Applying Fuzzy Logic to Image Processing Applications : A Review

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Abstract

Fuzzy image processing is a collection of different fuzzy approaches to image processing. Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy image processing consists of 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. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the modification of membership values. After the image data are 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, a fuzzy integration approach and so on.

There is uncertainty in many aspects of image processing. In many image processing applications, we have to use expert knowledge to overcome the difficulties (e.g. object recognition, scene analysis). Visual patterns are inherently ambiguous, image features are corrupted and distorted by the acquisition process, object definitions are not always crisp, knowledge about the objects in the scene can be described only in vague terms, and the outputs of low level processes provide vague, conflicting, or erroneous inputs to higher level algorithms.

These problems are fuzzy in the nature. The question whether a pixel should become darker or brighter than it already is and the question where is the boundary between two image segments, all of these and other similar questions are examples for situations that a fuzzy approach can be the more suitable way to manage the imperfection. In fact fuzzy set theory and fuzzy logic offer us powerful tools to represent and process human knowledge in form of fuzzy if-then rules.

Fuzzy image processing plays an important role in representing uncertain data. There are many benefits of fuzzy image processing. Firstly, fuzzy techniques are able to manage the vagueness and ambiguity efficiently and deal with imprecise data. Secondly, fuzzy logic is easy to understand. Fuzzy reasoning is very simple in mathematical concepts. In many image processing applications, expert knowledge is often used to work out the problems. Expert knowledge, in the form of fuzzy if-then rules, is used to deal with imprecise data in fuzzy set theory and fuzzy logic. Fuzzy method will be more suitable to manage the imperfection than the traditional way. Input of the fuzzy inference system (FIS) is the original image and composed by a highpass filter, a first-order edge detector filter (Sobel operator) and a low-pass (median) filter.

Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. This research problem deals with Fuzzy inference system (FIS) which represents greater robustness to contrast and lighting variations. 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.

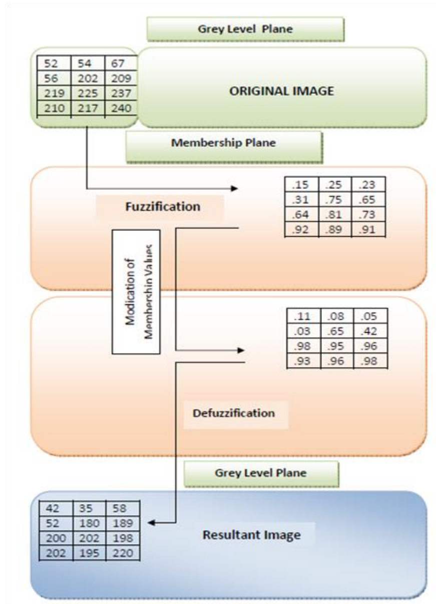


Image Edge Detection:

Segmentation is the process that subdivides an image into a number of uniformly homogeneous regions. Each homogeneous region is a constituent part or object in the entire scene. The objects on the land part of the scene need to be appropriately segmented and subsequently classified. Partitioning of an image is based on abrupt changes in gray level. If edges of the image can be extracted and linked, the region is described by the edge contour that contains it. The principal areas of interest within this category are the detection of edges of a digital image. An edge corresponds to local intensity discontinuities of an image. In the real world, the discontinuities reflect a rapid intensity change, such as the boundary between different regions, shadow boundaries, and abrupt changes in surface orientation and material properties. For example, edges represent the outline of a shape, the difference between the colors and pattern or texture. Therefore, edges can be used for boundary estimation and segmentation in scene understanding. They can also be used to find corresponding points in multiple images of the same scene.For instance, the fingerprint, human facial appearance and the body shape of an object are defined by edges in images.

Fuzzy Noise Estimation:

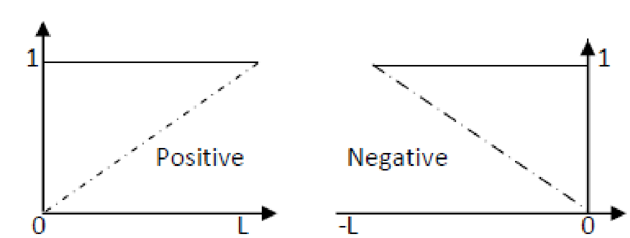
In this part we want to determine whether a pixel is corrupted or not. For this, the following criteria areconsidered:1. If a pixel is severely noisy, there aren't any similar gray level value in its neighborhood pixels, so the minimum gray value difference of that pixel and its 8-neighborhoodpixels is large. Reversely, if minimum gray level difference of a pixel and its neighbourhood pixels is small, one assumes that the pixel is not categorized as a noisy pixel. Hence we use minimum gray level differences as the first parameter of our fuzzy rule based system:

dif = = min $|f(x, y) - f(x', y')|$,where (x', y') is an 8-neighborhood pixel of (x,y).

