IMAGE EDGE DETECTION USING FUZZY LOGIC

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Abstract

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. 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. Edge detection of an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image.

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.

Introduction

A digital image is a representation of a two-dimensional image as a finite set of digital values. In image processing, the digitization process includes sampling and quantization of continuous data. The sampling process samples the intensity of the continuous-tone image, such as a monochrome, color or multi-spectrum image, at specific locations on a discrete grid. The grid defines the sampling resolution. The quantization process converts the continuous or analog values of intensity brightness into discrete data, which corresponds to the digital brightness value of each sample, ranging from black, through the grays, to white. A digitized sample is referred to as a picture element, or pixel. The digital image contains a fixed number of rows and columns of pixels.. Pixels are parameterized by position, intensity and time. Typically, the pixels are stored in computer memory as a raster image or raster map, a two-dimensional array of small integers. Image is stored in numerical form which can be manipulated by a computer. A numerical image is divided into a matrix of pixels (picture elements).

Digital image processing allows one to enhance image features of interest while attenuating detail irrelevant to a given application, and then extract useful information about the scene from the enhanced image.

Image Processing Operations

Image processing operations can be roughly divided into three major categories:

a) Image Restoration
b) Image Enhancement
c) Image Compression
d) Image Segmentation

Image Restoration:

Restoration takes a corrupted image and attempts to recreate a clean image. As many sensors are subject to noise, they results in corrupted images that don't reflect the real world scene accurately and old photograph and film archives often show considerable damage.

Image Enhancement:

Image Enhancement alters an image to makes its meaning clearer to human observers. It is often used to increase the contrast in images that are substantially dark or light. Enhancement algorithms often play attention to humans' sensitivity to contrast.

Image Compression:

Image compression is the process that helps to represent image data with as few bits as possible by exploiting redundancies in the data while maintaining an appropriate level of quality for the user. Large amounts of data are used to represent an image, so image has to be compressed when transferring from one place to another.

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.

Brief Review Of Image Edge Detection

Unlike the real world, images do not have edges. An edge is sharp change in intensity of an image. But, since the overall goal is to locate edges in the real world via an image, the term edge detection is commonly used. An edge is not a physical entity, just like a shadow. It is where the picture ends and the wall starts, where the vertical and the horizontal surfaces of an object meet. Edges characterize object boundaries and are, therefore, useful for segmentation, registration, and identification of objects in scenes . A straightforward example of edge detection is illustrated in figure Original picture has a uniform grey background. The edge enhanced version of the same image has dark lines outlining the three objects figure . Note that there is no way to tell which parts of the image is background and which are object, only the boundaries between the regions are identified.

Comparison Of Original Image With That Of Edge Enhanced Image

Various Techniques for Edge Detection

Edge detection of an image reduces significantly the amount of data and filters out information that may be regarded as less relevant, preserving the important structural properties of an image. Therefore, edges detected from its original image contain major information, which only needs a small amount of memory to store. The original image can be easily restored from its edge map.
Two major methods involved are

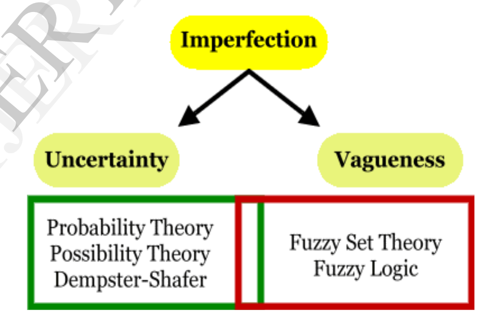
a)Gradient-based method: Gradient-based methods detect edges by looking for maxima and minima in the first derivative of the image.
b) **Laplacian (zero-crossing) based method**: The Laplacian based methods search for zero crossings in the second derivative of the image in order to find edges, usually 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.

Brief review of Fuzzy Logic

Fuzzy logic is a powerful problem-solving methodology with a myriad of applications in embedded control and information processing. Fuzzy provides a remarkably simple way to draw definite conclusions from vague, ambiguous or imprecise information. In a sense, fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions. As shown in Figure fuzzy logic and probability theory are the most powerful tools to overcome the imperfection.

Imperfection And Theories To Handle It

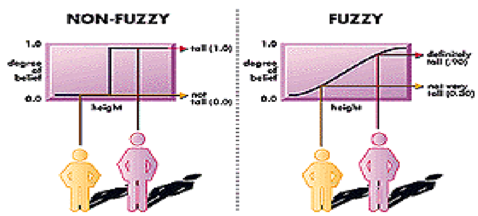


What Is Fuzzy Logic?

Fuzzy Logic is a multivalued logic, that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc to account for the real world data which exists between true and false, fuzzy logic was created. Instead of an element being 100% true or false, fuzzy logic deals with degrees of membership and degrees of truth, instead of yes and no. Something can be partially true and partially false at the same time. Fuzzy logic has the ability to add an extra layer of intelligence to the computer and swifter, more practical means of problem solving.

