Chapter 25
Corner Detection Using Fuzzy Principles

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ABSTRACT

Reliable corner detection is an important task in pattern recognition applications. In this chapter an approach based on fuzzy-rules to detect corners even under imprecise information is presented. The uncertainties arising due to various types of imaging defects such as blurring, illumination change, noise, et cetera. Fuzzy systems are well known for efficient handling of impreciseness. In order to handle the incompleteness arising due to imperfection of data, it is reasonable to model corner properties by a fuzzy rule-based system. The robustness of the proposed algorithm is compared with well known conventional detectors. The performance is tested on a number of benchmark test images to illustrate the efficiency of the algorithm in noise presence.

INTRODUCTION

The human visual system has a highly developed capability for detecting many classes of patterns including visually significant arrangements of image elements. From the psychovisual aspect, points representing high curvature are one of the dominant classes of patterns that play an important role in almost all real life image analysis applications (Lowe, 1985; Loupias & Sebe, 2000; Fischler & Wolf, 1994). These points encode a significant amount of shape information. Corners are generally formed at the junction of different edge segments which may be the meeting (or crossing) of two edges. Cornerness of an edge segment depends solely on the curvature formed at the meeting point of two line segments. Corner detection is one of the fundamental tasks in computer vision and it can be regarded as a special type of feature segmentation. Extracted corners

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can be used for measurement and/or recognition purposes. A large number of algorithms already exist in the literature. In particular, corner detection on gray level images can be classified into two main approaches. In the first approach, the gray level image is first converted into its binary version for extraction of boundaries using some thresholding technique. After a successful extraction of boundaries, the corners or the high curvature points are detected using directional codes or other polygonal approximation techniques (Freeman & Davis, 1977). In the second approach, the gray level image is taken directly as an input for corner detection. In this chapter, the discussion is restricted to the second approach only. Most of the general-purpose detectors based on gray level, use either a topology-based or an auto-correlation- based approach and most recently machine learning strategies (Rosten et al., 2010). Topology based corner detectors, mainly use gradients and surface curvature to define the measure of cornerness. Points are marked as corners, if the value of cornerness exceeds some predefined threshold condition. Alternatively a measure of curvature can be obtained using autocorrelation (Kitchen &Rosenfeld, 1982; Zheng et al., 1999; Rattarangsi & Chin, 1999; Teh & Chin, 1989; Rosenfeld & Johnston, 1973).

There exits several classical corner detection algorithms for estimating corner points. Such detectors are based on a local structure matrix which consists on the first partial derivatives of the intensity function. An clear example is the Harris feature point detector (Harris & Stephens, 1988), which is based on a comparison: the measure of the corner strength - which is defined by the method and is based on a local structure matrix - is compared to an appropriately chosen concrete threshold. Another well known corner detector is the SUSAN (Smallest Univalue Segment Assimilating Nucleus) detector which is based on brightness comparison (Smith & Brady, 1997). It does not depend on image derivatives. The SUSAN area will reach a minimum while the nucleus lies on a corner point. The effectiveness of the above mentioned algorithms is acceptable. Recent studies such as (Zou et al., 2008) demonstrate that the Harris corner detector performs better for several circumstances in comparison to the SUSAN algorithm.

Data from natural images are always imprecise and noisy due to inherent uncertainties that may arise from the imaging process (such as defocusing, wide variations of illuminations, etc.). As a result, precise localization and detection of corners become difficult under such imperfect situations. On the other hand, Fuzzy systems are well known for efficiently handling of impreciseness and incompleteness (Zadeh, 1965; Pal et al., 2000; Yua et al., 2007) due to imperfection of data. Therefore it may result reasonable to model corner properties using a fuzzy rule-based system as they have been successfully applied to image processing in a wide variety of applications (Karmakar & Dooley, 2002; Basak & Pal, 2005; Jacquey et al., 2008). This chapter seeks to contribute to enhance the application of fuzzy logic to image processing, just as it has been proposed in (Russo, 1999). The method adopts a template-based rule-driven procedure and has been specifically developed to deal with topics related to image processing purposes. This method is able to address many different processing tasks (Tizhoosh, 2003; Liang & Looney, 2003; Kim, 2004) and to produce better results than classical methods when applied to some critical issues such as noise (Tizhoosh, 2003; Russo, 2004; Yüksel, 2007).

Only few fuzzy approaches have specifically addressed the problem of corner detection for general purposes, one of the first works is reported in (Li, 1999). Banerjee & Kundu have proposed in (Banerjee & Kundu, 2008) an algorithm to extract significant gray level corner points. The measure of cornerness in each point is computed by means of the fuzzy edge strength and the gradient direction. Different corner fuzzy-sets are obtained by considering different threshold values from the fuzzy edge map. However, the algorithm's main

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