IJCSE International Journal of Computer Sciences and Engineering **Open Access**

Research Paper **Vol.-7, Issue-6, June 2019** **E-ISSN: 2347-2693**

Medical Image Edge Detection Using Modified Morphological Edge Detection Approach

J. Mehena

Dept. of Electronics & Telecommunication Engineering, DRIEMS, Cuttack, Odisha, India

Corresponding Author: jibanananda.mehena@driems.ac.in

DOI: https://doi.org/10.26438/ijcse/v7i6.523528 | Available online at: www.ijcseonline.org

Accepted: 14/Jun/2019, Published: 30/Jun/2019

***Abstract*—** Medical imaging solution technology plays a vital role in the diagnosis and treatment of patients suffering from serious illness. In medical images, edge detection plays a vital role for recognition of the human organs. The performance of the edge detection determines the result of the processed image. Unfortunately, medical images like CT and MRI encounter a various number of noises such as Gaussian, Poisson and salt and pepper noise. Salt and pepper noise is frequently encountered in acquisition, transmission, and storage and processing of images. The presence of salt and pepper noise in an image may be either relatively high or low. Various filtering techniques have been proposed for removing salt and pepper noise. Conventional edge detection algorithms are belong to the high pass filtering which are not fit for noisy medical image edge detection because noise and edge belong to the scope of high frequency. In real world applications, medical images contain object boundaries, object shadows and noise. Therefore, they may be difficult to extract the edges in the presence of noise in medical images. Hence, a modified morphological edge detection algorithm is proposed to detect the edges in medical image. The performance of the proposed method is found to be better for detecting the edges and noise filtering than conventional techniques.

***Keywords*—** MRI, Edge Detection, Morphology, Image Analysis, Brain Tumor.

I. Introduction

A digital image is a binary representation of a two-dimensional (2D) array [1], and can be in the form of a vector or raster type. Raster uses a finite set of digital values, called pixels, to present an image. It contains a fixed number of rows and columns of pixels. In general, the term digital image usually refers to raster image also called bitmap image. Vector image is comprised of geometrical primitives such as points, lines, curves, and shapes or polygons. These are based on mathematical equations to represent images. Digital images can be classified according to the number and nature of single or more values carries intensity information. A binary image is a digital image which has only two possible values (i.e. 0 or 1) for each pixel. Typically, the two colours which are used for a binary image are black and white though any two colours can be used. A grayscale image, values for each pixel is a single sample, carries intensity information.

Grayscale is the term which refers to the ranges of shades between black and white. These images are also called monochromatic as there is no colour component in the image, like in binary images. Colour image contains colour information for each pixel. For visually acceptable results, it is necessary to provide three values (colour channels, typically, Red, Green, and Blue in RGB format) for each pixel [2]. The RGB colour space is commonly used in computer displays, but other spaces such as HSV are often used in other contexts. A true-colour image of a subject is an image that appears to the human eye just like the original, while a false colour image is an image that depicts a subject in colours that differ from reality.

Edge is a part of an image that contains significant variation. The edges provide important visual information since they correspond to major physical, photometrical or geometrical variations in scene object [3]. Physical edges are produced by variation in the reflectance, illumination, orientation, and depth of scene surfaces. Since image intensity is often proportional to scene radiance and physical edges which are represented by changes in the intensity function of an image.

The most common edge types are steps, lines and junctions [4]. The step edges are mainly produced by a physical edge, an object hiding another or a shadow on a surface. It generally occurs between two regions in a constant mode with different grey levels. The step edges are the points where the grey level discontinuity occurs, and localized at the inflection points. They can be detected by using the gradient of intensity function of the image. Step edges are localized as positive maxima or negative minima of the first-order derivative or as zero crossings of the second-order derivative. It is more realistic to consider a step edge as a combination of several inflection points. The most commonly used edge model is the double step edge.

This research paper is organized as follows. In Section II, edge detection methods are described. Basic morphological operations and the proposed watershed algorithm are described in section III and IV. Performance evaluation metrics, experimental results and comparison with existing algorithms are presented in Section V and VI. Finally, conclusions and discussions come in Section VII.

II. EDGE DETECTION METHODS

The first and second order of derivatives of an image is the most common in the edge detection methods. For instance, to detect step edges, one can look for maxima of the absolute value of the first derivative or zero crossings of the second derivative of an image [5]. Conventionally, edge is detected according to some early brought forward algorithms like Sobel, Prewitt, Laplacian of Gaussian operator and Canny algorithms but in theory these operators belongs to the high pass filtering, which are not suitable for noisy images**[6]**.

