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A Novel Approach To Improve Sobel Edge Detector

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Abstract

An improved edge detection algorithm based on k-means clustering approach. Being a fundamental tool in image processing, edge detection aims to identify the points in an image at which image brightness changes sharply or regularly. In Medical Science, edge detection is very useful, such as in segmentation of MRI image. Magnetic resonance imaging (MRI) produces a detailed image of any human body part, by using the natural magnetic properties of the body tissues. Since body tissues contain hydrogen atoms, which made to emit radio signals. These radio signals are then detected by a scanner. Magnetic Resonance imaging is a medical test used to diagnose tumors of the brain on the basis of high quality images produced by it. In this paper edge detection is made to determine the location of a tumor. The edge detection technique presented in this paper uses k-means clustering approach to generate the initial groups. These groups are then input to the mamdani fuzzy inference system, which generates different threshold parameters. When these parameters are fed into the classical sobel edge detector, it is found that images obtained are more enhanced and provide exact location of a tumor in a brain.

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1. Introduction

In the field of medical image processing, edge detection is an important technique useful for extracting images of part of human body. The edge detected image of any body part help radiologist in diagnoses and treatment. Medical imaging consists of techniques which are used in generating images of any part of human body to either diagnosing the diseases or to study normal anatomy and function [1]. Medical Resonance Imaging (MRI) used in radiology, is one of the medical imaging technique which uses the magnetic field generated from the hydrogen atoms of the

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body tissues [2]. This magnetic field emits radio signals which are then detected by the scanner used to create high quality images of the organs and tissues inside human body. The examination of images produced by MRI scan is made by various edge detectors [3].
The performance enhancement of different edge detectors based on retrieval of correct information is a key research issue in most of the countries of the world due to development in medical equipment generating digital images. It has been observed that the choice of input parameters [4] like threshold parameter greatly decided the performance of most of the edge detectors [5], [6] such as Canny, Rothwell, Iverson et.al.

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In this paper, we are enhancing the edge detection capability of the Sobel edge detector by using a fuzzy edge detection approach with k-means clustering algorithm. MRI images of a human brain are taken as an input image. Previous approaches involve the use of convex hull algorithm [7], [8], [9]. These algorithms in order to find out the next valley point in the image histogram [4], [10] depends on the different sections of the image histogram [6], which makes them restricted to some specific type of images.
The paper is organized as follows: Section II describes the Sobel edge detector. Section III describes the mamdani fuzzy inference system. Section IV is about threshold detection using k-means clustering approach using fuzzy logic. These threshold values then made input to the Sobel edge detector. Section V shows simulation results and section VI is conclusions.

2. THE SOBEL EDGE DETECTOR

The Sobel edge detection method is proposed by Sobel in 1970 [11]. The Sobel operator is the magnitude of the gradient computed by

$$M = \sqrt{s_x^2 + s_y^2}, \quad (1)$$

Where the partial derivative is computed by

$$s_x = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6) \quad (2)$$

$$s_y = (a_0 + ca_1 + a_2) - (a_6 + ca_5 + a_4) \quad (3)$$

With a constant c=2

Like the other gradient operators, s_x and s_y can be implemented using convolution masks:

$$s_x = \begin{array}{|c|c|c|}\hline -1 & 0 & 1 \\ \hline -2 & 0 & 2 \\ \hline -1 & 0 & 1 \\ \hline \end{array} \quad s_y = \begin{array}{|c|c|c|}\hline 1 & 2 & 1 \\ \hline 0 & 0 & 0 \\ \hline -1 & -2 & -1 \\ \hline \end{array} \quad (4)$$

The Sobel edge detector gives more emphasis on the image pixels that are closer to the center of the mask. This operatorprecedes the edges where the gradient is highest in grayscale images, this method also used in finding the estimated absolutegradient magnitude values at each point.

