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Digital Image and video processing Based on Edge Detection : A Review

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ABSTRACT

The images Edge detection is one of the most important concerns in digital image and video processing. In the real time video and image processing, edge detection has been greatly benefited and thus, new avenues for research opened up. The digital image and video processing consists of the implementation of various image processing algorithms like edge detection using Sobel, Prewitt, Canny and Robert etc. In this paper various research on image edge detection is studied and concluded the best one for further improvement in the same field.
Keywords: Robert, Sobel, Prewitt, edge detection, Gaussian filter.

I. INTRODUCTION

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There is an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator are as follows:

- ✓ **Edge orientation:** The geometry of the operator determines a characteristic direction in which it is most sensitive to edges.
- ✓ **Noise environment:** Edge detection is difficult in noisy images, since both the noise and the edges contain high-frequency content. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels.
- ✓ **Edge structure:** The operator as wavelet-based techniques actually characterize the nature of the transition for each edge in order to distinguish, for example, edges associated with hair from edges associated with a face.
- ✓ There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories:
- ✓ **Gradient:** The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.
- ✓ **Laplacian:** The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location.

Applications such as these involve different processes like image enhancement, and object detection. Implementing such applications on a generable purpose computer can be easier but not very efficient in terms of speed.

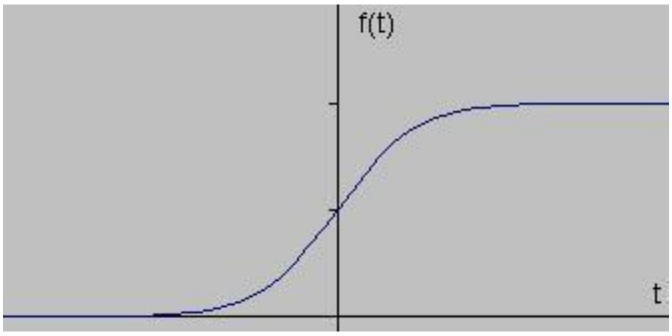

Figure 1. The signal applied to the edge detector.

There are two types of technologies available for hardware design. Full custom hardware design also called as Application Specific Integrated Circuits (ASIC) and semi-custom hardware device, which are programmable devices like Digital signal processors (DSP‟s) and Field Programmable Gate Arrays (FPGA‟s).

Full custom ASIC design offers highest performance, but the complexity and the cost associated with the design is very high. The ASIC design cannot be changed; time taken to design the hardware is also very high. ASIC designs are used in high volume commercial applications.

II. LITERATURE SURVEY

Many works have been performed on obtaining an edge detection operator. Most noted amongst these is the work of Canny [1] who showed that the ideal operator that maximizes the conventional signal-to-noise ratio in detecting a particular edge is correlation with the same edge model itself. However, this detection is not well localized and requires an additional localization criterion. A third criterion that suppresses multiple responses was also included and numerical optimization resulted in the desired edge detector.

Canny‟s edge detector for step edges is well approximated by the Derivative of Gaussian mask. In contrast, our edge detector formulation is based on the fact that SNR implicitly defines all the desired properties of good detection and localization (sharp peak, good localization and minimal off-center response), and thus given an edge model, the optimal SNR filter for this model also results in a good edge detector. While Canny [1] worked with finite extent filters. Deriche [2] used the same approach with infinite extent filters, with the objective of obtaining an efficient recursive implementation. The resulting operator has the form of an even, exponentially damped sinusoid and is different from our Step Expansion Filter.

Furthermore, the step expansion filter **is** also infinite in width, and has an efficient recursive implementation as well.

Another work using infinite width filters is due to Sarkar and Boyer [3], [4]. In this work, Canny‟s signal-to-noise ratio and localization criterion, along with another criterion for spurious response are optimized using the variational approach and nonlinear constrained optimization. A recursive approximation to these filters is also presented. A comprehensive set of results with different values of the Multiple Response Criterion (MRC) reveals that for some values of the MRC, the filters are somewhat similar in appearance to our Step Expansion Filter.

Spacek [5] combined all three of Canny‟s criteria into one performance measure and simplified the differential equation that yields the optimal filter. To yield the actual optimal filter, he fixed two of the six parameters involved and determined the remaining four using boundary conditions. The work of Petrou and Kittler [6] extends Spacek‟s works for ramp edges.

