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A Distributed Canny Edge Detector with Threshold Segmentation

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Abstract -The canny edge detection is one of the most implemented edge detection algorithms because of its superior performance in noisy environment. Because of its frame level statistics, it is intensive and having high latency. Applying basic canny edge detection algorithm on input image may cause excessive edges in smooth regions and to loss of significant edges in high-detailed regions. Based on block type and the local distribution of the gradients in the image block, we present a distributed canny edge detection algorithm based on threshold segmentation that adaptively computes the edge detection thresholds. The new block-based algorithm has a significantly reduced latency and can be easily used for parallel processing applications. This paper presents improved algorithm based on threshold segmentation in which threshold of pixel in an image is estimated by calculating the mean and variance of the grayscale values of the neighbor pixels. Experimental results demonstrate that proposed algorithm can preserve more useful edge information and more robust to noise.

Keywords - canny edge detection, distributed image processing, image statistics, threshold segmentation, noise restraining

I. INTRODUCTION

The Canny algorithm is a well known edge detector that is widely used in the previous processing stages in several algorithms related to computer vision. The canny edge detector has remained a standard for many years and has best performance among the existing edge detection algorithms. The canny edge detection is not more computationally complex as compared to other edge detection algorithms, but it necessitates additional preprocessing computations to be done on the entire image. In real time application a direct implementation of the canny algorithm has high latency and cannot be employed. The previously implemented edge detection algorithms used to compute the high and low thresholds off line and use the same fixed threshold values for all the images.

For image processing applications, the general purpose graphics processing unit has emerged as a powerful and accessible parallel computing platform. since they use the same fixed pair of high and low threshold values for all images, all of these implementations are frame-based and do not have good edge detection performance. Fixed pair of high and low threshold values for all input images are used in the most of the above existing implementations. As discussed later in this paper this results in a decreased edge detection performance. With the increasing demand for large size high spatial resolution visual content, the issue of increased latency and decreased throughput is becoming more significant. The image can be partitioned into blocks and the canny algorithm can be applied to each of the blocks in parallel as a first step. When the original canny directly applied to block level that would be failed. In this paper, we propose an adaptive threshold selection algorithm which computes the high and low threshold for each block based on the type of block and the local distribution of pixel gradients in the block having different edge features.

In the proposed algorithm the small size structural operator used to calculate statistical information of every single pixel in an image. When input image is divided into hundreds of blocks, the information in each block is much fewer. With the small sized structural operator precise results can be obtained. If the size of structural operator is large, time require to run the algorithm would be longer and edge is thicker. It takes less time to run the algorithm with small sized structural operator but it doesn't assure the edge obtained is continuous. It is easy to obtain continuous contour of an image using large sized structural operator.

To reduce the complexity of the algorithm variance of the grayscale values of the pixel in block is simply difference between brightest and darkest pixel. The smoothing parameter (б) plays an important role in smoothing effect. We have also performed comparative study of previous canny method and proposed method. The main contribution of our wok is to improve the edge detection performance by incorporating threshold segmentation with distributed image processing of blocks. In this the image statistics is used to reduce complexity of preliminary work that has been given by [4].

II. RELATED WORK

A highly efficient recursive algorithm for edge detection is presented. Using Canny's design [1], we show that a solution to his precise formulation of detection and localization for an infinite extent filter leads to an optimal operator in only one dimension and that also can be efficiently implemented by two recursive filters moving in opposite directions. To deal with the noise truncature immunity, the recursive nature of the filtering operation is used to reduce computational effort. Two-dimensional recursive filters are implemented as resulting filtering structures as two-dimensional case is considered. Hence, the filter size can be varied by changing the value of one parameter without affecting the execution time of the algorithm. Performance of this new edge detector has been given and compared to Canny's filters. Various experimental results are shown [1].

Edge detection serves as a pre-processing step for many image processing algorithms such as image segmentation, image enhancement. This paper provides a Canny edge detection algorithm that results in significantly reduced memory storage requirements, reduces latency and increased throughput with no loss in edge detection performance to store psycho-visually important information. This edge detection algorithm has been implemented on MATLAB simulation and FPGA implementation [2].

The Preliminary work of this method was presented in [3].In this paper they presented a distributed Canny edge detection algorithm that results in significantly reduced memory storage requirements, decreased latency and increased real time processing with no loss in edge detection performance as compared to the original Canny algorithm.

Though the computational cost of the architecture in [3] is very low compared to original canny edge detection but it was limited to only fixed size image and block with 512x512 and 64x64 respectively. FPGA-based hardware architecture of algorithm is presented in this paper and the architecture is synthesized on the Xilinx Virtex – 5 FPGA.

Later on the method presented in [4] gives the solution to the problem of fixed block size. The mask size can be chosen as small as possible to get precise results. The input image divided into nxn non-overlapping blocks and then classified blocks into six types uniform, uniform/texture, texture, edge/texture, medium edge and strong edge. They presented a novel distributed canny edge detection algorithm which has the ability to compute edges of multiple blocks at the same time. To achieve this adaptive threshold selection method has been proposed that predicts the high and low thresholds of the entire image while only processing the pixels of an individual block at the same time.

