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Edge Detection Using Fuzzy Logic

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Abstract
Edge detection is still difficult task in the image processing field. In this paper we implemented fuzzy techniques for detecting edges in the image. This algorithm also works for medical images. In this paper we also explained about Fuzzy inference system, which is more robust to contrast and lighting variations.
Keywords- Fuzzy, FIS.

I. INTRODUCTION

A. Criteria for Edge Detection

Several algorithms are existed for edge detection. Each algorithm is having its own drawbacks. A good edge detection algorithm should satisfy all of the below conditions.

a) Good detection: There should be maximum number of good edges.
b) Noise sensitivity: Edge detection algorithms should be able to detect edges with acceptable noise.
c) Good localization: The edge location must be reported as close as possible to the correct position, i.e. edge localization accuracy (ELA).
d) Orientation sensitivity: The operator not only detects edge magnitude, but italso detects edge orientation correctly.
e) Speed and efficiency: The algorithm should be fast enough to be usable in animage processing system. An algorithm that allows recursive implementationor separately processing can greatly improve efficiency.

B. Various Techniques for Edge Detection

Edge detection algorithms preserves most important information in an image. Hence the output. The original image can be easily restored from its edge map. Various edge detection algorithms have been developed in the process of finding the perfect edge detector.

Most of techniques may be grouped into two types such as gradient based edge detection and Laplacian-based edge detection. In the gradient based edge detection we find an estimate of the gradient magnitude using the smoothing filter and use the found estimate to determine the position of the edges. It means that the gradient method detects the edges by looking for the maximum and the minimum in the first derivative of the image. In the Laplacian method we find the second derivative of the signal and the derivative magnitude is maximum when second derivative is zero. In short, Laplacian method searches for zero crossings in the second derivative of the image to find edges. The original image can be easily restored from its edges.

Two main methods:-
a) Gradient-based method: Gradient-based methods detect edges by checking for maxima and minima in the first derivative of the image.

b) Laplacian (zero-crossing) based method: The Laplacian based methods search for zero crossings in the second derivative of the image in order to find edges usually the zero-crossings of the Laplacian or the zero-crossings of a non-linear differential expression. A number of edge detection techniques are available but there is no single detection method that performs well in every possible image context. Various edge detection techniques are used for edge detection like Canny edge detection, Krisch edge detection which are applied on various images. Choice of edge detector to be used depends upon the image properties like noise sensitivity, orientation sensitivity, speed and efficiency.

C. Brief review of Fuzzy Logic

Fuzzy logic is a perfect problem-solving methodology with a myriad of applications in embedded control and information processing [2]. Fuzzy provides a remarkably simple way to draw definite conclusions from vague, ambiguous or imprecise information. It means that fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions. Fuzzy logic and probability theory are the most powerful tools to overcome the imperfection.
Fuzzy logic may appear similar to probability and statistics as well. Even though fuzzy logic is different from probability the result appears to be same. The probability statement, “there is a 70% chance that Bill is tall” supposes that Bill is either tall or he is not. There is 70% chance that we know which set Bill belongs. The fuzzy logic statement, “Bill’s degree of membership in the set of tall people is .80” supposes that Bill is rather tall. The fuzzy logic answer

determines he is a member. There are no probability statements that pertain to fuzzy logic. Fuzzy logic deals with the degree of membership.

Fuzzy image processing has three main phases: image fuzzification, modification of membership values and if necessary, image defuzzification. The fuzzification and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Thus the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process the images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data is transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, and fuzzy integration approach.

Fuzzy image processing is important to represent uncertainty in data. Some of the main benefits of fuzzy image processing are given below:

- Fuzzy techniques are powerful tools for knowledge representation and processing
- Fuzzy techniques can manage the vagueness and ambiguity efficiently.
- Fuzzy logic is tolerant of imprecise data.
- Fuzzy logic is conceptually easy to understand.

The mathematical concepts behind fuzzy reasoning are very simple. What makes fuzzy nice is the “naturalness” of its approach and notits far-reaching complexity. In many image processing applications, expert knowledge is used to overcome the difficulties (e.g. object recognition, scene analysis). Fuzzy set theory and fuzzy logic offer powerful tools to represent and process human knowledge in form of fuzzy if-then rules.

