

# EDGE DETECTION TECHNIQUE IN DIGITAL IMAGE PROCESSING USING FUZZY LOGIC

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## ABSTRACT

*A digital image is a numeric representation of a two-dimensional image. Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware. Interest in digital image processing methods stems from two principal applications areas: improvement of pictorial information for human interpretation; and processing of image data for storage, transmission, and representation for autonomous machine perception. Edges characterize boundaries and edge detection is one of the most difficult tasks in image processing hence it is a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality.*

## INTRODUCTION

Image processing, a technology that allows people to manipulate and analyze data in the form of digital images, is quickly becoming a basic tool for survival in the information age. 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 Knowledge Base (FKB) utilized in an edge detection algorithm based on the fuzzy paradigm. The proposed method calculates fuzzy measure 'edginess' at each pixel of the image using masks of different sizes. Then the edge strengths calculated using these masks are used to form a fuzzy knowledge base which in turn is used to decide whether a given pixel belongs to an edge or not. When calculating the above mentioned fuzzy measures, the algorithm takes into account both step like edges and 'line edges' in the image being processed.

## CRITERIA FOR EDGE DETECTION

There are large numbers of edge detection operators available, each designed to be sensitive to certain types of edges. The Quality of edge detection can be measured from several criteria objectively. Some criteria are proposed in terms of mathematical measurement, some of them are based on application and implementation requirements. In all five cases a quantitative evaluation of performance requires use of images where the true edges are known.

- a) **Good detection:** There should be a minimum number of false edges. Usually, edges are detected after a threshold operation. The high threshold will lead to less false edges, but it also reduces the number of true edges detected.
- b) **Noise sensitivity:** The robust algorithm can detect edges in certain acceptable noise (Gaussian, Uniform and impulsive noise) environments. Actually, an edge detector detects and also amplifies the noise simultaneously. Strategic filtering, consistency checking and post processing (such as non-maximum suppression) can be used to reduce noise sensitivity.
- 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 it also detects edge orientation correctly. Orientation can be used in post processing to connect edge segments, reject noise and suppress non-maximum edge magnitude.
- e) **Speed and efficiency:** The algorithm should be fast enough to be usable in an image processing system. An algorithm that allows recursive implementation or separately processing can greatly improve efficiency.

## VARIOUS TECHNIQUES FOR EDGE DETECTION

Two main methods:-

- a) **Gradient-based method:** Gradient-based methods (referred in Appendix A) detect edges by looking for maxima and minima in the first derivative of the image.
- b) **Laplacian (zero-crossing) based method:** The Laplacian based methods (referred in Appendix B) 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 (referred in Appendix C). Choice of edge detector to be used depends upon the image properties like noise sensitivity, orientation sensitivity, speed and efficiency.

## BRIEF REVIEW OF FUZZY

Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision — something that humans have been managing for a very long time. Fuzzy logic sometimes appears exotic or intimidating to those unfamiliar with it, but once you become acquainted with it, it seems almost surprising that no one attempted it sooner. In this sense fuzzy logic is both old and new because, although the modern and methodical science of fuzzy logic is still young, the concepts of fuzzy logic reach right down to our bones.

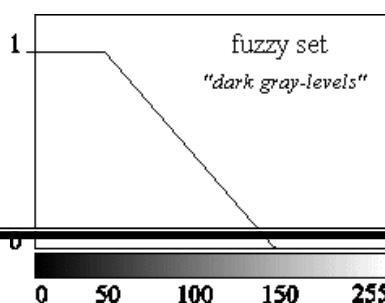
## WHY TO USE FUZZY LOGIC?

Here is a list of general observations about fuzzy logic:

- 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 not its far-reaching complexity.
- Fuzzy logic is flexible.  
With any given system, it's easy to massage it or layer more functionality on top of it without starting again from scratch.
- Fuzzy logic is tolerant of imprecise data.  
Everything is imprecise if you look closely enough, but more than that, most things are imprecise even on careful inspection. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end.
- Fuzzy logic can model nonlinear functions of arbitrary complexity.  
You can create a fuzzy system to match any set of input-output data. This process is made particularly easy by adaptive techniques like Adaptive Neuro-Fuzzy Inference Systems (ANFIS), which are available in the Fuzzy Logic Toolbox.
- Fuzzy logic can be built on top of the experience of experts.  
In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system.

## FUZZY IMAGE PROCESSING

The idea of fuzzy sets is simple and natural. For instance, we want to define a set of gray levels that share the property dark. In classical set theory, we have to determine a threshold, say the gray level



100. All gray levels between 0 and 100 are element of this set, the others do not belong to the set (left image in Fig.1). But the darkness is a matter of degree. So, a fuzzy set can model this

property much better. To define this set, we also need two thresholds, say gray levels 50 and 150. All gray levels that are less than 50 are the full member of the set, all gray levels that are greater than 150 are not the member of the set. The gray levels between 50 and 150, however, have a partial membership in the set (right image in Figure 1.24)

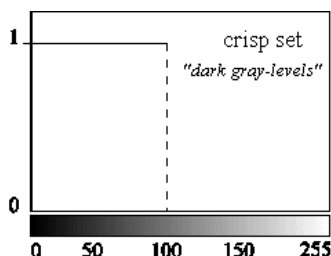


Fig : Representation of "dark gray-levels" with a crisp and a fuzzy set

## CONCLUSION

In this thesis work, better algorithm has been proposed to improve the detection of edges by using fuzzy rules. 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.

This technique uses the edge strength information derived using three masks instead of using a single mask as used in most of the edge detection techniques published in the literature. The advantage of using multiple masks is that it avoids detection of edges corresponding only to structures of a certain size or spurious noise, which is often the case with single-mask edge detection. Also, it is interesting to note that a nonlinear transformation from edge strength values to gray scale intensities results in better visual quality of the final edge map generated.

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