathematical concepts from set theory. Morphological techniques typically probe an image with a small shape or template known as a structuring element. There is variety of morphological process like erosion, dilation, opening and closing. In this work morphology is used as optional for the region growing method. Erosion and dilation is used depends on the image characteristics in the pre-processing step. In this work erosion is used for the image. Dilation, in general, causes objects to dilate or grow in size, erosion causes objects to shrink. The Process of dilation is the value of the output pixel is the maximum value 0 all the pixel in the input pixel's neighborhood. In a binary image, if any of the pixel is set to the value 1, the output pixel value is set to 1. Erosion is the value 0 the output pixel is the minimum value of the pixel in the input pixel's neighborhood.

G) 3D Volume Measurement

Volume measurement of particular part of gland, tumor and tissue using medical images are very important and also critical. Wrong calculation may lead to the wrong interpretation of the doctors for the treatment. There are many methods for the volume estimation like particle swarm optimization method, but the general method used for the volume estimation is, sum all pixels in the region (N_f) and multiplies the summation value with the corresponding pixel area (A). By multiplying result by the distance between medical image slices 3D volume can be estimated. In this paper the proposed visualization technique is direct volume rendering is used to visualize the segmented region easily. It represented the 3D of the volume data directly.

IV. DISCUSSION

Biomedical signal and image processing establish a dynamic area of specialization in both academic as well as

DOI : 10.18231/2454-9150.2018.0567

research aspects of biomedical engineering[1]. The concepts of signal and image processing have been widely used for extracting the physiological information in implementing many clinical procedures for sophisticated medical practices and applications. In this paper, the relationship between Computer Tomography, Magnetic Resonance Imaging and Hyperspectral Imaging signals and their derived interactions have been discussed. The methods in the area of information retrieval based on time-frequency representation have been investigated. Finally, some examples of analysis have been discussed in which the Bio-electrical signals and functional images have been properly extracted and have a significant impact on various biomedical applications. The PSNR, MSE, RMSE values are calculated and analyzed for CT, MRI and HSI images.

V. EXPERIMENTAL RESULTS

In this section discussed the performance of region growing segmentation with pre-processing and without pre-processing in brain. MRI and CT Digital Imaging and Communications in Medicine (DICOM) image of brain considered for analysis shown in Figure.6.

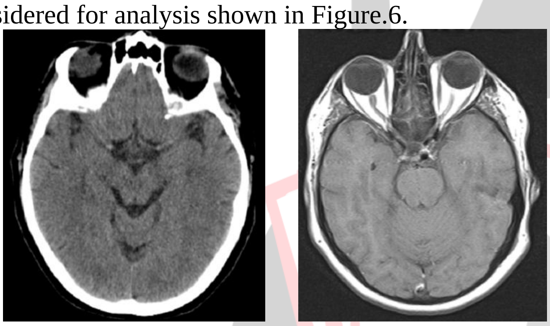
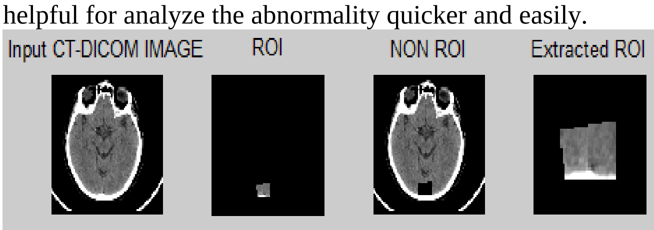


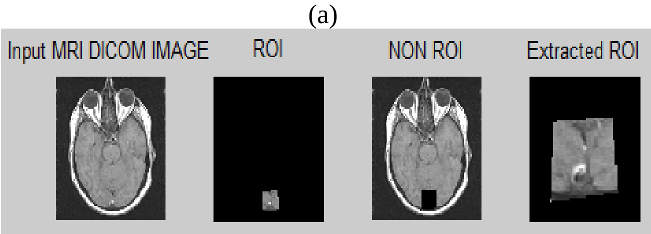
Figure. 6. Input image (a) CT image of mass and (b) MRI images of brain.

a) ROI Selection

A region of interest (ROI) is a portion of an image that we want to filter or perform some other operation on. We define an ROI by creating a binary mask, which is a binary image that is the same size as the image you want to process. In the mask image, the pixels that define the ROI are set to 1 and all other pixels set to 0. An example for the ROI extraction is shown in Figure 7. A rectangular shape is using to select the region of interest. By this selection method the meaningful information can be easily extracted. The ROI Selection process is mainly used for extracting the particular Region in an Original input image. It is more helpful for analyze the abnormality quicker and easily.



