A Novel Method for Edge Detection using Type 2 Fuzzy Logic

Neena A J,
PG Scholar,
ECE Department,
College of Engineering Cherthala,,Kerala, India

***Abstract*—Edge detection is an essential feature of digital image processing which is based on abrupt changes in pixel intensity. In this project a novel method for edge detection using type 2 fuzzy logic is proposed. Type 2 fuzzy logic can handle more degrees of uncertainty when compared to type 1fuzzy logic. A type 2 fuzzy inferencesystem (T2FIS) is developed in MATLAB in order to get a simple fuzzy rule based edge detection technique. The technique uses a 3 by 3 mask that slides over the whole image pixel by pixel. It highlights the edge pixels using fuzzy rules. FIS has four inputs corresponding to the four gradients of instantaneous scanning matrix and has two outputs for identifying the pixel under consideration as edge or "no edge"**

Keywords: G***eneralized type-2 fuzzy logic, edge detection, image processing,***

I INTRODUCTION.

An edge is the borderline between two regions with relatively distinct gray level properties. There exists some edge detection methods that make use of type-1 fuzzy systems, neural networks, interval-valued fuzzy operators , interval type-2 fuzzy systems combined with the Sobel operator, interval type-2 fuzzy systems with morphological gradient and improved Canny method based on interval type-2 fuzzy logic There are also traditional methods for image processing, like the Sobel, Canny, Roberts and Kirsch method.[1]

Here, a novel filter based on type 2 fuzzy logic is proposed for edge-preserving decomposition of an image. It differs from previous filters in its adaptive property. The refined image contains local means everywhere and preserves local salient edges. The reason for such a proposed method is that, in high dynamic range images the intensity variations in a very small area will be very high. So such intensity variations should result in a new edge formation. But most of the recent methods filter the edges globally. The inside intensity variations in a given area is not taken into account. In other words, one small gradient may also be an important edge locally. So the definition of salient edge should be changed. The filter is called fuzzy logic filter, and it will efficiently and effectively produce visually pleasing images.

II LITERATURE SURVEY.

Lot of techniques for edge detection exists like algorithms that make use of traditional methods (Robert, Sobel, and Prewitt), type-1 fuzzy systems, neural networks genetic algorithms with particle swarm optimization etc. [1]. The literature survey shows that current base detail decomposition techniques, based on the bilateral filter, are limited in their ability to extract detail at approximate scales. Hence, the use of an alternate edge-preserving operatoris recommended.

III TYPE 2 FUZZY SYSTEM

We have used type2 fuzzy logic based edge detection in this project due to the following reasons stated below.

Type-2 fuzzy sets allow us to handle linguistic uncertainties, which can be expressed as: words can mean different things to different people.[2]

• Type-2 Fuzzy Logic (FL), handles uncertainties hidden in the information/data as well as vagueness by modelling these using Type-2 Membership Functions(MF). All set theoretic operations for Type-1 fuzzy sets, can be performed for Type-2 fuzzy sets.

• A fuzzy relation of higher type (e.g., type-2) has been regarded as one way to increase the fuzziness of a relation. Increased fuzziness in a description means increased ability to handle inexact information in a logically correct manner.

•Uncertainty in the primary membership grades of a type-2 MF consists of a bounded region that we call the footprint of uncertainty of a type-2 MF.It is the union of all primary membership grades.

• Upper and Lower MFs: An upper MF and a lower MF are two type-1 MFs that are bounds for thefootprint of uncertainty of an interval type-2 MF. The upper MF is a subset having the maximum membership grade of the footprint of uncertainty; and the lower MF is a subset with the minimum membership grade of the footprint of uncertainty

Figure 1 depicts the difference between type 1 and type 2 MF.

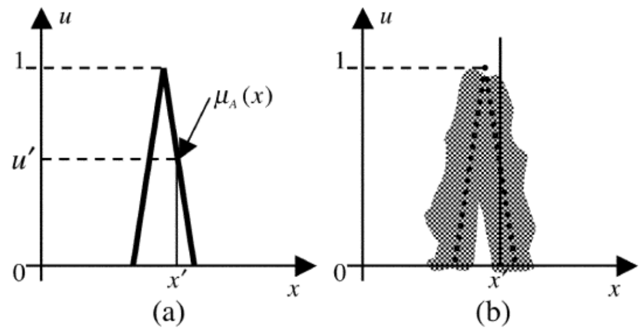

Fig. 1. (a) Type-1 MF. (b) Blurred type-1 MF.

