Adaptive Edge Detection Based on Interval-valued Fuzzy Sets

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Abstract—**In this paper, we present an adaptive method for the edge detection based on interval-valued fuzzy sets (IVFSs). We use the method of slipping window with selecting windows of different sizes in different zones of the image. The adaptation of edge detection in different regions may improve its accuracy. This is especially true in images that include different regions with different edge features. The proposed adaptation in edge detection is also fast. Simulations illustrate that the proposed method has improved accuracy as compared to other methods that use IVFSs, but they are not adaptive.**

Keywords: Edge detection, interval-valued fuzzy set, interval-valued fuzzy entropy, adaptive edge detector.

I. INTRODUCTION

Edge detection is one of the most common operations in image analysis. Most popular algorithms are based on measuring the grey-level differences of some neighborhood pixels.

On the other hand, the concept of fuzzy sets was first presented by Zadeh in 1965 [1]. In fuzzy set theory, a degree of membership in the interval [0, 1] is assigned to each element of the set. This concept has proved to be a strong tool for representing human knowledge. Fuzzy set theory has since been used in many of different fields: control, signal processing, communication and so on.

Since the inception of fuzzy sets by Zadeh, many of its extensions aim to treat the imprecision and uncertainty [2] in image processing applications (see [3] for a rapid discussion about some of these theories). Some of the very well-known extensions of the theory are Atanassov's intuitionistic fuzzy sets (A-IFS), Interval type2 fuzzy set, and interval-valued fuzzy sets (IVFSs). Among these is a well-known generalization of the ordinary fuzzy set, the interval-valued fuzzy set, also first introduced by Zadeh [4]. An IVFS is defined by an interval-valued membership function; each element of an IVFS is associated with not just a degree of membership but also the length of its membership interval. IVFSs have since been used in a number of different fields such as: image processing [5], approximate reasoning [6, 7, and 8], interval-valued logic [9–11], medicine [12].

Recently, an edge detection algorithm based on IVFSs, was proposed in 2009 [13]. Theoretical and experimental analysis showed that this method contains some advantages relative to the very well-known Canny's edge detector. But Canny's detector is still better than the IVFSs method in some cases. For example, if the image needs windows of different sizes in different regions, the edges that are detected by Canny's detector are more complete.

The adaptation in edge detection may improve its accuracy. We could divide regions of any image into three types: regions without edges, regions with partial edges and regions with localized edges. The adaptation of edge detection in the all regions is useful. In this paper, we present an adaptive method for the edge detection based on IVFSs. In this method, we select suitable size of the window in the different zones of the image. The proposed method is more useful in images that include different regions with different edge features. The proposed adaptation in edge detection is also fast. On the other side, the proposed adaptation method could apply to any edge detection methods that use the method of slipping window.

The aim of this paper is to use some concepts of IVFSs theory for adapting the edge detection in grayscale images. This paper is organized as follows. Section 2 reviews an existing IVFS method for edge detection. Next, the proposed adaptive edge detection is discussed in Section 3. Section 4 presents several experimental examples and compares our results with those obtained by the not adaptive method. Conclusion is considered in Section 5.

II. INTRODUCTION TO IVFS METHOD

In this section, we briefly review an IVFS method for edge detection. For complete information see [13].

A. Necessary definitions

First, we must calculate an IV_n (interval-valued) fuzzy set of image (matrix) f. The calculated IV_n matrix is denoted as G^n. An element of f is belongs to an edge if there is a big enough difference between its intensity and its neighbors' intensities. In this method is represented the difference between f (x, y) and the intensities of neighboring elements as a length, which becomes from the interval associated with the element (x, y). For this reason, is assigned an IVFS to each matrix f and