(a)



(b)

Figure.7. Selection process (a) Input CT Image, ROI selection, Non-ROI and Extracted ROI selection. b) Input MRI Image, ROI selection, Non-ROI and Extracted ROI selection.

b) De-noising

It is essential to reduce or eliminate the noise from the medical images before further process.

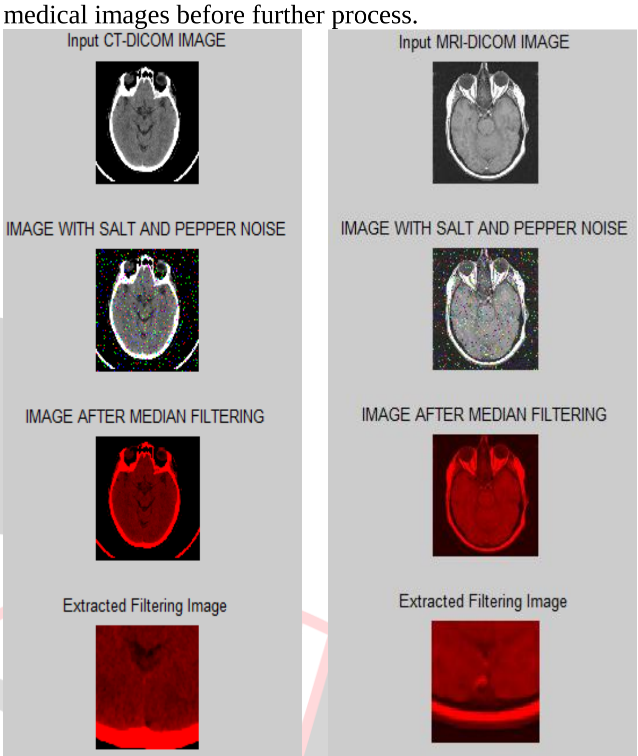


Figure.8. Filtering process

(a) Input CT-DICOM Image, Image with Salt and Pepper Noise, Image After Median Filtering & Extracted Filtering Image. (b) Input MRI-DICOM Image, Image with Salt and Pepper Noise, Image After Median Filtering & Extracted Filtering Image.

Noise in the medical images may lead to an incorrect segmentation and edge or shape of tissue or any region will not preserve. Noises are generally occurred due to the bit error in the capturing and transmission of images. Here for the de-noising, order filter is used. Rank, median, min, and max are the order filters. In which rank and median are the well using filters. De-noising by using filters such as Min filter, Median filter and Max filter for the particular ROI is shown in Figure 8.a and Figure 8.b.

c) Image Enhancement:

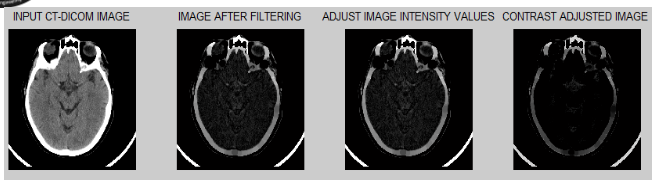
Image enhancement technology[23] plays a very important role in image processing. By enhancing some information and restraining other information selectively, it can improve visual effect. Here histogram equalization method is used, which enhance the image and normalize the intensity throughout the image. The histogram of a digital image with intensity levels in the range [0, L-I] is a discrete function, $h(r_k)=n_k$ where rk is the kth intensity value and n_k is the number of pixels in the image with intensity rk. Histograms are frequently normalized by the total number of pixels in the image. Assuming an M x N image and its normalized histogram is computed as,

$U(r_k) = n_k/MN, \ K=0,1,\ldots\ldots.L-1$

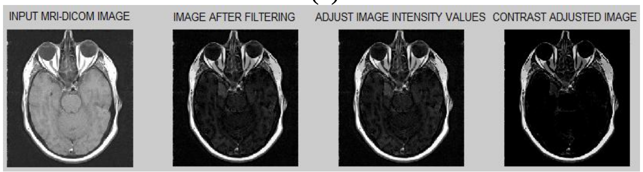
$u(r_k)$is related to probability of occurrence of r_k the image.

