Chapter 16
High Speed Soft Computing Based Circuit for Edges Detection in Images

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Abstract In this chapter a technique for detecting edges in images is presented. The technique is based on applying soft computing techniques such as fuzzy logic and Lukasiewicz algebra operator. The utility of this technique is related to the simplicity of the operations for edge calculation that makes it very suitable for low cost hardware implementation and high processing speed.

Keywords Edge detection · image · soft computing · fuzzy logic · Lukasiewicz algebra operator

16.1 Introduction

Many image processing techniques requires the detection of edges. An edge is defined as a sharp change in the luminosity intensity between a pixel and another adjacent one. Most of the edge detection techniques can be grouped in two categories: gradient based techniques and Laplacian based methods. The techniques based on gradient use the first derivative of the image and look for the maximum and the minimum of this derivative. Examples of this type of strategies are: the Canny method [1], Sobel method, Roberts method [2], Prewitt method [3], etc. On the other hand the techniques based on Laplacian look for the cross by zero of the second derivative of the image. An example of this type of techniques is the zero-crossing method [4].

Normally the edge extraction mechanisms are implemented executing the corresponding software realisation on a processor. Nevertheless in applications that demand constrained response times (real time applications) the specific hardware implementation is required. The main drawback of implementing the edge detec-
tion techniques in hardware is the high complexity of the existing algorithms. In
this chapter a technique for detecting edges in images is presented. The technique
is based on applying soft computing techniques such as fuzzy logic and Lukasiewicz
algebra operator. The utility of this technique is related to the simplicity of the
operations for edge calculation [5] that makes it very suitable for low cost hardware
implementation and high processing speed.

16.2 Edge Detection Algorithm

The process of edge detection in an image consists of a sequence of stages. The first
stage receives the input image and applies a filter in order to eliminate noise. Then
a binary image is obtained applying a threshold in order to classify the pixels of the
image under two categories, black and white. Finally, in the last stage the detection
of edges is performed.

16.2.1 The Filter Stage

The filter stage allows to eliminate noise patterns. The target of the filter step
consists in eliminating all those points that do not provide any type of informa-
tion of interest. The noise corresponds to nonwished information that appears in
the image. It comes principally from the capture sensor (quantisation noise) and
from the transmission of the image (fault on transmitting the information bits).
Basically we consider two types of noise: Gaussian and impulsive (salt & pep-
pers). The Gaussian noise has its origin in differences of gains of the sensor, noise
in the digitalization, etc. The impulsive noise is characterized by some arbitrary
values of pixels that are detectable because they are very different from its neigh-
bours. A way to eliminate these types of noise is by means of a low pass filter.
This filter makes smoothed of the image replacing high and low values by average
values.

The filter used in the proposed edge detection system is based on the bounded-
sum Lukasiewicz’s operator. This operator comes from multi-valued Lukasiewicz
algebra and is defined as:

\[ \text{BoundedSum}(x, y) = \min(1, x + y) \] (16.1)

where \( x, y \in [0, 1] \). The main advantage of applying this operator comes from
the simplicity of the hardware realisation as it is seen in Section 16.3.

The Lukasiewicz’s bounded sum filter performs the smoothing of the image and
is suitable for salt & peppers noise as well as Gaussian. Figure 16.1 shows the effect
of applying this type of filter.