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Construction of Fuzzy Relations to Generate the Edge of Images using B-R Edge Detectors

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Abstract

In this paper, an emerging edge detection technique which computes edges of several images using the combination of Bergholm edge detector with Rothwell edge detector is presented. Here, the edge detection of images using Bergholm-Rothwell (B-R) edge detectors is compared with Bergholm and Rothwell edge detectors separately.

Keywords: *Edge detection, rothwell edge detector, bergholm edge detector, B-R edge detectors.*

INTRODUCTION

Edge detection is a very important image processing operation, which is essential in order to carry out various higher level tasks such as motion and feature analysis, understanding, recognition and retrieval from databases. Over four decades of research work on edge detection have resulted in the development of a plethora of simple to complex techniques [1- 7]. The problem of edge detection has been tackled using various different paradigms such as surface fitting, optimization of a criterion, statistical testing and soft computing. Among the various methods in all the paradigms, the popular are the ones based on finding the amount of edge at each pixel of the image. The edge of several images can be detected by applying different techniques but no methods are fully efficient for edge detection of images. Depending on the intensity of image, edges in an image can be meaningful or non-meaningful discontinuities of function. So, intensity takes a greater role for edge detection of images.

For simplicity, we can take the first-order derivative in order to calculate the gradient at each pixel in several images. Canny proposed a method called as non-maximum suppression method which is related to gradient magnitude computation [8–10]. According to him, NMS be used to obtain edges of single pixel width by considering the post-processing process and the gradient operator. Generally, most of the edge detectors are based on the three performance conditions such as good detection, good localization and only one response to a single edge. But for the optimizations of these conditions, trade-off is required.

BERGHOLM EDGE DETECTOR

The main idea is to initially detect the edges applying a high degree of smoothing and then focus on these edges by tracking them over decreasing smoothing scale. This means the edges that have emerged from higher smoothing levels guide the detection at successive lower levels [11–16]. In order to detect the edge of images, Bergholm proposed a new method known as coarse-to-fine tracking method [6]. This method is used to detect the edge but it depends on the resolution.

	e	ne
E	True Positives	False Positives
NE	False Negatives	True Negatives

Fig. 1: *Bergholm Computational Matrix.*

In the beginning of the algorithm, an edge map E (i, j, σ0) is created by using an edge detector and setting the smoothing Parameter rσ0 to a high value. Thresholding is also used at this first stage to clear weak edge points. The edge detectors which can be employed by the edge focusing scheme should be based on smoothing the image with a Gaussian filter and using non-maximum suppression to identify the true edges. Subsequent steps of the algorithm are performed by detecting new edges at a smoothing level σ, reduced each time by a step length S.

In each edge focusing step we consider only the edge points yielded from the previous step and their neighbors.In addition, thresholding is omitted after the first stage of the edge focusing process. The choice of the step length S is of great importance. The value S= 1/2 is selected, so that the edge points do not move further than one pixel per focusing step.

The edge focusing is repeated until the smoothing parameter reaches a pre-set low value σ end. We begin with the assumption that N different edge detectors will be combined.

The first step of the algorithm comprises the correspondence test of the edge images, Ei for i = 1. . .N. This process aims to assign a correspondence value to each pixel which is then stored in a separate array V of the same size as the initial image.

The correspondence value is indicative of the frequency of identifying a pixel as a true edge by the set of detectors and ranges from 0 to N. In practice, the correspondence test can be implemented by summing the edge images Ei. Intuitively, the higher the correspondence associated with a pixel, the greater the possibility for that pixel to be a true edge. Hence, the above correspondence can be used as a reliable measure to distinguish between true and false edges. The main goal of this method is to estimate the correspondence threshold CT, (from the set CTiwhere i = 1. . . N) Which results in an edge map that gives the finest fit to all edge images Ei. The correspondence threshold evaluation is accomplished by using Receiver Operating Characteristics analysis. In our case, the classification problem includes two true classes {e, ne}, which stand for the edge and non-edge event respectively. Moreover, the classifier's output consists of the classes: predicted edge and predicted non-edge, which are denoted by {E, NE}.

Given a detector (classifier) and the set of image points, a 2× 2 matrix is constructed, called a confusion matrix. In order to calculate the points on the Receiver Operating Characteristics curve, we apply each correspondence threshold CTion the correspondence test outcome, i.e., the matrix V mentioned above. This means the pixels are classified as edges and non-edges according to whether their correspondence value exceeds a CTior not. Thus, we end up with a set of possible best edge maps Mj, for j = 1. . . N, corresponding to each CTi. Every Mj is compared to the set of the initial edge images Eiin order to calculate the True Positive (TPratej) and the False Positive (FPratej) rates associated with each of them. The diagnosis line is formed by connecting the points (P, P) and (0, 1) in the ROC plane. The value of the best CT determines how detailed the final edge image, EGT, will be. In the case of a noisy environment there should be a trade-off between an increase in information and the decrease in noise.