In point of technical view, the edge detection methods can be grouped into two categories: search based and zero crossing based. The search based methods detect the edges by first computing a measure of edge strength, such as magnitude of gradient of the image intensity function and then searching for local maxima in a direction that matches with the edge profile such as the gradient direction. The first-order derivative is regularly used to express the gradient. The zero crossing based methods search for zero crossings in a second order derivative expression computed from the image in order to find edges, such as the laplacian or a non-linear differential expression [7].

In point of conceptual view, the edge detection methods are categorized into contextual and non contextual approaches. The non contextual methods work autonomously without any prior knowledge about the scene and the edges. They are flexible in the sense that they are not limited to specific images. However, they are based on local processing focused on the area of neighboring pixels. The contextual methods are guided by a priori knowledge about the edges or the scene. They perform accurately in a precise context. It is clear that autonomous detectors are appropriate for general purpose applications. However, contextual detectors are adapted to specific applications which always include images with same scenes or objects. The steps of edge detection are as follows.

- **Smoothing:** Suppress as much noise as possible without destroying the true edges.
- **Enhancement:** Application of a filter to enhance the quality of the edges in the image.
- **Detection:** Determine which edge pixels should be discarded as noise and which should be retained.
- **Localization:** Determine the exact location of an edge. Edge thinning and linking are usually required in this step.

III. BASIC MORPHOLOGICAL OPERATIONS

There are many techniques for edge detection such as Sobel operator, Prewitt operator, Robert's and canny edge detection. Sobel operator is used in image processing techniques, particularly in edge detection. The sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical, it is therefore relatively inexpensive in terms of computations. Canny edge detection operator uses a multistage algorithm to detect a wide range of edges in images. Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images. Basically, there are two masks, one for detecting image derivatives in X and other for detecting image derivative in Y. To find edges, a user convolves an image with both masks, producing two derivative images (dx and y). The strength of the edge at given location is then the square root of the sum of the squares of these two derivatives. Robert's edge detection method is one of the oldest methods and is used frequently in hardware implementations, where simplicity and speed are dominant factor [8].

Dilation, erosion, opening, closing are the basic mathematical morphological operators [9, 10]. Dilation is defined as the maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill up the spaces. Erosion is just opposite to dilation. It is defined as the minimum value in the window. The image after dilation will be darker than the original image. It shrinks or thins the image. Opening and closing both parameters are formed by using dilation and erosion. In opening, firstly image will be eroded and then it will be followed by dilation. In closing, first step will be dilation and then result of this is followed by erosion. All above operators perform their tasks by using structuring elements, which is a matrix of 0's and 1's.Structuring elements have various sizes and shapes[10].

In the following, we introduce some basic mathematical morphological operators of grayscale images. Let $F(x,y)$ denote a grayscale two dimensional image, B denote structuring element. Dilation of a grayscale image $F(x,y)$ by a grayscale structuring element $B(s,t)$ is denoted by

$$(F \oplus B)(x,y) = \max\{F(x-s, y-t) + B(s,t)\} \qquad (1)$$

Erosion of a grayscale image $F(x,y)$ by a grayscale structuring element $B(s,t)$ is denoted by

$$(F \ominus B)(x,y) = \min\{F(x-s, y+t) + B(s,t)\} \qquad (2)$$

Opening and Closing of grayscale image $F(x, y)$ by grayscale structuring element $B(s, t)$ are denoted by

$$F \circ B = (F \ominus B) \oplus \mathrm{B} \quad (3)$$

$$F \cdot B = (F \oplus \mathrm{B}) \ominus B \quad (4)$$

Erosion is a transformation of shrinking, which decreases the grayscale value of the image, while dilation is a transformation of expanding, which increases the grayscale value of the image. But both of them are sensitive to the image edge whose grayscale value changes obviously. Erosion filters the inner image, while dilation filters the outer image. Opening is erosion followed by dilation and closing is dilation followed by erosion. Opening generally smooth the contour of an image, breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminates small holes, and fills gaps in the contours. Therefore, morphological operation is used to detect image edge and at the same time denoised the image.