The notion central to fuzzy systems is that truth values (in fuzzy logic) or membership values (in fuzzy sets) are indicated by a value on the range [0.0, 1.0], with 0.0 representing absolute Falseness and 1.0 representing absolute Truth.

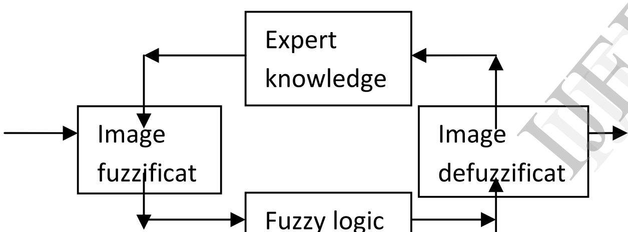
An Example To Demonstrate Fuzzy Logic



Structure of Fuzzy Image Processing

Fuzzy image processing is not a unique theory. 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 has three main stages: image fuzzification, modification of membership values, and, if necessary, image defuzzification.

General Structure Of Fuzzy Image Processing



Let us discuss the important blocks of a fuzzy system

1. Fuzzification

It initiates the fuzzy system by converting the real time data (such as temperature, costs, etc) into fuzzy inputs. For example, a real world input such as a "cost" of $100,000 may be converted to a fuzzy input value of "very expensive." This is called a *label*, and the conversion process is performed by a *membership function*.

There can be any number of labels in a fuzzy system, and an equal number of membership functions.

2. Rule Evaluation

After the fuzzification step produces a set of fuzzy inputs, these inputs can then be processed using *rule evaluation*. Fuzzy "rules" are usually if-then statements that describe the action to be taken in response to various fuzzy inputs.

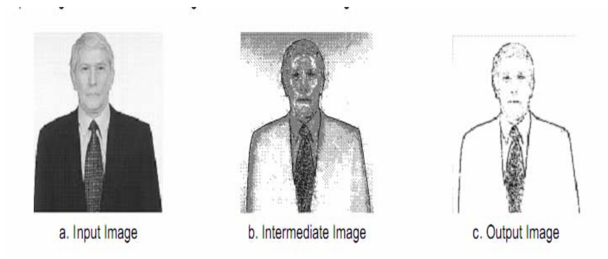
The syntax is :

if *anticedent1* **and** *antecedent2..**then** consequent1* **and** *consequent2…*

3. Defuzzification

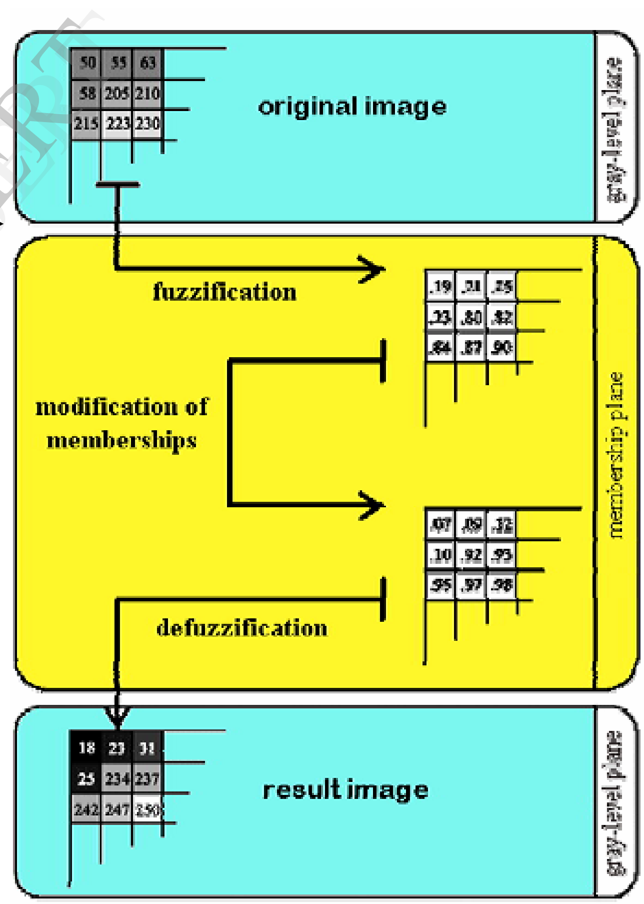
After rule evaluation step the fuzzified and processed outputs are defuzzified through a process called defuzzification.

Comparison of Images in a Fuzzy Algorithm



The images shown above showcases the various steps involved before edge detection using fuzzy algorithm. The algorithm given below provides a detailed description regarding the various steps involved in fuzzy algorithm.

Fuzzy Algorithm For Image Edge Detection



Conclusion:

Thus from the above depicted facts, it is evident that fuzzy logic yields its best in image edge detection technique under digital image processing. The algorithm so far we have designed suits almost all 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.

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

Future Scope: 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 color images in that case, and the detection would become significant.