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AN EFFICIENT APPROACH FOR FUZZY BASED EDGE DETECTION USING INFORMATION THEORY

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Abstract: Digital image processing is used in the significant form of applications like image enhancement, image segmentation, compression and many others. The proposed process fastens the performance of Sobel based edge detection of a captured image using fuzzy logic. The important intention of this proposed technique to extract anatomical structure (edges) by input threshold values. The proposed research deploys the concept of Shannon Entropy-based image segmentation to provide edge threshold to Sobel detector. Entropy method is the information theoretic algorithm which sections the image histogram into distinct regions established on behalf of highest worth to localized minimal entropy or localized maximal information. The simulation outcome proves that a significant improvement in Sobel based edge detection is accomplished using proposed fuzzy model.

Keywords: Fuzzy logic, sobel, canny, edge detector, shannon measure.

1. INTRODUCTION

In the present scenario, image processing is a representation of information of a picture in two-dimensional formats with the set of finite values. Digital image is the result of these finite digital values. Digital histogram processing is using computer algorithms to participate in the handling of a picture in digital cameras. In the ideal edge detection based articles, gray value distribution lead to define a set of connected splines that defines the boundary of a subject[1]. The edges of object surface marking and curves correspond to surface orientation discontinuities. The original image needs to be simplified when area detection process is focussed, the subsequent extraordinary undertaking of deciphering the information contents. Edge detection is used as an efficient operation in image analysis. Edges are outlined as regional alterations of intensity in an image, and these will not be the physical entity[2]. It happens on the boundaries between two in the neighborhood areas of a scene/ image. In the image, edges are the place finish and partitions each vertical and the horizontal surfaces of an object. If sensors affect infinitely small footprints, an edge could be recorded between pixels with an image. In the floor image, edges could also be located on each and every character tree [3]. In proposed research[4] investigates the distance as a parametric measure in such cases edges are discovered on behalf of texture data available from the bark of trees. Edges are scale-stylish, and an aspect has other edges, however at a unique scale, an area nonetheless has no width. Here edges may be used for estimation of the boundaries and then segmentation within the image. Accordingly, the thought is proved that edge detection method is acquainted valuable in the number of contexts and used for registration and segmentation after which identification of objects in a scene[5]. It is vital to understand image processing systems like storage, processing, recognition, transmission, and on the finish interpretation of such visible image. The human notion has the capability to collect it is, integrate and interpret all this ample visual knowledge around us. There are rather challenging to impart such skills to a computing device with a purpose to understand with the visual expertise embedded in still images, portraits, and relocating pictures in our visual world[4].

The deployment of information theory in edge detection is motivated due to the role of randomness or entropy in segmentation of the image histogram.

Histogram is segregated into various groups each having a minimal randomness associated with the information content of an image. Thus in this work we are adopting the Shannon entropy function to divide histograms (segmentation) in such a way that the relative information content (entropy is preserved).

The researchers investigated on the image evaluation the place many builders present one of a kind sort of tactics. The works also based on the brink detection where an additional strategy used to become aware of edges sharply. Side detection has significant value in image evaluation. Edges are in fact outlined as boundaries of the object in a picture. Moreover, extensively used for segmentation, registration, and identification motive of an object in an image[6].

In [7] introduces the principles of fuzzy faintly consistent capabilities. These features had been characterised and investigated surely in the slight of the notions of *q*-neighbourhoods, fuzzy θ-inedge, quasi-confidence and fuzzy θ-closure. The information transition can also be suitable if the co-subject of kernel is in a fuzzified in common fuzzy scenario. Sooner or later a comparative reap potential of concerning the mutual interrelations among the many fuzzy R-map, fuzzy entirely constant, fuzzy close to steady and fuzzy steady capabilities along with fuzzy faintly steady services is made.

In [3] promises the applying of an Adaptive Neuro-Fuzzy Inference approach (ANFIS) to hydrologic time sequence modeling and is illustrated via an utility to model the river glide. Preliminary understanding to the ANFIS modeling method can be provided. The potential of the approach is that it does no longer require the model structure to be well-known a priori, not like more in general than now not series modeling approaches. The final result confirmed that the ANFIS forecasted flow series preserves the statistical residences of the reasonable glide sequence.