A new measure of quality is proposed for evaluating the performance of available methods of image segmentation and edge detection. The technique used here is intended for the evaluation of low error results by using both the neighborhood pixel statistics and error-interaction criteria. The proposed mathematical model is extremely simple, even from the perspective of computational execution point of view. A training of the measure has been put in practice, which uses visual evaluation and image statistics of a set of error patterns by number of observers. By incorporating the results were obtained for a selected test images, especially to compare with other recently proposed and/or currently employed quality measures.[5]

Threshold segmentation is a method which is frequently used but using this method it is difficult to extract complex information in image and hence new segmentation method is proposed in which each pixel has its own threshold based on the texture of edge. The threshold of a pixel in an image is obtained by calculating the mean and the square variance of the algorithm based on threshold segmentation. The result obtained shows that it is apparent to get the better results by proposed algorithm than by the canny operator.[6]

III. OVERVIEW OF CANNY EDGE DETECTION

3.1 Canny edge detection algorithm

Canny developed the algorithm that effectively derives an optimal edge detector for the step edges corrupted by additive white Gaussian noise. The canny edge detector algorithm consist of following steps –

Image smoothing - G(x,y) is a 2D Gaussian and I(x,y) is the input image, Then the smoothed image H(x,y) calculated as

$$H(x, y) = G(x, y) * I(x, y)$$

Horizontal and vertical gradient calculation - Gx(x, y) and Gy(x, y) at each pixel location calculated by using the convolution of the input image I(x, y) with partial derivatives of a 2D Gaussian function which is given as

$$G(x, y) = \frac{1}{2\pi\sigma} \exp(\frac{-x^2 + y^2}{2\sigma^2})$$

Gradient magnitude and direction - Computing the gradient magnitude M(x, y) and direction θG(x, y) at each pixel location as

$$M(x, y) = \sqrt{Gx^2(x, y) + Gy^2(x, y)}$$

$$\theta_G(x, y) = \arctan\left(\frac{G_y(x, y)}{G_x(x, y)}\right)$$

Non-Maximal Suppression (NMS) - The data obtained contains some spurious edges which are removed after applying NMS operation to the image.

Adaptive threshold selection - The high and low threshold calculated based on histogram of the magnitudes of the gradient.

Hysteresis thresholding - Hysteresis thresholding is performed to determine the final edge map of the image.

3.2 Proposed system

In the proposed system, the input image is divided into m x m overlapping blocks and each block processed independent of other. With the use of L x L gradient mask, the m x m overlapping blocks are obtained by first dividing the input image into n x n non-overlapping blocks and then extending each block by (L + 1)/2 pixels along the boundaries to prevent edge artifacts respectively. Then we are going to apply the threshold segmentation to each block to get the detailed edge performance in which NMS operation at boundary pixels requires the gradient values of the neighboring pixels of the considered boundary pixels in a block. In this new segmentation method each pixel is having own threshold based on block statistics which helps to remove edge artifacts.

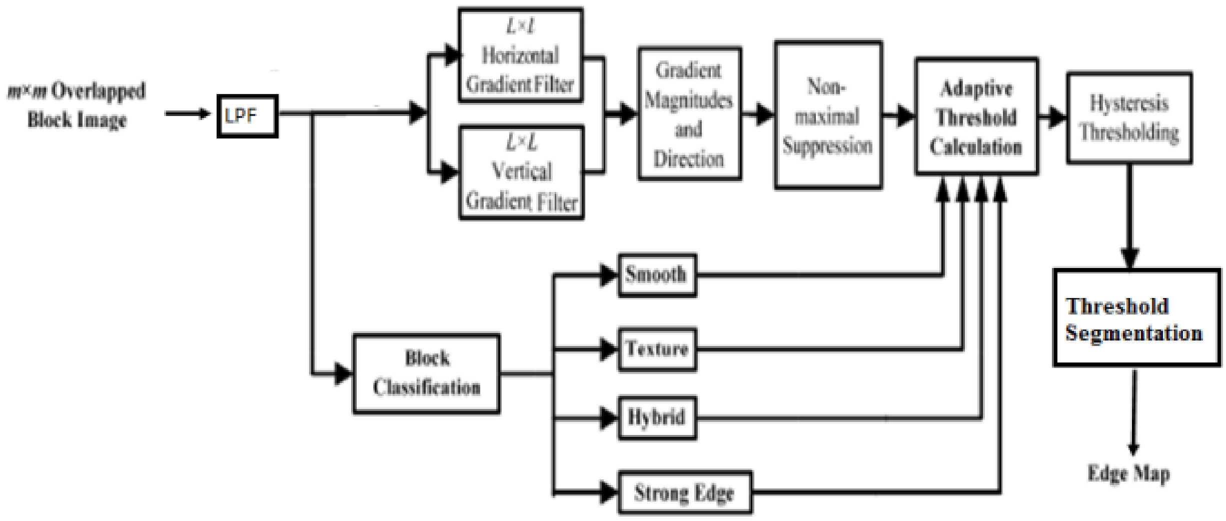

Figure 1. Block schematic of proposed system

3.3 Performance analysis

The performance of the proposed threshold based algorithm is mainly affected by the size of the block and size of the mask (structural operator). So the selection of proper mask size for image is very important.

