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A Noval Algorithm For Denoising and Segmentation of Brain MRI using Rough Set Theory

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Abstract-*Rough set Theory have been used as a module of hybrid solutions in data mining and machine learning domain. The main aim of proposed method is to develop a novel algorithm for object based edge detection and segmentation of Magnetic Resonance Images (MRI) using Rough set theory. In this work, pixel intensity value is considered as an attribute to discriminate objects within the image. The intensity thresholds, is obtained from image histogram. Where histogram serves as feature of an object. The performance is validated using Jaccard Similarity Index (JSI) and Peak Signal to noise Ratio (PSNR).The proposed method better performance than Active Contour and CLICK methods.*

Keywords—*Roush set Theory, Edge detection, Magnetic Resonance Images(MRI), Segmentation.*

I.INTRODUCTION

The soft computing methods such as Fuzzy Logic, Genetic Algorithms Neural Network, Rough Set, etc. try to represent model for vagueness and uncertainty under Granular Computing framework. The Computer Added Systems (CAD) help in identification and localization of abnormal tissues. In recent decades, a lot of research done on non-invasive techniques. MRI is characterized by a high-contrast sensitivity that makes it possible to depict the differences among soft tissues within the body. However, MRI has two other characteristics that affect the ability to visualize anatomic structures and pathologic features: (a) blurring of the image, which affects the visibility of small objects (image detail), and (b) visual noise, which reduces visibility of low-contrast objects. This proposal paper establishes a relationship between CT denoising and uncertainty model defined by Rough Set Theory (RST). RST already has shown some promising outcomes in image processing problems including segmentation, clustering whereas not much attention has been paid in image compression. The first part of the proposal paper is a novel method for object based segmentation and edge derivation given the noisy MR images. The edges are closed and continuous in nature and segmentation accuracy turns out to be better than well-known methods. The prior information is used as cues in various image denoising frameworks. Magnetic resonance imaging (MRI) provides rich

Three-dimensional (3D) information about the human soft tissue anatomy. It reveals fine details of anatomy, and yet is non-invasive and does not require ionizing radiation such as r -rays. It is a highly flexible technique where contrast between one tissue and another in an image can be varied simply by varying the way the image is made. There are different types of MR images, from that T1-weighted and T2-weighted images are used to detect tumor. T1 is the longitudinal relaxation time. It indicates the time required for a substance to become magnetized after first being placed in a magnetic field or, alternatively, the time required to regain longitudinal

Magnetization following an RF pulse T2 is the "transverse" relaxation time. It is a measure of how long transverse magnetization would last in a perfectly uniform external magnetic field.

The remaining part of paper is organized as follows: In Second section comprehensive literature Review is present, the proposed method is described in section III, The result Discussion is done in section IV and Concluding remarks mentioned in section V.

II. LITERATURE REVIEW

The Rough Set Theory (RST) was anticipated by Z. Pawlak in 1982 for alternative to Fuzzy set theory [1]. Amit Satish Unde proposed Active contour based variational energy minimization frame work for edge detection and tumor segmentation[2], James F. Peters, RST induces notion of approximation space [3], RST has access to look at subset of object as one unit instead of dealing with individuals. Aboul Ella Hassanien[4] in this paper promising approach to solving the medical image approach to classifying perceptual objects by means of features. Sankar K. Pal B. Uma

Shankar, and P. Mitra [5] it has been proved that an image object extraction in the method of rough sets and granular computing and ‘‘rough entropy of image’’ is defined based on the concept of image granules. Pradipta Maji and Shaswati Roy[6], An unsupervised feature selection method is introduced, based on maximum relevance-maximum significance criterion, to select relevant and significant textural features for segmentation problem. Chunming Li, John C. Gore, Christos Davatzikos[7] it deals with the MICO formulation can be naturally extended to 3D/4D tissue segmentation with spatial/spatiotemporal regularization. Gopu M, Rajesh T [8], explain about the Rough set theory can be used as a feature subset selection algorithm and determines and removes the dispensable attributes representing the redundant information.

III. Methodology

The proposed method majorly Consist of four blocks Noisy input image, Pre-processing, Edge detection and segmentation. The pre-processing is done with the help of statistical parametric mapping (SPM12) tool box with this skull present within the MRI is removed. The edge detection and segmentation is done using Rough set Theory.

