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Corner Detection Using Multi-directional Gabor Filters ⋆

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Abstract

Exploiting the characteristics of corner, an information entropy-based corner detection algorithm using the multi-directional Gabor filters is proposed in this paper. Different from the methods which detect corners by analyzing plane curve contour shape or finding for local maxima of curvature, the proposed method combines with the gray level changing information at edge contour pixels and pixels around the contour pixels to find corner . Firstly, the Canny edge operator is used to extract edge map and the gaps in the edge map are filled. Secondly, the imaginary parts of Gabor filters are used to smooth the edge pixels and their surrounding pixels along multi-directions. Finally, the gradient direction information entropy at the edge pixels is used to detect corners. Experimental results show that the proposed algorithm attains better detection performance, higher localization accuracy and noise robustness than the existing several algorithms.

Keywords: Corner Detection; Imaginary Parts of the Gabor Filter; Gradient Direction Information Entropy

1 Introduction

Corner is a stable image sparse feature, which preserves the important information of image. There are many applications based upon the corner detection including three-dimensional scene reconstruction, object tracking and stereo matching [1,2]. In generally, corner detection methods can be classified into three groups: intensity-based methods [3–9], model-based methods [10–15] and contour-based methods [16–22].

The gray intensity-based method which mainly depends on the different among homogeneous region, edges and corners intensity-variation is used to extract corner. Moravec [3] indicated that in homogeneous region, the intensity variation is small. And only in perpendicular to edge ridge direction where the intensity variation is large. But on the corner, the variation is largest at all directions. Harris et al. [4] developed Moravec's idea and applied the first-order partial derivatives of Gaussian filter to construct auto-correlation matrix and the eigenvalues were used to detect corner, which has good property to detect L-type corner [5] and conducts affine transforms.

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However, it is sensitive to noise, because the input image is smoothed by isotropic Gaussian kernel [6]. Later, many improved methods have been proposed, the Gabor wavelet [7], the adaptive scale selection [8] and double threshold selection [9] were used to detect corner in the structure of Harris algorithm. Those methods have better corner location and noise robust than Harris.

Model-based methods find corner by fitting a small patch of an image into a predefined model. Most scholars focus on the representation of isotropic Gaussian kernel such as simple corner model [10], complex corner model [11] to detect corner. In 2013, Shui [12] used Anisotropic Direction Derivative (ANDD) representation of the universal corner model to describe Y-type, X Ctype and star-like corners. The different corner models are smoothed by the ANDD filter and the multi-scale representations of any corner types are acquired. The ANDD-based detector was proved to have better performance than isotropic Gaussian kernel-based detector [6]. Unlike the method using first or second order partial derivative of image, SUSAN [13] adopted local image with zero-order information and Univalue Segment Assimilating Nucleus (USAN) to detect corner. This method is robust to noise but its localization is weak. Many improved methods based upon SUSAN have been proposed such as [14]. Now, SUSAN has been widely used in 3D image feature detection [15].

Contour-based methods first extract edge contour from input image by some edge detector, and then analyze contours' shape information to detect corner. Recently, most of the existing contour-based methods are based upon the Curvature Scale-space (CSS) technique [16]. The algorithm first uses Canny [17] to extract edge and then fill gaps at broken edges. Then the multi-scale directional derivative Gaussian is used to smooth the image and the local curvature maximum is defined as candidate corner. Lastly, in order to get the accurate corner location, the candidate corner is traced and selected by the Gaussian scales with coarse to fine. Mokhtarian [18] used Gaussian kernels with several scales to smooth the different lengths of edge curves, which had the better property of extracting edge structure information and suppressing noise. As Masood [19] pointed, the CSS suffers from three main problems. First, curvature estimation technique is sensitive to both noise and local variation of contour. Second, it is difficult to choose Gaussian scales. Third, the threshold is difficult to determine. The Direct Curvature Scale Space (DCSS) [20] and Chord-to-point Distance Accumulation (CPDA) [21] can be used to reduce the compute complexity and improve the noise robustness. He & Yung [22] proposed the adaptive curvature threshold method based on Region of Support (ROS), which reduced the influence of threshold choosing. The largest problem of contour-based method is that if there were local variation on the contour or noise influence, it would affect the detection performance.

The contour-based methods only depend on the edge of plane curve contour shape, without considering the gray information of the edge. Intensity-based methods only depend on gray intensity. In this paper, a new method which considers both contour shape and grey information is proposed. Gabor filter has the same properties with human visual system [23] which is suitable to be selected as the model. The optimal filters to extract local feature have different applications, such as face recognition and edge detection. Pellegrino [24] proved that the imaginary part of Gabor filters can extract fine directional intensity variation information around a pixel. Kadir [25] proposed that entropy has the ability to reflect the information of image. Inspired by the low self-similarity at all directions of corner, we used the gradient direction information entropy of edge pixels as a new corner measure. In this paper, we will present a new corner detection algorithm which combines the edge contour shape and intensity variation information using the multi-directions imaginary parts of Gabor filters. The multi-directions imaginary parts of Gabor filters are used to extract the fine intensity variation information of the input image along multi-