 DOI : 10.18231/2454-9150.2018.0567

ISSN : 2454-9150 Vol-04, Issue-04, July 2018



(a)



(b)

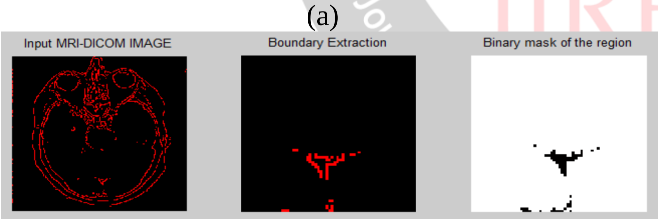
Figure.9. Image Enhancement process.

(a)Input CT-DICOM Image, Image after Filtering, Adjust Image Intensity values & Contrast Adjusted Image
(b) Input MRI-DICOM Image, Image after Filtering, Adjust Image Intensity values & Contrast Adjusted Image. Image enhancement result DICOM images are shown in Figure 9.a and 9.b respectively.

d) Morphology process

Morphology is an elective process in the pre-processing included for region growing process. In the region growing segmentation the tumour part alone extracting using the seed point, it may not preserve shape and edge of the tumour because of the closeness in gray level of different tissue and due to the presence of noise. Tumour region may spread over the neighborhood pixel, so dilation or erosion is done for the correct boundary extraction. Figure.10 shows the morphology process of Mass MRI images.

(a)



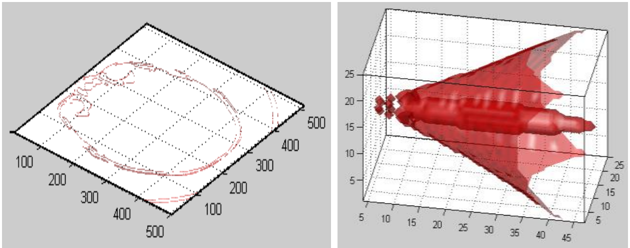
(b)

Figure10. Morphological process.

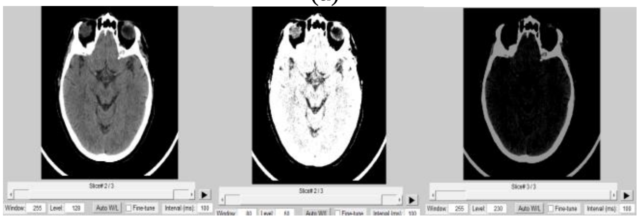
(a)Input CT-DICOM Image, Boundary Extraction of extracted view, Binary Mark of the Region
(b) Input MRI-DICOM Image, Boundary Extraction of extracted view, Binary Mark of the Region.

e) Volume rendering and Visualization

The volume visualization allows exploring the Infract itself as 3D model[11] or with added MR image slices in all three anatomical planes. Furthermore it is possible to explore the brain from each point of view. To get an assumption about the Infract dimensions, the visualization displays the size in milli meters. the volume calculation result depends on the 3D model[6]. Figure 11 shows the 3D visualization of the segmented region.



(a)



(b)

. Figure 11.DICOM-CT Image 3D Volume rendering and Visualization

A volumetric pixel (volume pixel or voxel) is the three-dimensional (3D)[10] equivalent of a pixel and the tiniest distinguishable element of a 3D object. It is a volume element that represents a specific grid value in 3D space. However, like pixels, voxels do not contain information about their position in 3D space. Figure 12 and Figure 13 shows time series display of Hyperspectral imaging[15][16].

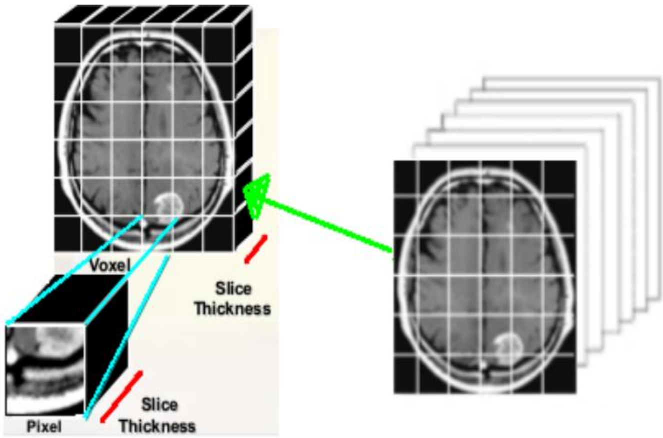


Figure 12 Illustration of a pixel and a voxel in Hyperspectral imaging.