IV. PROPOSED MORPHOLOGICAL EDGE DETECTION ALGORITHM

Morphology commonly refers to a broad set of image processing operations that process images based on shapes. Morphological operations selects appropriate structuring element of the processed image and makes use of the basic theory of morphology including erosion, dilation, opening, closing and synthesized operation to get clear medical image edge. In the process, the synthesized modes of the operations and the feature of structuring element decide the result of the processed image. Detailed saying, the synthesized mode of operation reflects the relation between the processed image, original image and the selection of structuring element decides the effect and precision of the result. Therefore, the keys of morphological operations can be generalized for the design of morphological filter structure and the selection of structuring element. We must select appropriate structuring element by texture features of the image and the size, shape and direction of structuring element must been considered roundly. Usually, we select structuring element by 3×3 square. By the operation features of morphology, erosion and dilation operations satisfy:

$$F \ominus B \subseteq F \subseteq F \oplus B \quad (5)$$

Where, F denote a grayscale medical image, B denote structuring element. Opening and closing operations satisfy:

$$F \circ B \subseteq F \subseteq F \cdot B \quad (6)$$

The edge of medical image F, which is denoted by $E_d(F)$, is defined as the difference set of the dilation domain of F and the domain of F. This is also known as dilation residue edge detector:

$$E_d(F) = (F \oplus B) - F \quad (7)$$

Accordingly, the edge of medical image F, which is denoted by $E_e(F)$, can also be defined as the difference set of F and the erosion domain of F.This is also known as erosion residue edge detector:

$$E_e(F) = F - (F \ominus B) \quad (8)$$

The dilation and erosion often are used to compute the morphological gradient of the medical image F, denoted by $G(F)$ (Adrian et al., 2006):

$$G(F) = (F \oplus B) - (F \ominus B) \quad (9)$$

The morphological gradient highlights sharp gray level transition in the medical image. The opening top hat transformation of medical image F, which is denoted by $TH_o(F)$ is defined as the difference set of F and the opening domain of F. It is defined as

$$TH_o(F) = F - (F \circ B) \quad (10)$$

Similarly, the closing top hat transformation of medical image F, which is denoted by $TH_c(F)$, can also be defined as the difference set of the closing domain of F and the domain of F, it is defined as

$$TH_c(F) = (F \cdot B) - F \quad (11)$$

The top hat transformation, which owes its original name to the use of a cylindrical structuring element function with a flat top, is useful for enhancing detail in the presence of shading. The effect of erosion and dilation operations is better for medical image edge by performing the difference between processed image and original image, but they are worse for noise filtering. As opposed to erosion and dilation, opening and closing operations are better for filtering. But because they utilize the complimentarily of erosion and dilation, the result of processed image is only correlative with the convexity and concavity of the image edge. Accordingly, what we get is only the convex and concave features of the image by performing the difference between processed image and original image, but not all the features of image edge.

Modified morphological approach is proposed here for finding the edges of the medical image. Opening and closing operation is firstly used as preprocessing to filter noise. Then smooth the image by first closing and then dilation. The perfect medical image edge will be performed by the difference between the processed image and the image before dilation, the following is the modified morphological approach:

$$E_{IM}(F) = (M \cdot B) \oplus B - M \cdot B \quad (12)$$

Where, $M = (F \cdot B) \circ B \quad (13)$

V. PERFORMANCE EVALUATION METRICS

In image processing applications, the performance evaluation plays main role to assess the image quality. The importance of performance evaluation is recognized in the computer vision community. Predicting the performance in an image understanding task of practical value however, is difficult. The method used to evaluate the performance of edge detectors is to measure the quality of edge detectors using root mean square error, signal to noise ratio, peak signal to noise ratio, structural similarity index and edge keeping index are discussed in this thesis. The evaluation of edge detection performance obeys the three important criteria. First, the edge detector should find all real edges and not find any false edges. Second, the edges should be found in the correct place. Third, there should not be multiple edges found for a single edge.

Commonly used metric for image quality assessment are root-mean-square error, E_{RMS} , root-mean square signal to noise ratio, SNR_{RMS} , and peak signal-to-noise ratio, SNR_{PEAK} .The values are calculated using the equations as follows.

$$E_{RMS} = \sqrt{\frac{1}{MN}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c) - O(r,c)]^2} \qquad (14)$$

$$SNR_{RMS} = \sqrt{\frac{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c)]^2}{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c)-O(r,c)]^2}} \qquad (15)$$

$$SNR_{PEAK} = 10\ log\frac{(L-1)^2}{\frac{1}{MN}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c)- O(r,c)]^2} \qquad (16)$$

Where $O(r,c)$ is the original image, $E(r,c)$ is the reconstructed image and L is the number of gray level equal to 256.