3. MAMDANI FUZZY INFERENCE SYSTEM

The Fuzzy logic is an approach in the field of computation according to which rather than using usual "true or false" (1 or 0), which is used by modern computers as a Boolean logic, "degrees of truth" is determined. Dr. LotfiZadeh from the University of California [12], at Berkeley in the 1960s, while working on the problem that how the computer can understand natural language, was the first one to present the idea of fuzzy logic. Natural language which is used for many activities in the universe is not easily translated into the absolute terms of 0 and 1. Fuzzy logic to some extent seems similar to the working of a human brain. A human brain while taking any decision or reaching to any result initially aggregates some related data, from that data generates some partial truths. These partial truths are further aggregated by human to create some new truths of higher level, when these truths exceed some threshold values, a decision is taken or certain resultant state is being reached e.g. motor reaction. The working of an artificial computer neural network and the expert systems is analogous to the above process.

The mapping from a given input to an output is expressed by the fuzzy inference system using fuzzy logics. The resultant output helps in taking the decisions and detection of various patterns. The fuzzy inference system involves the concept which is described in membership functions, logical operations, and if-then rules [12]. A fuzzy inference process whose initial state starts from the fuzzification and end at a state of a defuzzification.

The fuzzy inference system can be classified into two types: Mamdani type and Sugeno type. The Fuzzy logic toolbox is used to implement each type of classification of fuzzy inference systems.In the study of fuzzy logic system Mamdani's fuzzy inference system is the most common system. This inference system developed using fuzzy set theory was first control systems. It was proposed in the 1975 by EbrahimMamdani [13] as an attempt to control a steam engine and boiler combination by synthesizing a set of linguistic control rules obtained from experienced human operators. Mamdani's effort was based on the fuzzy algorithms for complex systems and decision processes. Although in the inference process described in the next few sections differs somewhat from the methods described in the original paper, the basic idea is much same. Mamdani-type inference, as defined for toolbox, expects the output membership functions to be fuzzy sets. After in the aggregation process, there is a fuzzy set for each output variable that needs defuzzification.

Sugeno-type fuzzy inference system was introduced in 1985 by Takagi-Sugeno-Kang [14] is similar to Mamdani-type in the context of fuzzification and application of fuzzy operator. But Sugeno type system has an output membership function either a linear or a constant. This system is computationally efficient and works well with optimized and adaptive techniques, which makes it very attractive in controlling problems, particularly for dynamic non-linear system. These adaptive techniques can be used to customize the membership functions so that fuzzy system best models the data. This system allows us to describe expertise in more intuitive, more human-like manner. However, Mamdani Fuzzy inference system entails a substantial computational burden.

The Mamdani-type fuzzy inference system defuzzified the fuzzy inputs, in order to generate the fuzzy output, whereas Sugeno-type fuzzy inference system calculate the weighted average to compute the crisp output which thus provide better processing time. In the area of system design Mamdani-type fuzzy inference system is less flexible than Sugeno-type.

4. THRESHOLD DETECTION USING K-MEANS CLUSTERING APPROACH

In this research paper, the K-means segmentation method is used for further segmentation. In this method the procedure defines to obtain different threshold values, the histogram was segmented into groups/classes. Then this algorithm is used to calculate total image cluster centers, used to evaluate the most significant value of threshold. This proposed method is basically a measure of class separation. The local threshold method is used to find K-means segmentation threshold.

The basic steps of the algorithm of the proposed technique are:

- Input image I.
- An image histogram H is calculated for different gray values and using K-means segmentation method image histogram is divided into different groups (set of pixels).