In [8] proposed, fuzzy logic is quite younger thought. Most important skills of this idea are that it makes it possible for the normal description, in linguistic terms, of problems that will have to be solved as a substitute than regarding relationships between targeted numerical values.

Some expertise wanted for membership operate definition, was taken from supervised highest probability classification. Additionally, the idea for outcome assessment got here from PCI's Image Works used for the supervised process. Results of two procedures, both based on pixel using pixel method, had been when put next and targeted encouraging conclusion remarks to come out.

In [9] implication operator became the basis of multiple arts discussed in literature. Firstly, all general logical operators and unary negative operators are investigated a lot. The implication kernels are major backstage phenomenon behind multiple of inference mechanism, like syllogism, tollens and ponens in many of customary functions.

In [10] proposed approaches with which this venture of site viewers is solved. The work discussed morphological aspect detection and fuzzy common sense system to repair this challenge and evaluation between two approaches is furnished.

In 2012 [11] Biswas & Sil proposed praised style-2 fuzzy models to address the uncertainties in classical Canny edge detector. Their results gave nice performance on the standard benchmark images as well as general radiological images.

In [6] proposed entropy as a proment alternative to distinguish bi-modal distributions. To control the divergence of uncertain variables via uncertainty distributions, this paper purpose at introducing the notion of move-entropy for uncertain variables headquartered on not sure conception, as just right as investigating some mathematical houses of this thought. Some valuable examples are additionally furnished to calculate unsure move-entropy. Also, the minimal pass-entropy precept is proposed in this paper. Finally, a be proficient of generalized go-entropy for uncertain variables is applied.

In [12] gifted a novel manner for picture steganography which belongs to methods taking the

potential of sharp areas in portraits with the intention to quilt a gigantic wide variety of knowledge. Quite often, the method is headquartered on the sides reward in a photograph. A move-section detector is used for this reason. Beedges, an immoderate payload manner for color snapshots is exploited. These two techniques are blended so that one could produce an enterprise new steganographic algorithm. The experimental proves a high signal to noise ratio for the application of per pixel based image watermarking.

2. FUZZY LOGICS

Fuzzy logic is a mathematical tool of computing based on "levels of truth" alternatively compared to classical "true or false" (1 or 0) Boolean logic on which the latest computer is established. The notion of fuzzy logic used to be first developed by Dr. Lotfi Zadeh of the College of California at Berkeley in Sixties[5].

Dr. Zadeh was engaged on the quandary of computer understanding of natural language. Traditional language will not be able to translate into the absolute phrases of 0 and 1. However in applying it could wish to pursue additional knowledge to feed a computer is in some state in between and so, most often, are the result of computing. Fuzzy logic entails zero and one as extreme instances of truth (or "the state of issues" or "fact"). However, also involves the more than a few states of fact in A comparison that, for example, between the results so between two things would be not "tall" or "quick" but ".38 of tallness".

In this article we present a novel approach for edge detection in images using information theory. In the rest discussion of this article Section III gives a brief introduction to Shannon entropy function, while Section IV paves a base framework for the deployment of entropy based model for edge detection. Section V discusses about the experimental outcomes and Section VI concludes the article.

3. SHANNON ENTROPY MEASURE

Shannon's entropy measure $H_s(p_{m_1, m_2})$ gives the best definition of lossless compression of a given signal within the adapted constraints [3]. It is defined as:

$$H_s(p_{m_1, m_2}) = -\sum_{m_1}\sum_{m_2} p_{m_1, m_2} \log p_{m_1, m_2}$$

where, p_{m_1, m_2} is the bi-dimensional random variable defining the 2D probability information. In the suggested research art we have evaluated the values of p_{m_1, m_2} inherited from the information content of gray level co-occurrence matrix (C_{m_1, m_2}) [5], [6] of an input image as given by the relation $p_{m_1, m_2} = C_{m_1, m_2}/(MN)$ where M, N depicts the frame dimension along the x and y directions respectively. The deployed function for defining the entropy and calculation of threshold is given by:

$$\text{Entropy}(t) = -\sum_{m_1=0}^{t}\sum_{m_2=t+1}^{L-1} p_{m_1, m_2} \log p_{m_1, m_2} - \sum_{m_1=t+1}^{L-1}\sum_{m_2=0}^{t} p_{m_1, m_2} \log p_{m_1, m_2}$$

where, L represents the highest gray value present in the input image with $m_1, m_2 \in [0, 1, 2, ..., L-1]$ and $t \in [0, 1, 2, ..., L-2]$.

The entropy value for each possible threshold is evaluated using the above defined mathematical representation for each $t \in [0,1,2,....,L-2]$ for a given image to be segmented using the bi-dimensional distribution p_{m_1, m_2} that is evaluated using the knowledge of gray-value based co-occurrence matrix C_{m_1, m_2}. The numbers of regional-minima points are investigated from the gray index versus entropy (t) based plot. The gray index pursuing the smaller localized minima can be suggested for the possible portions for histogram groupings.

4. FUZZY LOGIC BASED EDGE DETECTION

In this proposed model fuzzy inference system (FIS) is applied for edge detection to improve the performance. Fuzzy logic based automatic edge threshold approach is deployed. In this approach multiple edge threshold values are determined for the input image; an image is segmented into groups which depend on intensity histogram. Each group has the different threshold value. Thus histogram grouping the problem concerned

in this work. In our proposed research, it uses an input image to determine the multiple edge thresholds where the input image gray value distribution is segregated into various groups deploying Shannon Entropy method and output of algorithm applied to FIS system. Moreover, FIS efficiency is evaluated to solve the edge detection problem.

In the proposed system, Sobel operator is used for edge detection and histogram of the image is calculated. Successive segmentation methodology depends on the gray value of the image. It is defined as regional thresholding technique which is widely used in image processing. Shannon entropy algorithm works on gray level threshold values of each pixel and spatial correlation neighborhood information because of this algorithm is used to obtain better results in the noisy image. Image processing areas, where many of the segmentation techniques are discussed to maintain reasonable thresholding values and computational time. The proposed segmentation algorithm is well-known segmentation technique because it is quite stable and simple calculation. Firstly the gray level valued clusters of the image are identified or calculated. The proposed algorithm works on gray values. It is why mostly termed as the thresholding region based segmentation algorithm. The competitive K-means segmentation algorithm thresholding have high complexity rate and processing rate is quite slower.

Image preprocessed in different processing stages, between the various stages. Sobel operator provides the filter to get information of edges in the horizontal and vertical direction of the image. Figure 1 depicts the functional workflow representation of the experimented model in this work. The threshold for Sobel detection is provided by proposed model of histogram grouping.

In the proposed work, the Shannon Entropy based method is used for contiguous extraction of image thresholds. In this method, the procedure defined to obtain different threshold values to partition it into groups/classes. Then this algorithm is used to calculate total image cluster centres, used to evaluate the most significant value of threshold. The local threshold method is used to find k successive segmentation threshold. If input is RGB scale image, output of entropy plot in each plane can be concatenated and resultant will be thresholded color image. The implementation of the proposed technique is:

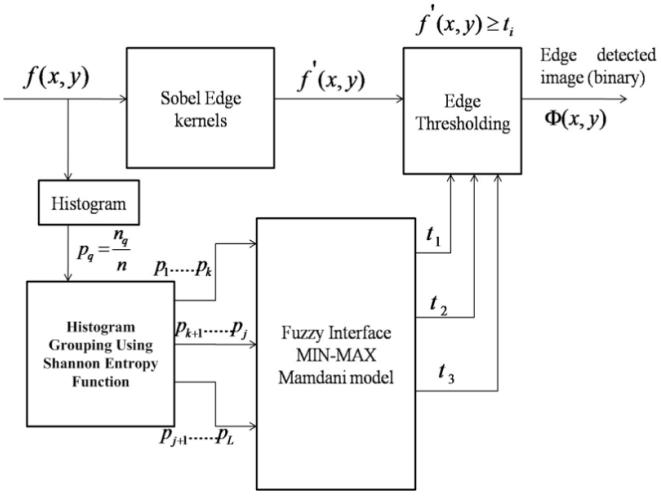

Figure 1: Fuzzy based edge detection using Shannon function based histogram grouping.