Another two metric widely used in medical image processing application are the SSIM and EKI. Those are discussed as follows.

The Structural Similarity (SSIM) index is a method to measure the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared provided the other image is regarded as of perfect quality. The structural similarity index correlates with human visual system and is used as a perceptual image quality evaluation metric. The SSIM is defined as function of luminance, contrast and structural components [11].

Edge Keeping Index (EKI) is used to evaluate and establish how well the edges are maintained during the detection process. The thicknesses of various cardiac boundaries are better extracted using the edges of corresponding muscles. The steps for implementation of this criterion are as follows [12]:

- Separate convolution of original and filtered images with the Laplacian kernel
- Involves subtraction of mean intensity values of pixels from each of the convolution results to remove any DC shifts.
- The sum of the product of pixel-to-pixel multiplication of both the resultant images is then obtained, which forms the essence of EKI.
- The product is normalized using the square root of the product of the squares of the individual pixel intensities in-order to obtain a numerical value.

VI. EXPERIMENTAL RESULTS AND ANALYSIS

In this research work, the proposed morphological edge detection algorithm is compared with a variety of existing methods for edge detection. Figure 1 is the original MRI image. Figure 2 is the MRI image with 5% salt and pepper noise density. Figure.3 to Figure 7 are the results of processed MRI image after respectively applying Sobel, Prewitt, Robert, Canny and generalized morphological edge detection algorithms. Figure 8 is the result of processed MRI image using proposed morphological edge detection algorithm. The experimental results show that the proposed algorithm is more efficient for medical image denoising and edge detection.

On the other hand, the quality assessment parameters like E_{RMS} , SNR_{RMS}, SNR_{PEAK} ,SSIM and EKI are applied on medical MRI image with salt and pepper noise density 5 and 10%.Table 1, shows the values of different quality assessment parameters with different noise level. It is observed that the proposed method yields lower E_{RMS} , higher SNR_{RMS} , SNR_{PEAK}, SSIM and EKI with salt and pepper noise of two different noise densities. This is evidence that the proposed algorithm is more efficient for edge detection and noise suppression than the existing techniques.

VII. CONCLUSIONS

In this research work, a modified morphological algorithm is proposed to detect medical MRI Image edge. It is found to be a better method for edge information detecting and noise filtering than differential operation, which is sensitive to salt and pepper noise. It is a better compromise method between noise smoothing and edge orientation, but the computation is more complex than general morphological edge detection algorithms. The experimental results show that the proposed algorithm is more efficient for medical image denoising and edge detection than the usually used template based edge detection algorithms such as Sobel, Prewitt, Robert, Canny edge detector and general morphological edge detection algorithm. From the experimental result, we conclude that the proposed algorithm can suppress salt and pepper noise and simultaneously preserve finer edge.