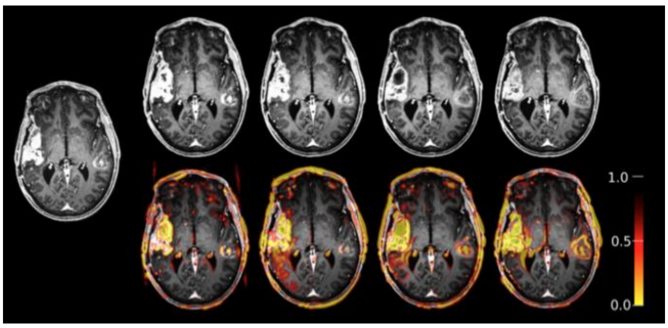


Figure 13 shows the image above for a time series for tumor treatment assessment.

f) Histogram Plot

The method of histogram same to balance for intensity differences between each station of input images. This

DOI : 10.18231/2454-9150.2018.0567

object/image can cause the appearance of tilted or bimodal fat peaks in the image histogram[3]. The simplest method for texture analysis is the computation of the statistical moments of the histogram inside a region of interest.Figure14 shows the histogram value of intensity and pixel value.

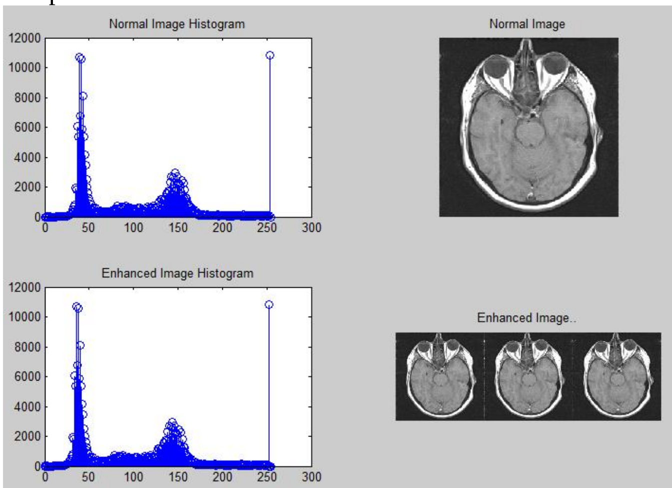


Figure 14 Normal and Enhanced Images and its histogram views.

g. Image Quality Metrics

Measurement of image quality is very important to numerous image processing applications. Mean-squared error (MSE). MSE measures the average squared difference between actual and ideal pixel values. This metric is simple to calculate but might not align well with the human perception of quality. Peak signal-to-noise ratio (PSNR): PSNR is derived from the mean square error, and indicates the ratio of the maximum pixel intensity to the power of the distortion. Like MSE, the PSNR metric is simple to calculate but might not align well with perceived quality. As before X is the reference image and Y is the test image. The error signal between X and Y is assumed as 'e'. Then

$$MSE(X,Y) = \frac{1}{N}\sum_{I=1}^{N} e_i^2 = \sum_{I=1}^{N}(x_i - y_i) \quad \text{.......(2)}$$

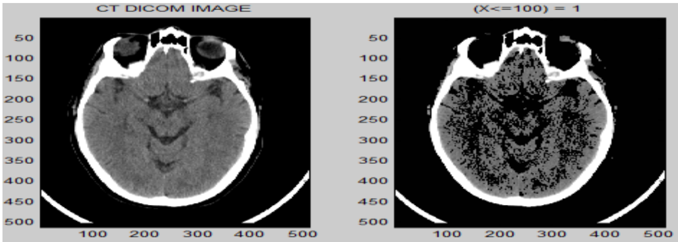
$$PSNR(X,Y) = 10_{\log_{10}} \frac{255^2}{MSE(X,Y)} \quad \text{.................(3)}$$

Where N represent Number of pixels in an image. However, The PSNR[13] does not correlate well with perceived visual Quality. Table-1 shows PSNR, MSE and RMSE value DICOM-CT, DICOM-MRI and Hyperspectral Images. Figure 15.a and 15.b shows Peak Signal Noise Ratio analysis for DICOM images.