3.3.1 Impact of structural operator (б) - The choice of б depends on the image characteristics. The large size of structural operator corresponds to higher value of б, it results in smoothing but degrades the edge performance. Likewise the small б is best suits for textures and true edges. Also the small sized structural operator requires less time for block processing, the same is shown in figure 2.

3.3.2 Impact of block size - The size of the block must be chosen as small as possible that able to detect all psycho-visually important edges. The quality of resultant edge map is analyzed by evaluating Pearson's correlation coefficient (PCC) because PCC is more robust to changing block size as shown in figure 3.

IV. RESULTS

The results in this paper are the assumption to show the comparison of conventional canny algorithm and proposed algorithm using parameters block size and mask size.

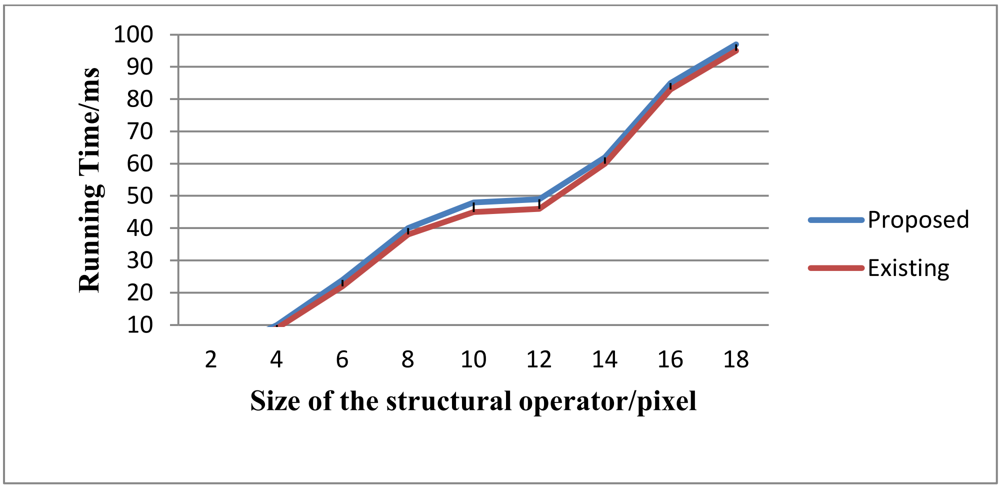

Figure 2. Chart for running time of proposed method

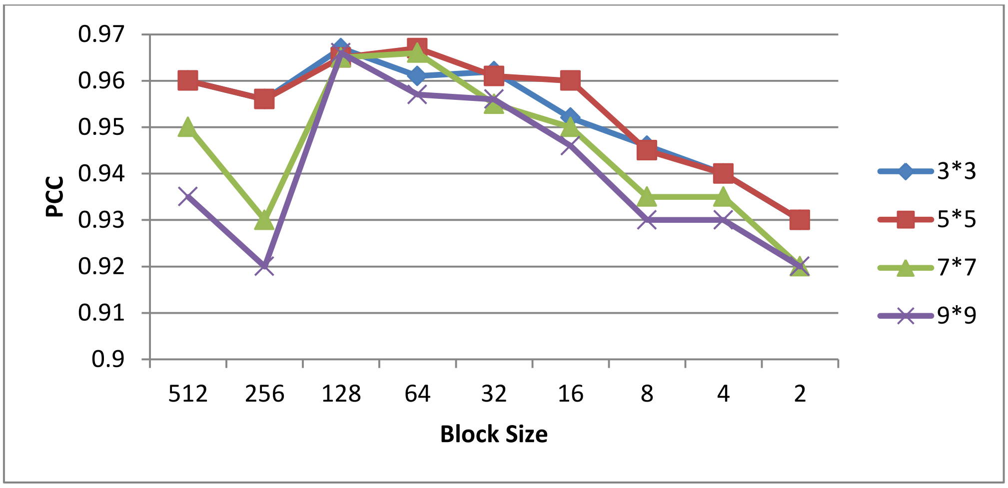

Figure 3. Effective block size for proposed method

V. CONCLUSION

The goal is to improve the edge detection performance by incorporating the threshold segmentation. The proposed algorithm is mainly focusing in order to use the segmentation in which the threshold is set by calculating the mean and square of the grayscale values of its neighbor pixels. In this paper it is assumed that the proposed algorithm provides better result with reduced run time than the original canny algorithm. The improvement in the run time of the proposed algorithm is shown by graphical representation. The image segmentation has good advantage in noise restraining with wide applicability.

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