2. If a pixel has many similar pixels in its neighbourhood, one assumes that it is uncorrupted, so we can use number of similar pixels to an assumed pixel in its 8-neighborhood as an important parameter to realize whether the pixel is corrupted or not[10]. For this, we determine the number of pixels in the 8-neighbourhood of a given pixel that their graylevel differences with central pixel is less than a predefined threshold. We may exploit this number as the second parameter of our fuzzy rule based system.

Fuzzy Image Smoothing:

To compute the correction term Δ for the processed pixel value, we use a pair of fuzzy rules for each direction. The idea behind the rules is the following: if no edge is assumed



to be present in a certain direction, the (crisp) derivative value in that direction can and will be used to compute the correction term. The first part (edge assumption) can be realized by using the fuzzy derivative value, for the second part (filtering) we will have to distinguish between positive and negative values. Therefore we define two fuzzy membership functions positive and negative with linear membership functions.

Conclusion:

The fuzzy set theory has attracted more and more attention in the area of image processing because of its inherent capability of handling uncertainty. Fuzzy set theory provides us with a suitable tool, which can represent the uncertainties arising in image processing and can model the relevant cognitive activity of the human beings. Fuzzy operators, properties, mathematics, inference rules have found more and more applications in image segmentation. Despite the computational cost, fuzzy approaches perform comparable to or better than their crisp counterparts. The more important advantage of a fuzzy methodology lies in that the fuzzy membership function provides a natural means to model the uncertainty prevalent in an image scene. Subsequently, fuzzy logic application results can be utilized in feature extraction and object recognition phases of image processing and subsequent computer vision.

References

1. Gonzalez, R.C., Woods, R.E., Digital Image Processing, 2nd Ed, Prentice-Hall of India Pvt. Ltd.
2. Milindkumar V. Sarode, Dr. S.A.Ladhake, Dr. Prashant R. Deshmukh," Fuzzy system for color image enhancement", proceedings of world academy of science, engineering and technology,Volume 36,December 2008,ISSN 2070-3740
3. Aboul Ella Hassanien, AmrBadr, "A Comparative Study of Digital Mamography Enhancement Algorithms based on Fuzzy Logic", School in informatics and Control, Vol 12, No. 1, March 2003
4. Tizhoosh, "Fast Fuzzy Edge Detection", Fuzzy Information Processing Society, 2002. Proceedings. NAFIPS. 2002 Annual Meeting of the North American, Conference on Pattern Recognition &Machine Intelligence Lab, Waterloo University, Ont., Pages 239-242
5. http://en.wikipedia.org/wiki/Pulmonary_embolism
6. Arakawa, K., "Median Filter Based on Fuzzy Rules and its Applications to Image Restoration", Fuzzy Sets Syst, pp. 3-13, 1996.
7. Chang-Shing Lee, Yau-Hwang Kuo, Pao-Ta Yu, "Weighted fuzzy mean filters for image processing, Fuzzy Sets and Systems", Volume 89, Issue 2, 16 July 1997, Pages 157-180, ISSN 0165-0114, 10.1016/S0165-0114(96)00075-9.
8. Van De Ville, D., Nachtegael, M., Van der Weken, D., Kerre, E., E., Philips, W., Lemahieu, I., "Noise Reduction by Fuzzy Image Filtering", IEEE Transactions on Fuzzy Systems, Vol. 11, NO 4.,Pages 429-436, August, 2003.
9. Dailey D. J., Cathey F. W. and Pumrin S. 2000. An Algorithm to Estimate Mean Traffic Speed Using Uncalibrated Cameras. In proceedings of IEEE Transactions on intelligent transport systems, Vol. 1,Issue 2, Pages 98-107
10. Desai U. Y., Mizuki M. M., Masaki I., and Berthold K.P. 1996. Edge and Mean Based Image Compression,MIT Labs, Available at http://hdl.handle.net/1721.1/5943, Series/Report No. AIM-1584
11. J. C. Bezdek. (1981). Pattern Recognition with Fuzzy Objective Functions. Plenum, New York.
12. M. N. Mahani, M. K. Moqadam, H. N. pour, etc. (2008). Dynamic Edge Detector Using Fuzzy Logic, CSISS 2008, Sharif University ofTechnology, Kish.
13. L. Liang and C. Looney. (2003). Competitive Fuzzy Edge Detection, Applied Soft Computing , pp. 123 - 137 .
14. G. Mansoori and H. Eghbali. (2006). Heuristic edge detection using fuzzy rule-based classifier, Journal of Intelligent and Fuzzy Systems, Volume 17, Number 5, pp. 457-469