Figure 1: Type 1 and Type 2 MF

III.PROPOSED MODEL FOR EDGE DETECTION

In this section the proposed model for edge detection based on a type-2 fuzzy inference system isdescribed. The block diagram of the model is shown in figure 2

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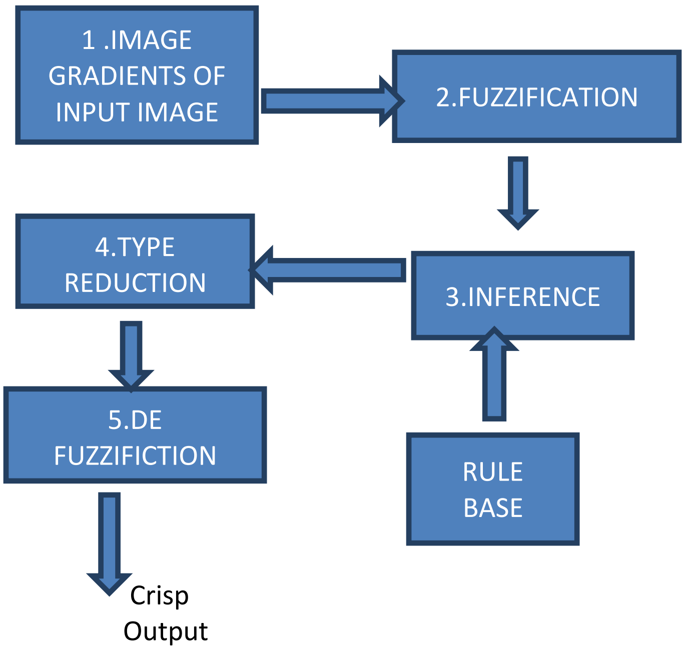

Figure 3: Block diagram of Edge detection Model using T2FLS

1. Image gradients

The first step in the whole process is reading an input gray scale image for applying the edge detectionmethod.In this step the morphological gradient technique, described below is applied to obtain the gradients in the four directions, and then use them as inputs for the proposed Generalized Type 2Fuzzy Inference System (GT2FIS).The morphological gradient of a gray scale image can be defined as the difference between the intensity values of two neighboring pixels that belong to a given structural element.

The core of gradient edge detection is, of course, the gradient operator. Image gradients are represented in figure 3

2. Fuzzification: The fuzzifier maps crisp inputs into generalizedtype-2 fuzzy sets to process within the FLS. Here we use type-2 singleton fuzzifier as it is fast to compute and, thus, suitable for the generalized type-2 Fuzzy Logic System (T2FLS) real-time operation. Singleton fuzzification maps the crisp input into a fuzzy set, which has a single point of nonzero membership. The inputs are represented by the gradients Di of the original image, and each of them will be an input to the fuzzy system.

3. Inference

Once the input and output variables are defined, with their respective membership functions, the inference process is performed in the system, and for this the following steps are needed

3.1 Input linguistic variables:

Four inputs are defined, in which each one has threeGaussian membership functions with uncertain mean.

The linguistic variables used for the four inputs are: low, medium, high. In order to adapt the membership functions to the range of gray tones depending on the image, we obtainthe maximum, minimum and middle values of Di and we use these values for calculating the mean of the membership functions.

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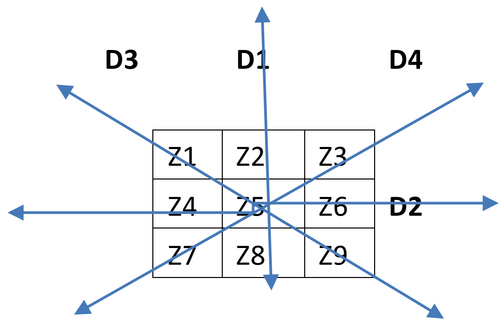
Figure 3 below: 3*3 Matrix indicating edge direction D and coefficients Zi



3.2 Defining The Fuzzy Rules

The structure of the rules in the generalized type-2 FLS is the standard Mamdani-type FLS rule structure used in the type-1 FLS and an interval type-2 FLS,. The antecedents and the consequents sets are represented by generalized type-2 fuzzy sets. The fuzzy rules are the following. [1]

If (D1 is HIGH) or (D2 is HIGH) or (D3 is HIGH) or (D4 is HIGH) then (S is EDGE)

If (D1 is MEDIUM) or (D2 is MEDIUM) or (D3 is MEDIUM) or (D4 is MEDIUM) then (S is EDGE)

If (D1 is LOW) and (D2 is LOW) and (D3 is LOW) and (D4 is LOW) then (S is NO_EDGE).

