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A computationally efficient technique for real-time detection of particular-slope edges

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Abstract Identification of oblique lines of a particular slope is needed for various applications such as motion tracking for smart cameras. Wavelets and gradient-based techniques, such as Sobel and Canny, do not classify edges based on their slopes. The Hough transform (HT) does classify edges based on their slopes but with high computational complexity, even using its most improved versions. This paper presents a computationally efficient technique for detecting edges of a particular slope. The angle of the required edges is converted into pixel increments over rows and columns. Using these two simple parameters, parallel, oblique lines of a particular slope are formed. A first-order, orthonormal Haar low-pass filter (LPF) is used over the formed lines to filter out undesired edges. The hardware architecture of the proposed technique is fully described, including processing time, based on the number of clock cycles, and fixed-point implementation. A line-based memory mechanism was used to minimize the memory requirements to two simple registers. To demonstrate the computational advantage of the proposed technique, it is compared to the Sobel, Canny and HT detectors.

Keywords Edge detection · Motion tracking · Real-time implementation · Wavelet transform

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1 Introduction

1.1 Review of gray-scale edge detection techniques

Oblique edges at different angles reveal a great deal of visual information. In the case of still images, depth and height perceptions are based on the slopes of oblique edges. Figure 1 displays two examples for conveying depth and height perceptions through oblique edges of different slopes. In the case of videos, motion tracking can be performed using the slopes of edges in successive frames. In [9], an example of template tracking based on edge slopes was given.

In the early development of edge detection techniques, the quality criterion was the efficiency of detecting most of the edges with little attention to the computational complexity associated with the algorithm. The most widely used edge detection techniques have been the Laplacian, Sobel and Canny. In the Laplacian and Sobel detectors [11], second derivatives and the magnitudes of the first derivates were used, respectively, to detect discontinuities in pixel intensities. In either technique, a filter mask was used to implement the respective operator.

The Canny detector [2] is better described as a suit of algorithms, rather than an algorithm, that aims at improving the quality of the image in general and of the edge detection process in particular. The efficiency criterion was defined in terms of detecting all edges without generating spurious ones. Also the locations of the detected edges should be as close as possible to the real edges. The core of Canny detector is still the computation of the gradient magnitude and angle images. However, additional pre- and post-steps were added to achieve the desired efficiency [11]. First, a Gaussian spatial filter was applied to smooth out the image and reduce the adverse effect of the noise.

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