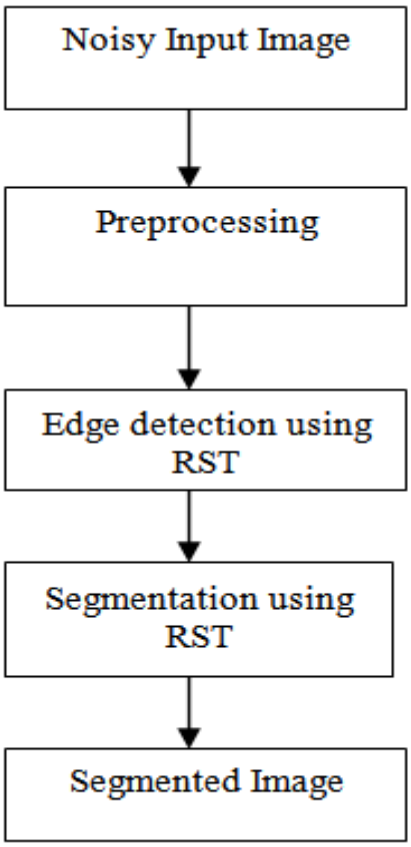

Figure 1: Block Diagram of proposed Method

Rough Sets provide a unique approach for approximation of sets using granular information. It provides distinction between overlapping boundary, in a given domain data. Rough set methods have been applied as a component of hybrid solutions in machine learning and data mining and also artificial neural network [9]. The rough sets have been found to be particularly useful for rule induction and feature selection. Rough sets concept can be distinct quite generally by means of topological operations, interior and closure, called approximations [10].

Given a set of objects S called the universe and an indispensability relation $r \subseteq S \times S$ representing our require knowledge about elements of S. Assume that r is an equivalence relation; Let X is a subset of S. Now characterize the set X with respect to r. To this end we will need the basic concepts of rough set theory given below.

- The lower approximation of a set X with respect to r is the set of all objects, which can be for certain classified as X with respect to r (are certainly X with respect to$r$).
- The upper approximation of a set X with respect to r is the set of all objects which can be possibly classified as X with respect to r (are possibly X in view of r).
- The boundary region of a set X with respect to r is the set of all objects, which can be classified neither as X nor as $not - X$ with respect to$r$.

NOW, SET X WOULD HAVE FOLLOWING TWO POSSIBILITIES

- Set X is crisp (exact with respect to$r$), if the boundary region of X is empty.
- Set X is rough (inexact with respect to$r$), if the boundary region of X is nonempty.

The equivalence class of r determined by element x is denoted by $r(x)$ .The indispensability relation in certain sense describes lack of knowledge about the universe. Equivalence classes formed by indispensability relation, called granules generated by r, represent elementary portion of knowledge perceived due to r. Thus in view of the indispensability relation, in general, it allows observing individual objects but forced to reason only about the accessible granules[11] of knowledge. Formal definitions of approximations and the boundary region are as follows:

- lower approximation of X

$$\underline{r}(x) = \bigcup_{x \in U} r(x) : r(x) \subseteq X \qquad (1)$$

- upper approximation of X

$$\bar{r}(x) = \cup_{x \in S} r(x) \cap X \neq \emptyset \qquad (2)$$

Image granules with upper and lower approximation of an object as conceptualized in Rough Set Theory

- boundary region of X

$$Br(X) = \bar{r}(x) - \underline{r}(x) \qquad (3)$$

The lower approximation of a set is union of all granules which are entirely included in the set; the upper approximation is union of all granules which have non-empty intersection with the set; the boundary region of set is the difference between the upper and the lower approximation.

The major contribution of this paper is to provide more information from noisy image to the denoising framework to boost up the performance. The edge [12] information can be used to stop across the boundaries. This encouraged the present work to select rough set theory to get imprecise edge information that is expected to include actual edges. Rough Set [8] model is used in this proposed work to reduce number of inconsistent objects. The granule information processing of Rough Set Theory (RST)[13] helps to visualize the possible presence of edge or heterogeneity in the granules. Granules are very small image blocks of size 2×1,1×2 or 2×2 etc. but in this paper we are using 2×2 image

The RST based approach, with the help of granules, provides partitions in the image to create lower and upper approximations of the objects. Note that, lower approximation set will be contained completely in upper approximation set. The difference of both approximations provides a possible edge region for a particular object or class present in the image. Here, in this work, we considered four major class/objects namely, CSF, White matter, Gray matter and Background in the brain MR images. For denoising task, as a regularization term, the Rough Edge (RE) of the image and Rough Class (RC) of each pixel are mentioned for the defined for image denoising.

The entire procedure is summarized below:

1. Estimate approximate thresholds from the noisy image histogram using window approach.
2. Optimize each threshold value discretely using rough entropy criteria under Granule framework.
3. Binarize the image with respect to each optimized threshold. For each threshold value is 1 or if pixel value is greater or equal to the threshold, 0 otherwise.
4. Join assigned symbols (1 or 0) of each pixel for all thresholds. This will lead to representing each pixel by a binary string of length n, if there are n-1 thresholds.
5. Classify all binary strings and there by pixels. Strings having same symbol at same position will be classified as same class.