Shen, Castan, and Zhao [7], [8] present as an optimal operator for edge detection, an exponential filter. Analytically, this exponential filter is equivalent to the integral of the Step Expansion Filter that we present. Unlike Shen et. al use Expansion Matching and optimize the SNR criterion, and obtain an exact analytical relationship between the variance of the expected input noise, and the width (decay parameter in the exponential term) of our Filter.

On the other hand, Shen and Castan [7] desire to: a) minimize the energy in the desired filter‟s response to noise, b) minimize the energy in the derivative of the above noisy response, and c) maximize the energy of the peak center response to the step edge. Unlike the SNR, these criteria do not consider the off-center response of the filter to the template (in this case the step edge model) as undesired noise. Also**,** their work does not address the problem of determining an appropriate detector width for a given input noise. Our approach also offers a general method for easily designing optimal SNR detectors for any edge model, not only step edges, and can also easily incorporate colored noise models. Another important point is that the edge maps generated by the two methods are not identical, since we detect the peaks of the filter output, whereas Shen and Castan obtain the zero crossings of the output of their exponential filter.

The fundamental difference here is that while the step expansion filter and the exponential filter are related by a simple integral equation, detecting the peaks of the step expansion filter output in a white noise environment (as per our analytical model) is not equivalent to detecting the zero crossings of in a white noise environment (as Shen and Castan propose) since the noise model undergoes a change (actually becomes more colored and low pass) due to the integration. A more detailed discussion of this point can be found in the work of Sarkar and Boyer [3].

Modestino and Fries [9] suggest to use the Laplacian of an image in order to detect edges. In their work they use random fields, and cast the problem as one of obtaining the minimum mean squared error estimate of the true Laplacian of the actual input image from a given noisy input image. This obviously results in the Wiener filter of the Laplacian as the optimal filter. Modestino and Fries do not use this filter itself, but instead use a spatial frequency weighted version of the Laplacian (basically a Gaussian low-pass spatial filter) to avoid difficulties in the digital implementation of the optimum Wiener filter.

Furthermore, their work is concentrated on realizing this filter using a recursive implementation. Note that their Wiener filter has no connection to the SNR optimization that we perform. The Wiener restoration filter use is based on regarding the given edge model as a blurring function, which has been shown to be an efficient and regularized implementation of the non-orthogonal expansion for matching[10].

Other ideas in the field of edge detection include the work of Dickley et al. [11] who obtained the spherical wave function as their ideal filter, based on the definition of an edge as a step discontinuity between regions of uniform intensity. Another significant work is that of Marr and Hildreth [12] who suggested the isotropic Laplacian of Gaussian mask on the image and identified the resulting zero-crossings as the edges of the image.

A numerical method using interpolated data proposed by Haralick [13] involved locating edges as the zero crossings of the second directional derivative in the direction of the gradient. A surface- fitting approach was used by Nalwa and Binford [14] wherein, at each point, the edge detector performs a best- fit of surfaces within a localized window, i.e., least squared error with minimal number of parameters.

Raman Maini and J. S. Sobel [15] evaluated the performance of the Prewitt edge detector for noisy image and demonstrated that the Prewitt edge detector works quite well for digital image corrupted with Poisson noise whereas its performance decreases sharply for other kind of noise.

Davis, L. S. [16] has suggested Gaussian pre-convolution for this purpose. However, all the Gaussian and Gaussian- like smoothing filters, while smoothing out the noise, also remove genuine high frequency edge features, degrade localization and degrade the detection of low- contrast edges. The classical operators emphasize the high frequency components in the image and therefore act poorly in cases of moderate low SNR and/or low spatial resolution of the imaging device.

Sharifi, M. et al. [17] introduces a new classification of most important and commonly used edge detection algorithms, namely ISEF, Canny, Marr-Hildreth, Sobel, Kirch and Laplacian. They discussed the advantages and disadvantages of these algorithms.

Shin, M.C et al. [18] presented an evaluation of edge detector performance using a structure from motion task. They found that the Canny detector had the best test performance and the best robustness in convergence and is one of the faster executing detectors. It performs the best for the task of structure from motion. This conclusion is similar to that reached by Heath et al. [20] in the context of human visual edge rating experiment.

III. CONCLUSION

Edge detection is an important pre-processing step in image analysis. Edge detection is an important work for object recognition and is also an essential pre-processing step in image segmentation. These edge detection operators can have better edge effect under the circumstances of obvious edge and low noise. There are various edge detection methods in the domain of image edge detection, each having certain disadvantages. Hence we will acquire satisfactory result if choosing suitable edge detection operator according to specific situation in practice.

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