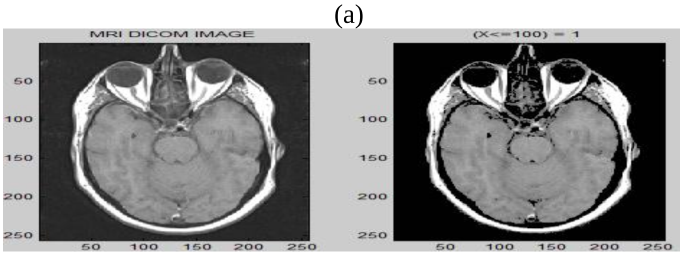
TABLE – 1

Comparative Measures of PSNR, MSE and RMSE values of DICOM-CT, DICOM-MRI and HSI Image types.

Sample Image Type	PSNR	MSE	RMSE (RMSE=sqrt(MSE).)
DICOM - CT	17.9065	1.0530e+03	1.02615
DICOM-MRI	16.8222	1.3516e+03	1.16258
HSI	21.6484	0.8530e+03	0.92358



(a)



(b)

Figure 15.a) Peak Signal Noise Ratio analysis for CT-DICOM image

b) Peak Signal Noise Ratio analysis for MRI-DICOM image

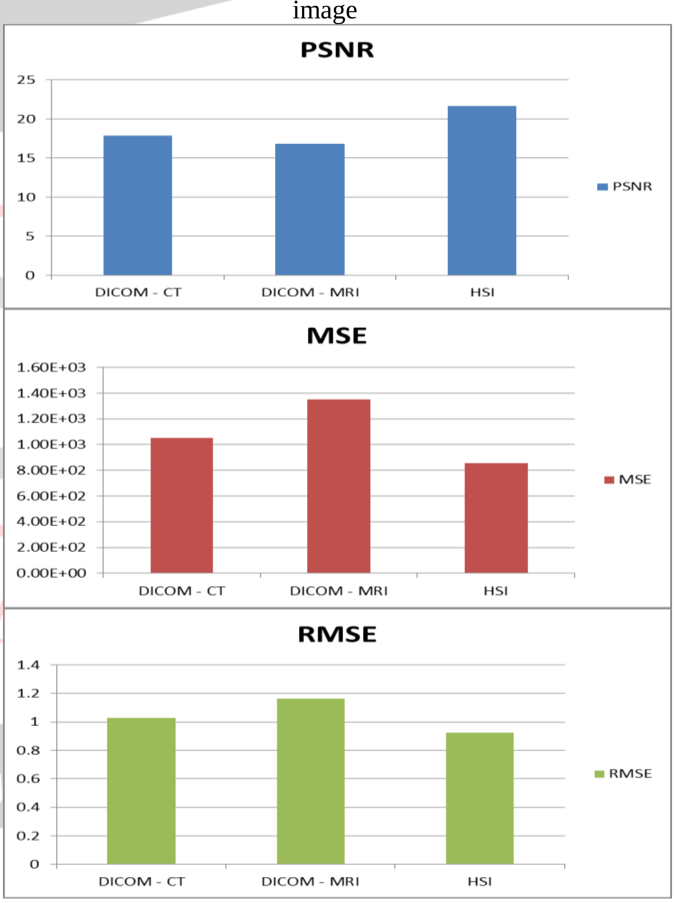


Figure 16 Bar chart for PSNR, MSE, RMSE value of DICOM-CT, DICOM-MRI and HSI images.

VI. CONCLUSION

The theoretical features of signal processing can be recognized in practice with an application to solve a real-life practical problem in the laboratory. Bioelectrical medical image segmentation is a very important technique for detecting abnormality in medical images. Segmentation is a technique which reduces the complexity in the medical images and makes the analysis easier and meaningful to understand. Region growing segmentation is a simple method which extracts the region of interest exactly. Thus, applying signal processing techniques yields reasonably

 DOI : 10.18231/2454-9150.2018.0567

encouraging results. By using volume visualization technique we can easily locate the small structure of 3D volume. Through this direct volume rendering technique small structure can visible easily and extract the true information separately for further analysis of doctor. Further this work can be extended for the detection, analysis and 3D visualization of various bioelectrical medical images in brain MRI/CT/HSI Images.