ROTHWELL EDGE DETECTOR

The uniqueness of this algorithm originates in the use of a dynamic threshold which varies across the image. The purpose of this thesholding is to remove the spurious edges included in the set of potential edges generated in the previous step of the algorithm. Rothwell designed an operator capable of recovering sound topological descriptions. Gaussian smoothing is applied prior to the computation of directional derivatives. The topological description of the image will be built on a base set Σ0, composed of pixels that exceed a pre-set threshold value low and have survived the non-maximal suppression suggested by Canny.

Quadratic interpolation is applied on the image points not included in Σ0, in order to include a part of them into the set of potential edge points [6]. The main edges and their location can be estimated by applying sub pixel interpolation technique after application of this stage. The distance of a pixel to the nearest edge point can be calculated using the masks (A1, A2), (B1, B2). This method gives *di* and *ni*, for *i* = 1. . . 4, where di is the distance of each pixel to the nearest edge point and ni is the strength of that edge point.

We consider the above procedure for the first mask as follows:
Mask A1:
For i = 2 : (row − 1)
For j = 2: (columns − 1)
d1 (i, j) = min (d1 (i − 1, j − 1) + 4, d1 (i − 1, j) + 3,
d1 (i − 1, j + 1) + 4, d1 (i, j − 1) + 3, d1 (i, j))
n1 (i, j) = strength of the minimum found above The rest of the masks can be applied on the image in a similar way. Given the distance di of each image point to the two nearest edges and their strength ni, it is possible to define the threshold function T (i, j). In case of outside points Σ0, linear interpolation can be applied.

The true edge identification is achieved by comparing the original image I (i, j) with the threshold function T (i, j). An edge is deemed present if it satisfies the condition:
I (i, j) > αT (i, j)
Where the parameter α (0 < α <1) serves to improve the detection, especially at points close to junctions where the edge strength weakens.

After application of this methodology edges will be created which will contain two or three pixels thick. The Rothwell edge detector deals with the Tsao-Fu thinning technique. In order to avoid preserving a weak edge at the expense of a strong one, edges should be ordered based on their strength prior to applying the thinning process. The emerged edges are thin and at accurate locations. The algorithm terminates with the retrieval of the topological description from the edge map in relation to the sub-pixel positions calculated in previous steps. We can apply

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Bergholm edge detector and Rothwell Edge detector separately for edge detection of images. But the combination of these edge detectors can be applied for edge detection of images.

EXPERIMENTAL RESULTS AND DISCUSSION

Fig. 2: *Original Image.*

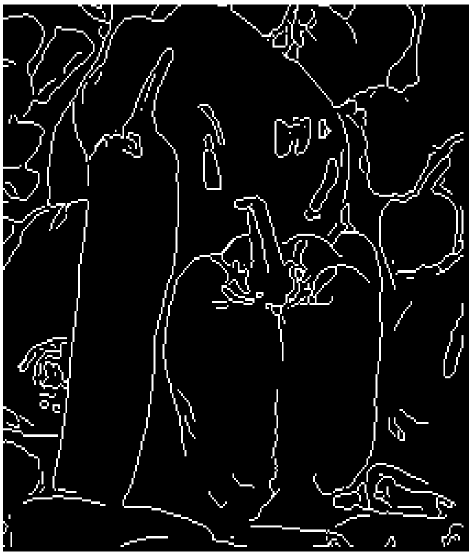

Fig. 3: *Result using Bergholm Edge Detector.*

Fig. 4: *Result using Rothwell Edge Detector.*

Fig. 5: *Result using B-R Edge Detectors.*

In this section, Figure 2 represents the original image. After applying the Bergholm edge detector the result image is represented in Figure 3. Similarly, after applying Rothwell edge detector the result image is represented in Figure 4. After applying the Bergholm edge detector on the original image, the Rothwell edge detector is applied on that intermediate image and the result image is represented in Figure 5.

CONCLUSION

In this paper, we have described a technique which is the quantitative combination of Bergholm-Rothwell (B-R) edge detectors implemented to produce an emerging edge context of images and compared with both edge detectors significantly. This technique is significant in the sense that the sample set is composed of detection results that emerge by the use of different edge detectors. From the experimental results and discussion, it is concluded that the proposed technique provides better result.

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Kalyan Kumar Jena received B. Tech. and M. Tech. degree in Computer Science & Engineering from BPUT, Odisha. He is continuing his Ph.D. in UU (IGIT, Sarang-Nodal Center), Odisha. He is working as an Assistant Professor in the dept. of CSEA, IGIT, Sarang. His publications comprise more than 15 papers in national and international journals. His research interests are image processing (edge detection) and parallel programming. He has more than 4 years of research as well as teaching experience. He acts as an editorial board member of various national & international journals and member of several national & international professional bodies. He has acted as supervisor of 37 M. Tech. students. He received Central as well as State Government awards and prizes in M. Tech., B. Tech., 10th, 7th, 5th and 3rd standards.

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