IV.RESULT AND DISCUSSION

In this proposed work we are explained and evaluate the RMSE, PSNR, JSI SI values. We are also comparing the parameter values of the existing methods with proposed method.
The evaluation measures used are defined as follows: Let I be noise-free image of size A× B and $\bar{I}$ be is its noise-free image.

A. ***Root Mean Square Ratio (RMSE):***

$$\text{MSE}=\frac{1}{AB}\sum_{i=1}^{A}\sum_{j=1}^{B}(I(i,j)-\bar{I}(i,j)) \qquad [4]$$

B. Peak-Signal-to-Noise Ratio (PSNR):

$$PSNR=10\log 10\left(\frac{M^2}{MSE}\right) \qquad [5]$$

Where M is maximum intensity level present in the image I.

C. ***Jaccard Index(JI)***:It measures the overlap between the segmented image[13,14] and ground image .If JI=0 ,it implies no overlap with ground image and the value of JI=1,implies that perfect segmentation. It is defined as

$$JI=\frac{|A\cap B|}{|A\cup B|} \qquad [4]$$

where A and B are two segments generated by proposed method and ground truth images.*In the results we are taken inputs as a ground truth image and noisy images for calculate the RMSE, PSNR, JSI . And we are also implemented with matlab 2017b and evaluated values comparison with the existing methods. Finally we proposed method is good in terms of JSI results with comparison AC, MICO and CLICK methods. An image quality metric that assesses the visual impact of three characteristics of an image: luminance, contrast and structure. so the JSI values are very important in contrast values. In the results the image is consider as 128*× 128 *dimensional.*

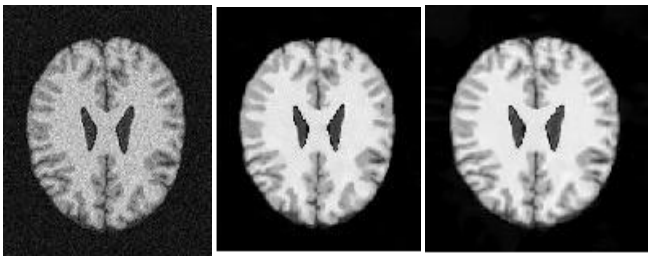

Figure.1.a) original image b) segmented image using AC, c) segmented image with MICO and CLICK methods

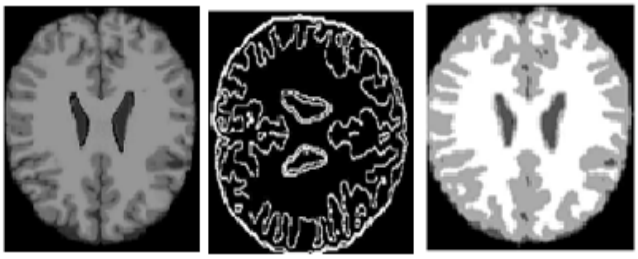

Figure.2.a) Noisy input image b) Edge detection using RST,c) Proposed method

Tab.1.Comaprison values with Existing Methods

Methods	RMSE	PSNR	JSI
AC Method	23.56	42.2	0.969
MICO[7]	24.62	44.6	0.952
CLICK[4]	25.30	45.0	0.976
Proposed Method	27.32	48.96	0.989