REFERENCES

[1] 'Advances in biomedical signal and image processing – A systematic review',J. Rajeswari, M. Jagannath, VIT University Chennai, Tamilnadu, India,www.elsevier.com/locate/imu,Informatics in Medicine Unlocked 8 (2017) 13–19.

[2] ‘Brain Image Enhancement - A Survey’, Mussarat Yasmin, Muhammad Sharif,World Applied Sciences Journal 17 (9): 1192-1204, 2012,ISSN 1818-4952.

[3] ‘MRI Brain Tumor Classification Using SVM and Histogram Based Image Segmentation’, Chinnu A,Department of Computer Science and Engineering, Sarabhai Institute of Science and Technology, Vellanad, Trivandrum, India,International Journal of Science and Research (IJSR).

[4] 'Performace Comparison of Differential medical image segmentation algorithms for normal or abnormal brain MRI', Manoj kumar.V,Sumithra.M.G,Bannari, International Journal of Latest Research in Science and Technology ISSN (Online):2278-5,299Vol.1,Issue 4 :Page No.369-372,November-December (2012).

[5] Digital Image Processing based Detection of Brain Abnormality for Alzheime r’s disease Dr. PSJ Kumar, Mr. Anirban Saha,International Journal Of Engineering And Computer Science ISSN:2319-7242,Volume 3 Issue 12 December 2014, Page No. 9479-9484.

[6] Abnormality Detection In Brain MRIICT Using Segmentation Algorithm And 3D Visualization E.Praveen Kumar, M.G.Sumithra, and P.Sunil Kumar,2013 Fifth International Conference on Advanced Computing (ICoAC).

[7] Advanced CT and MR Image Processing with FPGA Vladimir Kasik1, Martin Cerny1, Marek Penhaker1, Václav Snášel1,VSB - Technical University of Ostrava,Faculty Hospital Ostrava, Child Neurology Clinic, 17. listopadu 1790/5, Ostrava,.novak@fno.cz.

[8] Analysis and Comparison of Brain Tumor Detection and Modified MSRCR Technique for Hyper Spectral Images on Various Levels of Resolution Enhancement' Authors:T.ArumugaMaria Devi,2015/7,International Journal of Advanced Research in Electrical,Electronics&InstrumentationEngineering,Vol:4,Issue:7

[9] ‘Analysis and comparison of Brain Tumor Detection and Extraction Techniques from MRI Images’, Geetika Gupta, Rupinder Kaur, Arun Bansal, Munish Bansal,International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering,Vol. 3, Issue 11, November 2014.

[10] 'Visualization of 3D view of detected brain tumor and calculation of its volume',Sushma Laxman Wakchaure, Anil Khandekar,International Journal of Technical Research and Applications e-ISSN: 2320-8163, p-ISSN: 2321-7332,www.ijtra.com Volume 3, Issue 6 (November-December, 2015), PP. 120-126.

[11] 3D Visualisation of MRI images using MATLAB Duška Kleut, Milorad Jovanović and prof. dr Branimir Reljin,JOURNAL OF AUTOMATIC CONTROL, UNIVERSITY OF BELGRADE, VOL. 16:1-3, 2006.

[12] Modern Trends in Hyperspectral Image Analysis: A Review Muhammad Jaleed Khan , Hamid Saeed Khan, Adeel Yousaf, Khurshid, and Asad Abbas ,IEEE Access, March 28, 2018. Digital Object Identifier 10.1109/ACCESS.2018.2812999.

[13] Analytical study of Voltage and Current level changes in Video Signal on Image Statistics Parameters Measurement”, Dr.T.Arumuga Maria Devi, D.Muthukumar., International Journal of Scientific & Engineering Research (IJSER), ISSN 2229-5518, Impact Factor 3.8, Volume 7, Issue 4, April-2016 .

[14] “Signal Analysis of Various Filters for Voltage and Current Level Measurement in Series or Parallel RLC Resonant circuits on Hyper Spectral Data Magnification”, Dr.T.Arumuga Maria Devi, D.Muthukumar, Dr.P.Kumar, International Journal of Advanced Scientific Technologies, Engineering and Management Sciences (IJASTEMS), ISSN 2454-356X, Impact Factor 4.008, Volume 3 , Issue 12, December 2017.

