A Review of Fast Edge Detectors for Real-Time Document Capture

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1. Introduction

This work is interested with the plane object detection problem, which is a cross problem between the computer vision (CV) and document image analysis (DIA) fields. A plane object can be modeled as a rectangle suffering from perspective distortion within an image. A classical solution to this problem is based on the use of local features such as local interest points, patches, regions, etc. In particularly, the local features of a shape model are matched against those of an input image to find the possible matches. These matches are then post-processed to filter out the consistent matches by using some parameter estimator such as Hough Transform (HT), Random Sample Consensus (RANSAC), the Least Median of Squares (LMedS) [4], etc. In the CV field, typical applications include the detection of car license plates [3], ground plane objects [2], etc.

In recent years, there has been a noticeable shift of attention on the problem of camera-based document capture [1]. Document capture results in document location from a camera stream. Due to real-time constraints, time optimization is a major challenge in the literature. A few recent contributions have addressed these aspects [5] [6] [7] [8] [9].

In this paper, we present our first investigations on this problem considering the local features aspects. Therefore, edges constitute core local features to address this issue. To cope with real-time constraints, we will have a particular focus on fast edge detectors, as presented in section 2.

2. Fast Edge Detectors

Edge detection is a fundamental problem in the CV field. Contours appear as abrupt changes in intensity in a 2D signal, therefore it is a common technique to drive the contour detection with derivative operators. To gain robustness, compound operators are often employed which include a smoothing function and derivative operation.

Obviously, the first-order derivative operators are one of the ways to get the signal changes. The operator response is driven in terms of magnitude and direction of the gradient. They appear as separable filters presenting a lowest complexity $O(N\sigma)$ with N and the σ^2 as being the number of pixels in the input image and mask size, respectively. With suitable reformulation of operators, they can be implanted with SIMD (Single Instruction to Multiple Data) instruction [11] and parallel processing [12] and supported with LUT (Lookup Table) operations for optimization. For these different reasons, these operators are preferred in the literature for real-time edge detection as they ensure a better response time [18].

To cope with the control of the detector response, the hysteresis thresholding methods are under consideration, which proposed in [17] [13] [14] [15] [16]. At best of our knowledge, real-time requirements and tracking have little been investigated in these papers.

An alternative is to obtain the edge detection with a second-order differentiation. For a 2D signal, Laplacian operator is the standard approach to combine the derivative operation with Gaussian weighting for averaging. The resulting compound operator is the Laplacian of Gaussian (LoG).

Basically, LoG is not a separable filter and enters in a $O(N\sigma^2)$ complexity. The correlation product processes in the floating domain, making harder the LUT support [20] and parallel implementation of the operator. This results in a largest processing time making the operator little compatible with real-time uses-cases [18]. To solve with this problem, a large effort has been made in the literature to design fast LoG estimators like DoG (Difference of Gaussian), SURF (Speed Up Robust Features), Almost-gaussian operators [21]. LoG can be approximated with a difference of gaussian or a cascade averaging box filtering [21]. These estimators support a large processing improvement compared to root implementation time of the LoG operator [22].

3. Working in Progress

We have been dealing with some following tasks:

1 - To evaluate the fast edge detectors on the dataset [1], in terms of precision, and real-time abilities.

2- To investigate the reformation of the automatic hysteresis thresholding methods [17] [13] [14] [15] [16] into a tracking process to be applied to a camera stream.

3 - To extend investigations to content-based features [5] [6] [7] [8] [9] and real-time estimators [24].

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