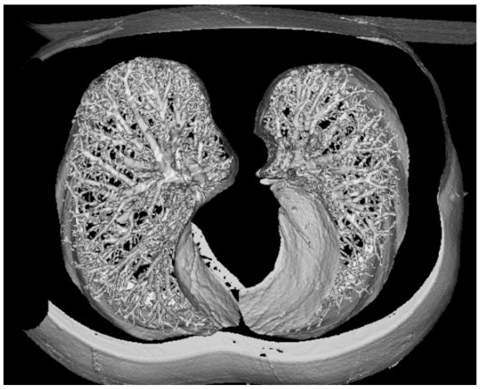

Figure 1. Original MRI Image

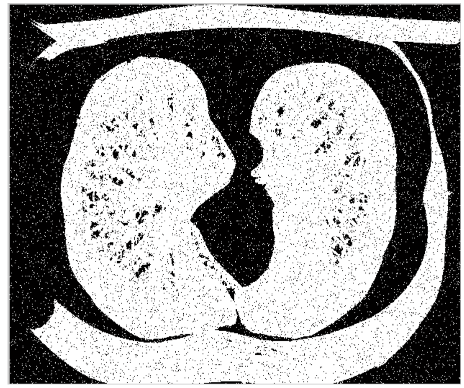

Figure 2. Original MRI Image with 5% Salt & Pepper Noise

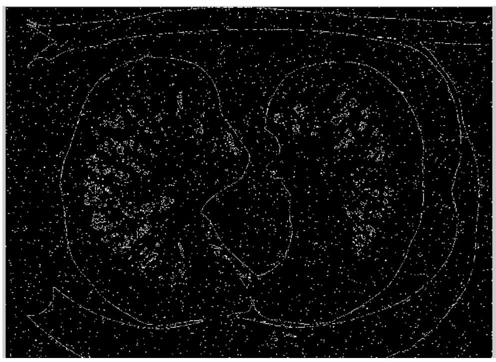

Figure 3. MRI Image processed by Sobel operator

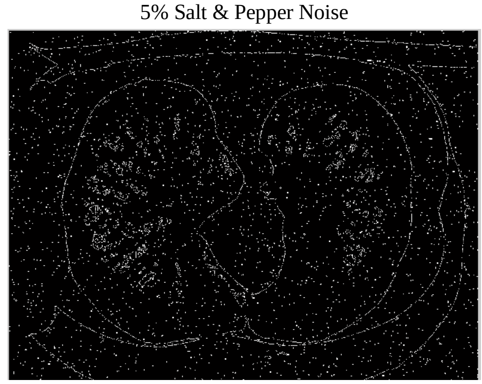

Figure 4. MRI Image processed by Prewitt operator

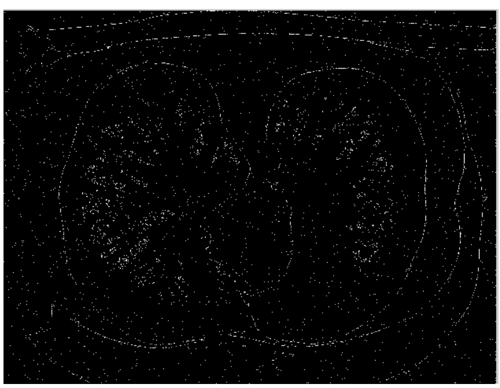

Figure 5. MRI Image processed by Robert operator

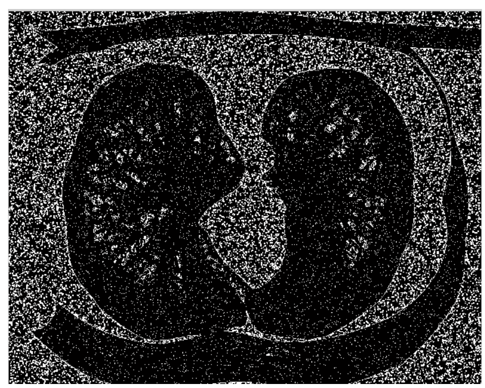

Figure 6. MRI Image processed by Canny Edge Detection Algorithm

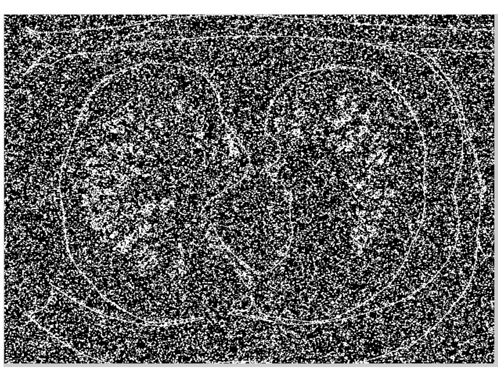

Figure 7. MRI Image processed by Morphological Algorithm

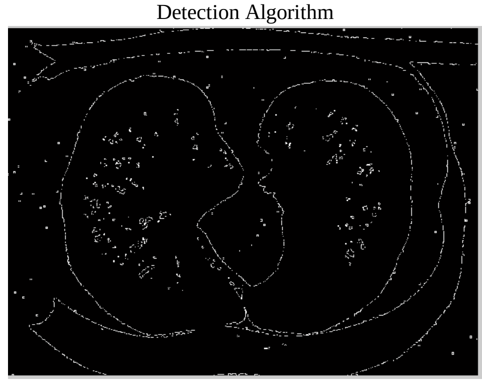

Figure 8. MRI Image processed by proposed Morphological Algorithm

Table-1. Quality Assessment Parameters of the Medical MRI Image

Noise Level (%)	Assessment Parameter	Sobel	Prewitt	Robert	Canny	Morphology	Proposed
5	E_{RMS}	0.759	0.758	0.760	0.747	0.743	0.569
	SNR_{RMS}	0.196	0.194	0.325	0.459	0.660	0.759
	SNR_{PEAK}(dB)	50.52	50.53	50.51	50.65	50.71	60.40
	SSIM	0.723	0.723	0.741	0.763	0.785	0.814
	EKI	0.539	0.542	0.583	0.575	0.659	0.748
10	E_{RMS}	0.755	0.754	0.757	0.741	0.728	0.568
	SNR_{RMS}	0.264	0.264	0.176	0.554	0.668	0.7726
	SNR_{PEAK}(dB)	50.56	50.57	50.53	50.734	50.879	60.422
	SSIM	0.736	0.736	0.725	0.787	0.802	0.819
	EKI	0.552	0.555	0.567	0.600	0.697	0.753