[15] “Graphical Representation of Voltage and Current Measurements in Series or Parallel RLC Resonant Circuits for Magnification Using Hyperspectral Analysis”, Dr.T.Arumuga Maria Devi, D.Muthukumar, Dr.P.Kumar,2017 IEEE International Conference on Intelligent Techniques in control, optimization and Signal Processing,, 978-1-5090-4778-9/17/$31.00 ©2017 IEEE.

[16] "A systematic novel approach for PC Based Hyper Spectral Analysis on Bio-medical signals", Dr.T.Arumuga Maria Devi, D.Muthukumar. Dr.P.Kumar,ICRTES'2018-International Conference on Recent Trends in Engineering and Sciences, Website: www.sciencepubco.com/index.php/IJET.

[17] ‘An efficiently identify the diabetic foot ulcer based on Foot Anthropometry using Hyperspectral Imaging’ ,Dr.T.Arumuga Maria Devi, Sorna Percy,2016/5,International Journal of Information Technology & Management Information System (IJITMIS),Volume 7,Issue 2.

[18] 'Simultaneous Visualization and Segmentation of Hyperspectral Data using Fuzzy K Means Clustering', Mathan Raja, Dr.T.Arumuga Maria Devi,2016/6,International Journal for Research in Applied Science and Engineering Technology (IJRASET),Volume 4.Issue VI.

[19] 'A Novel Technique of Resolution Enhancement in Hyperspectral Images on Proposed CHLAE',Dr. T.Arumuga Maria Devi, 2016/3,Journal of Chemical and Pharmaceutical Sciences (JCPS) Scopus indexed journal Volume 9 Issue 1.

[20] 'Hyperspectral Band Clustering on EBCOT Pre Encoding Technique',T Arumuga Maria Devi, I Rajeswari,2016/3,Journal of Chemical and Pharmaceutical Sciences (JCPS) Scopus Indexed Journal,Volume 9,Issue 1.

[21] ‘A Non Invasive Computer Aided Diagnosis system for Early Detection of Lunc Carcinoma in CT Medical Images',T.Arumuga Maria Devi,2016,International Journal of Latest Trends in Engineering and Technology (IJLTET),Volume 8,Issue 4-1.

[22] 'A Novel Approach for MRI Brain Image Segmentation using Local Independent Projection Model',Authors:S Mohamed Vijithan, Kumar Parasuraman, T Arumuga Maria Devi,2016,Journal:Digital Image Processing, Volume 8,Issue 7.Pages 237-243.

[23] 'A Modified MSRCR Technique for Hyper Spectral Images on Various Levels of Resolution Enhancement', Authors:T. Arumuga Maria Devi,2015/7,Journal:International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,Volume:4,Issue:7.

[24] 'Hyperspectral Image Classification Using Spatial and Spectral Features',Authors:T.ArumugaMariaDevi,Mrs.N.Rekha,2013/7,Journal:International Journal of Scientific and Engineering Research.

BIOGRAPHY

Dr. T. Arumuga Maria Devi Received B.E. Degree in Electronics & Communication Engineering from Manonmaniam Sundaranar University, Tirunelveli India in 2003, M.Tech degree in Computer & Information Technology from Manonmaniam Sundaranar University, Tirunelveli, India in 2005 and Worked as Lecturer in department of Electronics & Communication Engineering in Sardar Raja College of Engineering and also received Ph.D Degree in Information Technology – Computer Science and Engineering from Manonmaniam Sundaranar University, Tirunelveli , India in 2012 and also the Assistant Professor of Centre for Information Technology and Engineering of Manonmaniam Sundaranar University since November 2005 onwards. Her research interests include Signal and Image Processing, Multimedia and Remote Communication. Currently doing D.Sc in Periyar University.

Mr.D.Muthukumar Received MSc Degree in Information Technology from Alagappa University, Karaikudi, India in May 2003, M.Tech degree in Computer and Informatin Technology from Manonmanium Sundaranar University, Tirunelveli, India in April 2009. Currently, he is doing Ph.D in Computer and Information Technology and also working as Assistant Professor in the Department of Software System in Kamaraj College of Engineering and Technology, Virudhunagar, Tamilnadu. His research interests include Hyperspectral Image Processing.

 DOI : 10.18231/2454-9150.2018.0567