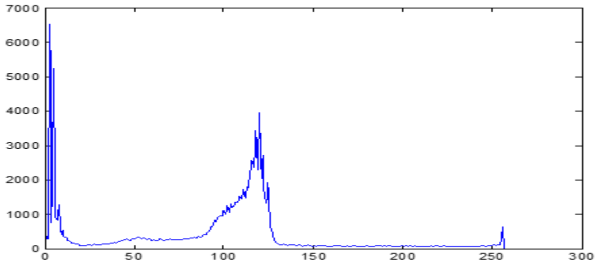


Fig. 1.1. Histogram of an image after segmentation

Above Figure 1.1 shows a grouping of pixels of a MRI image 7.tif using K-means algorithm

Using fuzzy reasoning process, the Mean of edge magnitude, Mode and pixel count of the each groups generated in above step are calculated from equations (5-7) [15]. Mode referred as most repeated value. And pixel count determines the number of pixels in the groups.

$\text{Mode}[K] = \text{calmode}$ (group k); (5)

$\text{Pixel count}[K] =$ Sum of pixels (group k)/sum of pixels (6)

Mean of the edge $[K]$ = calmeanedge (group k); (7)

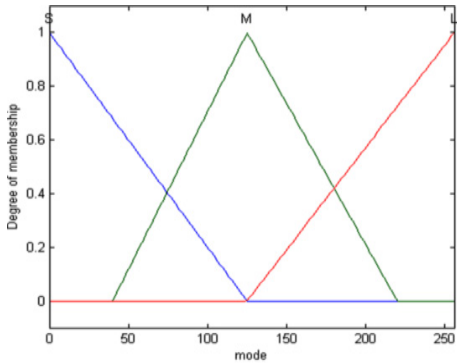


Fig. 1.2 Membership plot for mode

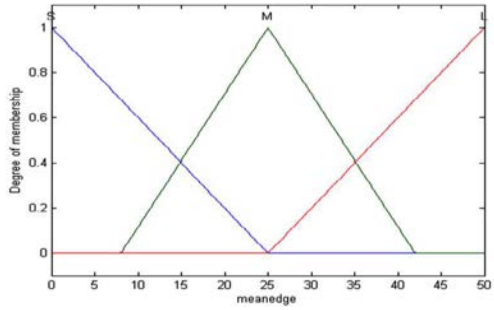


Fig. 1.3 Membership plot for mean edge

Above Figure 1.3 shows a plot of membership function for mean edge as discussed above.

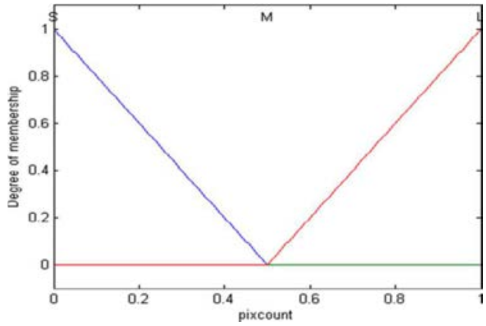


Fig. 1.4 Membership plot for pixel count

Above Figure 1.4 shows a plot of membership function for pixel count as discussed above.

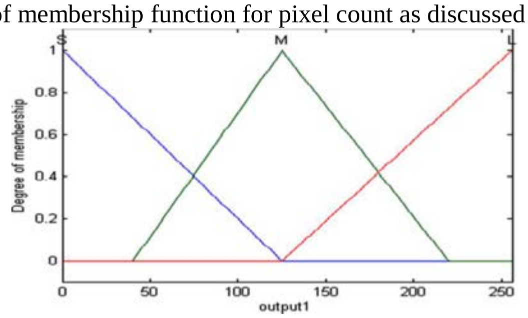


Fig. 1.5 Membership plot for output

Above Figure 1.5 shows a plot of membership function for output as discussed above.

- All three values are applied as input values of a group to FIS system. The FIS system describes the rule base where 18 inference rules are determined. Membership function used are practically chosen and shown in figure. Here three subsets are defined as “S” for small, “M” for the medium, “L” for large.

Membership functions are shown in figure of input and output function.