REFERENCES

[1] A.K.Jain, "*Fundamentals of Digital Image Processing*", Prentice Hall, **India**, pp.**80-123, 1989**.

[2] J.Mehena,M.C.Adhikary, "*Medical Image edge detection based on soft computing approach*", International Journal of Innovative Research in computer and communication Engineering, Vol. **3**, pp.**6801-6807**, **2015**.

[3] N.Senthilkumaran, R. Rajesh, "*Edge Detection Techniques for Image Segmentation - a Survey*", Proceedings of the International Conference on Managing Next Generation Software Applications ,**India**, pp.**749-760**, **2008**.

[4] S.Sridhar, "*Digital Image Processing*", Oxford University Press,**India**, pp. **286–335, 2011**.

[5] R.M. Haralick, "*Digital step edges from zero-crossing of second directional derivatives*", IEEE Trans. Pattern Anal. Machine Intell., Vol. **6**, pp. **58–68**,**1984**.

[6] J.Canny, "*A Computational Approach to Edge Detection*", IEEE Transactions on Pattern Analysis and Machine Intelligence", Vol. **8** , No.**6**, pp. **679-687**, **1986**.

[7] J.Kaur, S.Agrawal and R.Vig, "*Comparative Analysis of Thresholding and Edge Detection Segmentation Techniques*", International Journal of Computer Applications, Vol.**39**, No. **15**, pp.**29-34**, **2012**.

[8] R.Maini,H. Aggarwal, "*Study and Comparison of Various Image Edge Detection Techniques*", International Journal of Image Processing , Vol.**3**,No.**1**, pp.**1-12**, **2010**.

[9] P.Maragos, "*Differential Morphology and Image Processing*", IEEE Trans Image Processing, Vol. **5**, pp. **922-937**, **1996**.

[10] A.Bhargava, V. S.Nigam, "*Multi Objective Detection from High Resolution Satellite Images using Segmentation and Morphological Operation*", International Journal of Computer Sciences and Engineering, Vol.**5**, No.**7**, pp.**1466-1470**, **2019.**

[11] J.Serra, "*Image Analysis and Mathematical Morphology*", Academic Press, **New York**, pp.**101-112, 1982**.

[12] Z.Wang, A.C. Bovik, H.R.Sheikh, and E.P. Simoncelli, "*Image quality assessment: From error measurement to structural similarity*", IEEE Transactions on Image Processing, Vol. **13**, No.1, pp.**2356-2362**, **2004**.

[13] M.Kini,R.Pandey,A.R.Das and S.K. Malani, "*Comprehensive Image Processing for Automated Detection of Hypertrophic Cardiomyopathy*", International Journal of Computer and Electronics Research ,Vol.**3**,No.**2**, pp.**512-519**,**2014**.

[14] N.Senthilkumaran, C.Kirubakaran,N.Tamilmani "*Fuzzy Edge Detection Using Minimum Cross Entropy Thresholding for MRI Brain Image*", International Journal of Computer Sciences and Engineering, Vol.**6**, No.**7**, pp.**271-274**, **2018**.

[15] J.Mehena,M. C. Adhikary, "*Brain Tumor Segmentation and Extraction of MR Images Based on Improved Watershed Transform*",IOSR Journal of Computer Engineering, Vol.**17**,No.**1**,pp.**01-05**, **2015.**

Author Profile

Dr. J.Mehena is presently serving as professor and Head in the Department of Electronics & Telecommunication Engineering at DRIEMS, Cuttack, Odisha, India. He has 18 years of teaching and research experience. He received his M. Tech in Electronics Engg. from Visvesvaraya National Institute of Technology (VNIT), Nagpur and Ph.D. in the area of Digital Image Processing. He has published more than 20 research papers in national and international journals. His areas of interest include Digital Image Processing, VLSI Design and Signal Processing.