1. Input image I.
2. The image histogram H is calculated for different gray values and using Shannon Entropy based histogram segregation method, image histogram is divided into different groups (set of pixels). The simulation outcome is depicted by Figure 2.

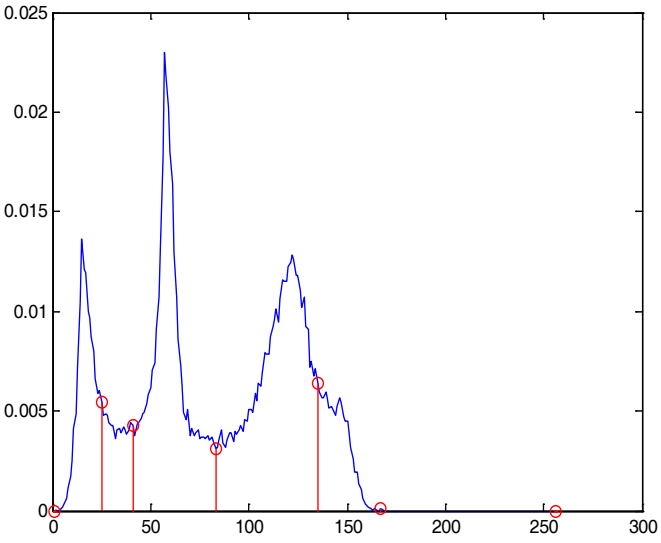

Figure 2: Image Histogram after segmentation

3. Using fuzzy reasoning process, the mean of edge magnitude, mode and pixel count of the

each groups are calculated. Mode determines the most occurring value in a group. And the number of pixels in a group is determined by pixel count.

5. The extracted parameters for each group deploying above step are further applied as input values of an individual group to fuzzy inference system. FIS system deploys the 18 inference rules for fuzzification and deffuzification as shown in Figure 3. Membership function used are practically chosen and shown in depiction. Here three subset are defined as "S" for small, "M" for medium, "L" for large. Membership function are shown in table.1 for input and output function.

Table 1
Membership plot for: (a) mODE, (b) MEAN_ EDGE, (c) PIXEL_COUNT, (d) output and (E) fuzzy rules set for Mamdani FIS

Rules / *Parameters*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mean edge	S	S	S	S	S	S	M	M	M	M	M	M	L	L	L	L	L	L
Mode	S	S	M	M	L	L	S	S	M	M	L	L	S	S	M	M	L	L
Pixel count	S	L	S	L	S	L	A	L	S	L	S	L	S	L	S	L	S	L
Output	M	M	M	M	M	M	M	M	M	L	M	L	M	L	M	L	L	L

FIS system produce edge threshold for Sobel detector to generate filtered output image. Basis of total number of groups in an image are; higher and lower threshold values. By using Mamdani's MIN – Max approach obtained the supports of composite input for each rule and use centroid to get a filtered output.

5. EXPERIMENTAL SETUP AND RESULTS

The Simulation is performed on DOS based 1GHz processor. The computing environment used here is MATLAB 2015.

In this proposed model, the histogram is developed from the image based on the intensity values of an image. The Shannon Entropy method is used to divide the original image histogram into different groups. In the proposed work, group 5 and group 6 are obtained.