This is depicted in figure 4.

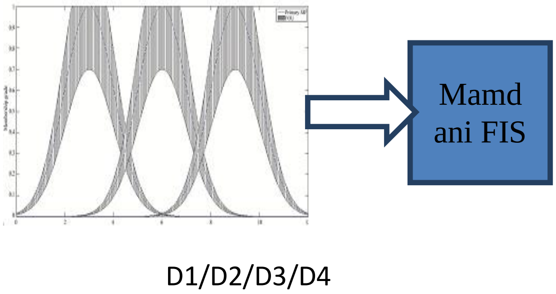


Figure 4: Membership functions of D1/D2/D3D/D4

The fired-rule output fuzzy sets have to be converted into a number by Output Processing block. Conversion of an interval Type-2 fuzzy set to a number requires twosteps. In the first step, an interval Type-2 fuzzy set is reduced to an interval-valued Type-1 fuzzyset called type-reduction. There are many type-reduction methods available. Karnikand Mendel have developed an algorithm, known as the KM Algorithm, used for type-reduction. It is very fast algorithm but iterative.[4].The second step of output processing, after type-reduction, is defuzzification. If atype-reduced set of an interval Type-2 fuzzy set is a Type-1 fuzzy set, the defuzzified value can beobtained by any of the defuzzification methods applied to Type-1 FL.[7]

IV.RESULTS&DISCUSSION

Lena, Cameraman, Houseetc were the input test images. They are converted to gray scale images and then input to the inference system. The results of edge detection using differentalgorithms for the 'house' image are shown in figure 6.

Fig 5: Original Input Image

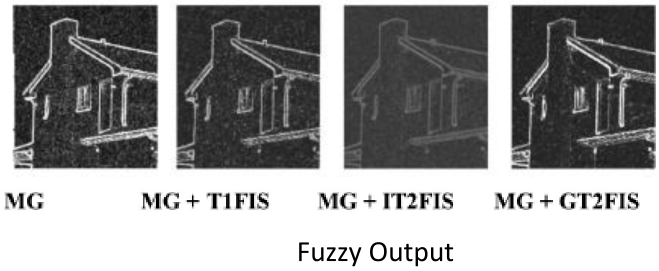


Figure6. Edge detected image a. Morphological Gradient(MG) b). MG+Type 1 Fuzzy Inference System c). MG+ interval Type 2 Fuzzy Inference System d). Morphological Gradient+ Generalized Type 2 Fuzzy Inference System.

Edge metrics are calculated using the technique called Figure of Merit(FOM) of Pratt.This measure represents the deviation of an actual (calculated)edge point from the ideal edge and itis defined as

$$\mathrm{FOM} = \frac{1}{\max(I_I, I_A)} \sum_{i=1}^{I_A} \frac{1}{1 + \propto d_i^2}$$

where I_A is the actual number of detected edge points, I_I is the number of edge points on the ideal edge, *d(i)* is the distancebetween the edge of the current pixel and its correct position inthe reference image, and α is a scaling constant.[6]

It is observed that the measurements obtained with theFOM were better when using the edge detection basedon generalized type-2 fuzzy inference systems. The more the value is closer to 1, there is little difference between the edge detected and ideal edge. This is shown in table 1 below.

Edge detector	Noise level 0	Noise level 0.002
MG	0.73	.65
MG+IT2FS	.91	,.93
Mg+GT2FIS	.95	.97

Table 1: Figure Of Merit(FOM)

V. CONCLUSION& FUTURE SCOPE

It can be inferred that type-2 fuzzy systems can be a good choice when the input image is corrupted with noise. This implies that this logic is needed in real-world devices and applications, in particular in the image processing area, because the devices that capture digital images are always exposed to external interference adding high noise levels or uncertainty to the images.

In future, Ant Bee Colony Optimization of membership functions can be done for yielding better results.

VI..REFERENCE

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