On the other side, many difficulties in image processing arise because the data/tasks/results are uncertain. This uncertainty, however, is not always due to the randomness but to the ambiguity and vagueness. Beside randomness which can be managed by probability theory, imperfection in the image processing can be distinguished into three types as follows:

- Grayness ambiguity
- Geometrical fuzziness
- Vague (complex/ill-defined) knowledge these problems are fuzzy in the nature.

II. PROPOSED WORK

Edge detection using fuzzy logic provides an alternative approach to detect edges. First-order linear filters are mostly applied for edge detection in digital images. Nevertheless they don’t allow good results to be obtained from images where the contrast varies a lot, due to non-uniform lighting. But in this research fuzzy inference system is applied for edge detection to improve the performance. A non-linear image filtering technique is presented which is based on fuzzy inference systems (FIS).

First, an input image is processed in different non-successive linear filtering stages, which means that the input to each filter is always the original image. The gray level in each pixel of the resulting image is then obtained by applying the FIS system to the corresponding values in the output images of the linear operators, in the same pixel. And evaluate the efficiency of a FIS system applied to the edge detection problem.

During input image pre-processing, three kinds of linear filters are applied to it: Sobel operators, used to estimate its derivatives in horizontal and vertical directions (hDH and hDV filters), a low-pass (mean) filter and a high-pass filter. The developed fuzzy system’s purpose is to determine if pixel evaluated is or is not present in one of image’s edges.

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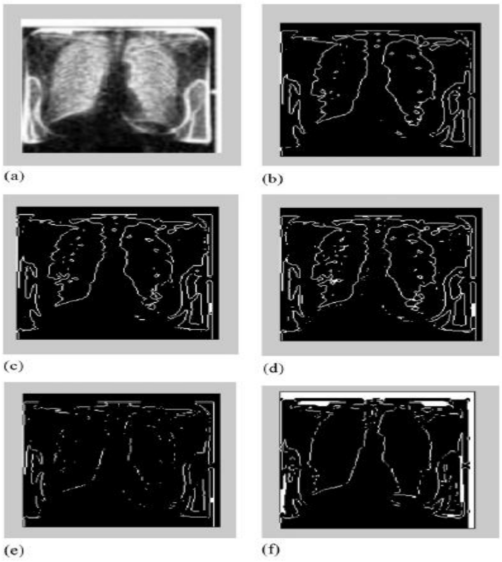
A. Methodology

Step1: Form 16 edge-detected templates with values ‘a’, ‘b’.
Step2: Apply the edge templates over the image by placing the centre of each template at each point (i, j) over the normalized image.
Step3: Calculate the intuitionistic fuzzy divergence (IFD) between each elements of each template and the image window (same size as that of template) and choose the minimum IFD value.
Step4: Choose the maximum of all the 16 (total no. of templates) minimum intuitionistic fuzzy divergence values.
Step5: Position the maximum value at the point where the template was centered over the image.
Step6: For all the pixel positions (considering the border pixels by taking the mirror values of the image), the max–min value has been selected and positioned.
Step7: A new intuitionistic divergence matrix has been formed.
Step8: Threshold the intuitionistic divergence matrix and thin.
Step9: An edge-detected image is obtained.

III. RESULTS

‘Lung’ image of size 189 _ 189 shown in (a). The hesitation constant for image is ci = 0.05. Edge-detected results with varying values of ct are shown. With c= 0.3and above, in (b)–(d) are giving a better result where the outer edges are clearly detected and no false edges are shown. Fig. (f) shows, the result with different values ofa = 0.25, b = 0.7 where the edges are not properly detected.



(a) Lung Image
(b) c = 0.2 th= 0.9
(c) c = 0.3 th=0.20
(d) c=0.35th=0.20
(e) c=0.4 th= 0.27
(f) c=0.45 th= 0.29

IV. CONCLUSION

This algorithm is adaptable to various environments. The weights associated with each fuzzy rule were tuned to allow good results to be obtained while extracting edges of the image, where contrast varies a lot from one region to another. During the performance tests, however, all parameters were kept constant.

The results allow us to conclude that, the implemented FIS system presents greater robustness to contrast and lighting variations, besides avoiding obtaining double edges.

V. FUTURE WORK

In fact, the proposed technique is to find more fine edges using fuzzy logic technique. In future, modification of fuzzy rules can produce better result. Further tuning of the weights associated to the fuzzy inference rules is still necessary to reduce even more inclusion in the output image of pixels not belonging to edges. Our proposed technique is restricted only to gray scale images, this can be extended to colour images in that case, and the detection would become significantly more
complex.

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