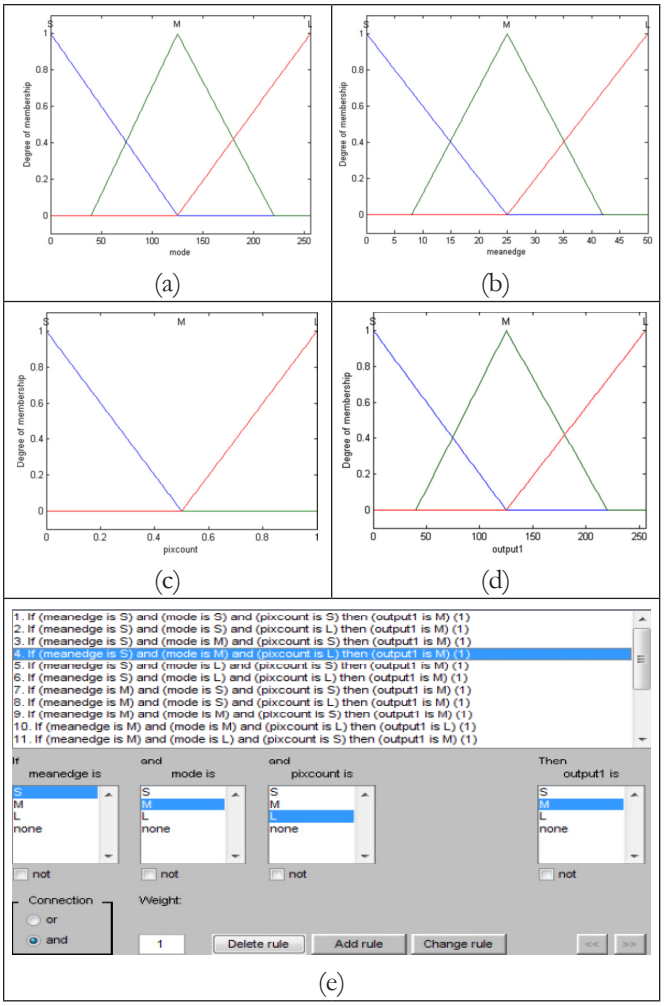

Figure 3: Fuzzy rules set for MIN-MAX Mamdani FIS System.

The threshold values are calculated for each group and then compare each threshold value against the odd threshold value. To filter edges from the input image so as to generate and edge detected output image, the proposed scheme is used here is the classical Sobel operators. The better result of edge detection scheme must be obtained among the different groups. The Shannon Entropy measure provides highly efficient results with the use of Sobel operator.

The original image and output image are compared to describe the efficiency of the proposed algorithm. The classical Sobel image and Canny image also compared to results. Our proposed method Shannon Entropy with Sobel gave the better than the other two images which can be compared by human visualization. The experimental outcomes are depicted by Table 2 & 3 respectively.

Table 2
Edge detection for test image-1

	group5	group6
Input image		
Classical Sobel detector		
Canny edge detector		
Sobel with proposed algorithm		

Table 3
Edge detection for test image-2

	group5	*group6*
Input image		
Classical Sobel detector		
Canny edge detector		
Sobel with proposed algorithm		

The performance comparison is accomplished on the behalf of extracted edges using various edge detectors investigated here. From the results of simulation it can be inference that the performance of Sobel edge detector gets enhances when its threshold for edge detection is generated using proposed scheme of Fuzzy Logic and Shannon Entropy method.

6. CONCLUSION

Edge detection plays an integral role in many of image processing applications like face detection, overlapped flower detection, brain tumor analysis and many other applications relevant to social welfare and medical sectors. In this article it is focuses to enhance the performance of classical Sobel detector using Fuzzy logic and Shannon Entropy based approach. The major concluding facts that is observed by simulation outcomes are listed below:

(a) The histogram grouping of input image, Shannon entropy function gives appropriate grouping of image histogram.

(b) The mean edge, pixel count and mode values are the key features to define the membership of fuzzy inference system.

(c) The performance of classical Sobel detector gets improved by proving its edge threshold using proposed scheme of Fuzzy Logic and Shannon Entropy based histogram grouping.

While comparing the performance of proposed approach for varied number of groups it is observed that group6 gives better performance as compared to group5. So it can be concluded that higher the number of relevant groups are attained better is the performance of proposed model.

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