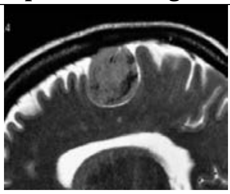
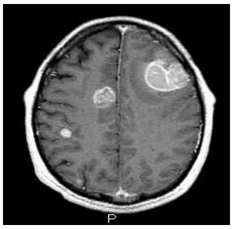
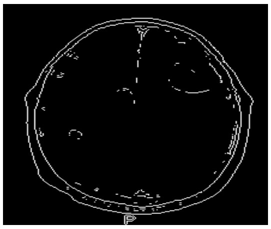
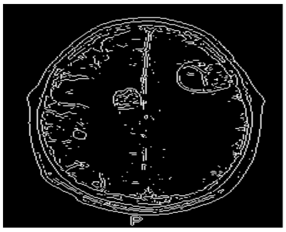
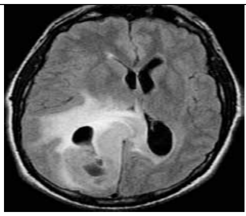
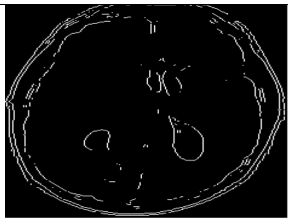
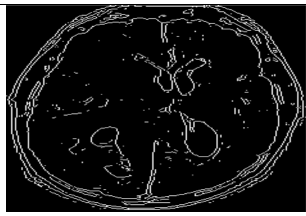
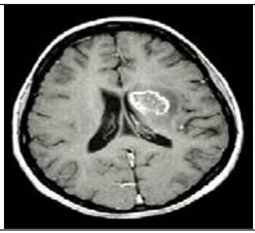
The table I show a selection of membership function using fuzzy rules set for MIN-MAX Mamdani FIS System as discussed above.

- The FIS system produces filtered output image. On the basis of total number of groups in an image with higher and lower threshold values. By using Mamdani's MIN – MAX approach obtains the supports of the composite input for each rule and use centroid to get a filtered output.

5. SIMULATION RESULTS

In our proposed method we take an MRI image of a human brain for edge detection. MRI image given as input to the system and its histogram segmented using our proposed method and get better results. In this step, a process must be executed after giving input, which checks all the required outputs and obtain the one which produces images in a proper and desired format. Each MRI image of a human brain is segmented while applying each type of edge detector. The performance evaluation of various edge detectors can be made by two ways. First on the basis of human judgment which is known as subjective method. Second on the basis of values of signal to noise ratio and mean square error between the edge detector image and the original image, this is known as an objective method.

TABLE II
Original images 7.tif, 30.tif, 9.tif, 35.tif respectively, edge detected image obtained from the different edge detector: classical Sobel, Sobel with the proposed method

SNo.	Input MRI image	Classical Sobel Detection	Sobel Detection with Proposed Method
1			
2.			
3.			
4.			

6. Conclusion& Future Scope

The selection of appropriate threshold values in image segmentation is a major issue for edge detection. The k-means clustering algorithm is more robust as slight errors due to noise in the gray values of thepixels of an image, are averaged out in while selecting a new mean which involves selection of new mean center in k-means clustering. Also, the implementation of the fuzzy inference system presents maximum robustness, lighting variation and avoiding the overlap of double edges.The subjective evaluation of the output edge detected images obtained from classical Sobel edge detector and modified Sobel edge detector is investigated which proved that the proposed method is efficient for edge detection of a MRI images as it enhances the performance of Classical Sobel Edge Detector along with retaining information about brain tumor and presenting the exact location of it which then can help in diagnosing the tumor through laser therapy, which involves recognition of tumor and then a laser of millimeters in size is directed to the tumor which heats the tumors to kill the tumor cells.
For future work, the modification in the fuzzy rule set will produce better results. Also, the Non Maximum

Suppression (NMS) method can be used as a post processing step, in order to remove some thick edges from the output image.

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