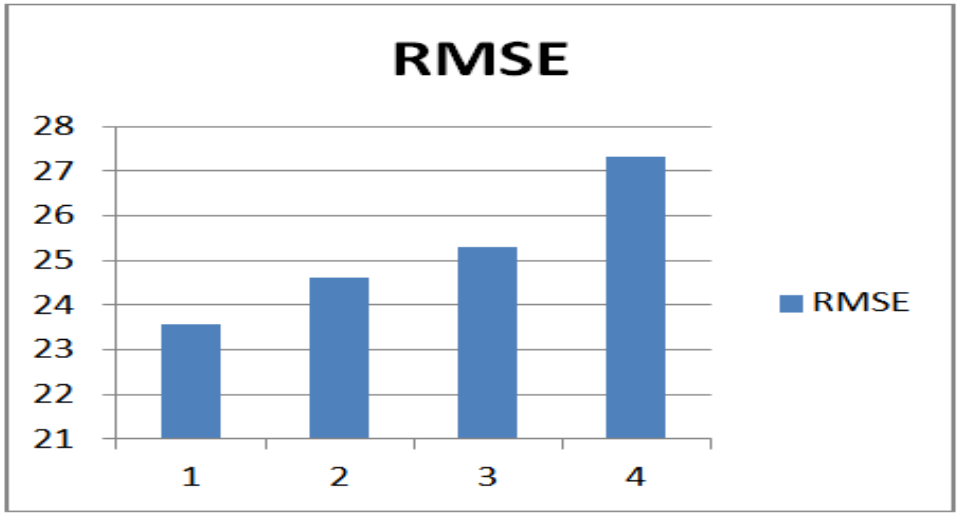

Fig.3.Comparison of Existing and Proposed Methods in terms of RMSE

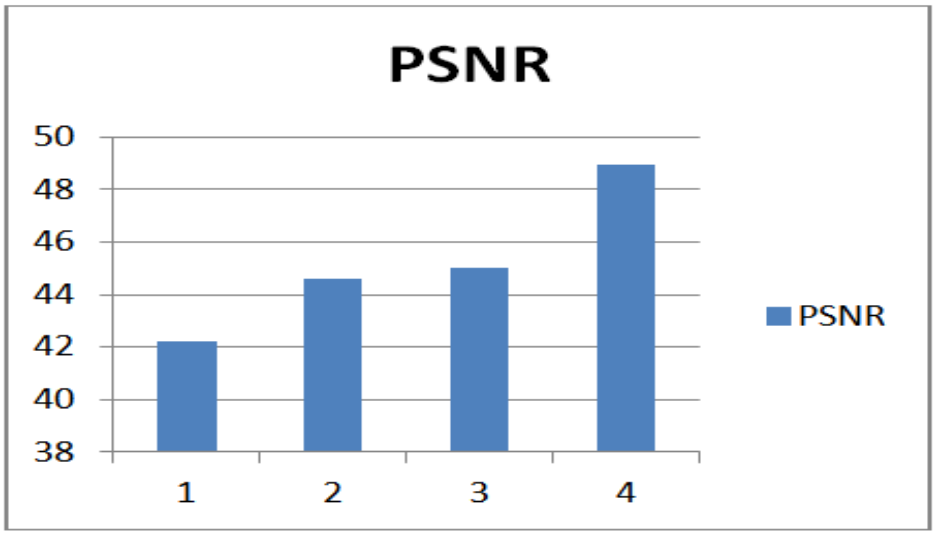

Fig.4.Comparison of Existing and Proposed Methods in terms of PSNR

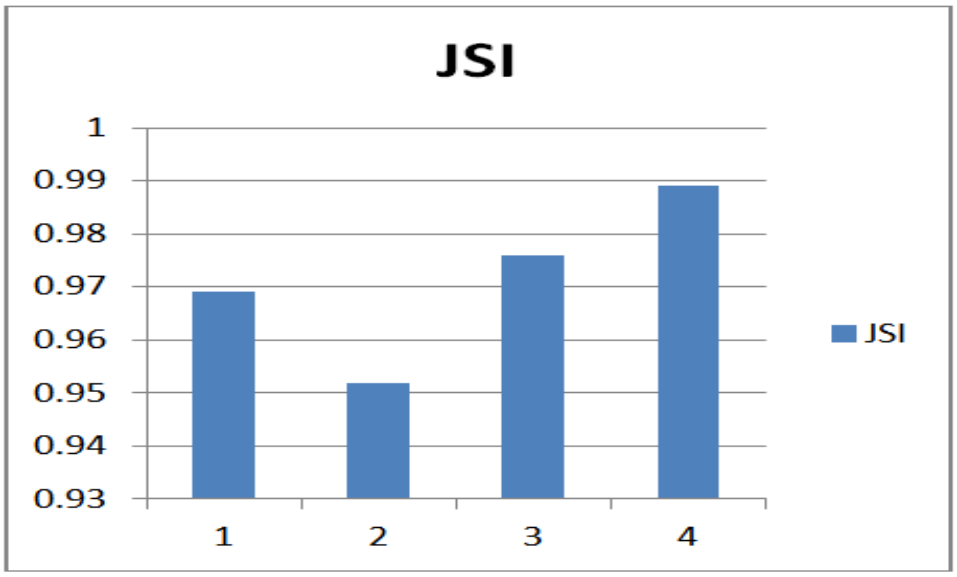

Fig.5.Comparison of Existing and Proposed Methods in terms of JSI

V. CONCLUSION

Rough set has capability to handle the uncertainty there in the data. This characteristic of RST makes it a suitable to obtain Edge and Edge Class information from the noisy image. The edge information and class information in order increase the performance of further diagnostic process. The obtained edge map is found to be continuous and closed and is capable of defining object boundaries even in noisy image. It appeared to be defining object boundaries in a better way compared to a couple of existing methods such as Canny Edge Detector and Active Contour methods, MICRO and CLICK methods.

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