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An Efficient Edge Detection Algorithm for Facial Images in Image Mining

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Abstract

Image mining is a vital technique which is used to mine knowledge straightforwardly from image. It normally deals with the study and development of new technologies that allow easy analysis and interpretation of the images. It is an interdisciplinary endeavor that draws upon expertise in various fields like computer vision, image retrieval, matching and pattern recognition. Edge detection is very important terminology in image processing and for computer vision. Edge detection significantly reduces the amount of data and filters out ineffective information, while preserving the important structural properties in an image. It is in the forefront of image processing for object detection, it is vital to have a good understanding of edge detection algorithms. In the present study, comparative analyses of different edge detection operators in image processing are presented. It has been observed from this research the performance of Canny edge detection algorithm is much better then Mar-Hildreth algorithm for extracting edges from the facial images which are used for face detection. The performances of these edge detection algorithms are analyzed by applying performance factors and from the experimental results, it is observed that the Canny edge detection algorithm works better than Mar-Hildreth edge detection algorithms.

Keywords: Edge detection, Face recognition, Image mining, Canny, Mar-Hildreth

Introduction

Face detection is the method of discovering all possible faces at different locations with different sizes in a given image. It has numerous computer vision applications. Face detection involves many research challenges such as rotation, scale, and pose and illumination variation. Image mining deals with the extraction of image patterns from a large collection of images. The problem of image mining combines the areas of understanding, content-based image retrieval, image data mining and databases [1].

Image processing plays an important role in various real time applications ranging from medical imaging to pattern and object recognition for different purposes. Edge detection refers to the process of identifying and locating pointed discontinuities in an image. The discontinuities are sudden changes in pixel intensity which characterize boundaries of objects in a scene. Edge detection is a fundamental tool in image processing and computer vision, particularly in the regions of feature detection and feature extraction, which intend at recognizing points in a digital image at which the image brightness changes sharply or, more properly has discontinuities.

Three fundamental steps involved in edge detection are:

1. Image smoothing for noise reduction: this step involve filtering the image for improving the performance of edge detector.
2. Detection: This step involves extracting all edge points that are potential candidates to become edge point.
3. Edge localization: This step involves selecting from the candidate edge points only the points that are true members of set of points comprising an edge.

The rest of the paper is organized as follows. Section 2 describes the literature survey of various edge detection algorithms and its comparison used in image processing. Section 3 discusses about the edge detection algorithms. Experimental results are analyzed in Section 4 and conclusion is given in Section 5.

Related Works

Wenshuo gao et Al., [2] proposed a technique which combines Sobel edge detection operator and soft-threshold wavelet de-noising to do edge detection on images which include White Gaussian noises. The frequently used methods which merge mean de-noising

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and Sobel operator or median filtering and Sobel operator can not eliminate salt and pepper noise very well. In this paper, firstly soft-threshold wavelet was used to remove noise, and then Sobel edge detection operator is used to detect edges in the image. This method is mainly used on the images which consist of White Gaussian noises. From the pictures obtained by the experiment, it shows that compared to the traditional edge detection methods, the technique proposed in this paper has a more understandable effect on edge detection.

Deepak Ghimire et al., [3] proposed a method to detect human faces in color images. Several existing systems use a window-based classifier that searches the entire image for the presence of the human face and such systems suffers from pose variation, scale variation, illumination changes, etc. Here, they proposed a lighting insensitive face detection method based upon the edge and skin tone information of the input color image. Firstly, image enrichment is performed, particularly if the image is acquired from an unconstrained light condition. Next, skin segmentation in RGB and YCbCr space is conducted. The result of skin segmentation is polished using the skin tone percentage index method. The edges of the input image are joined with the skin tone image to separate all non face regions from candidate faces. Candidate authentication using primitive shape features of the face is applied to decide which of the candidate regions corresponds to a face. The benefit of the proposed method is that it can detect faces that are of distinct sizes, in distinct poses, and that are making different expressions under unconstrained illumination conditions.

Pinaki Pratim Acharjya et al., [4] author made an attempt to review the edge detection techniques which are based on discontinuity intensity levels. The relative performance of different edge detection techniques is carried out with two images by using MATLAB software. It have been examined that that the Canny edge detector produces higher accuracy in detection of object edges with higher entropy, PSNR, MSE and execution time compared with Sobel, Roberts, Prewitt, Zero crossing and LOG.

M Sudarshan et al., [5] proposed an optimized edge detection algorithm suitable for the face recognition task. The main idea of the proposed method is to boost the significant edges and then apply successive thinning algorithms. The two advantages of this method over other gradient based systems is its ability to find missing and broken edges more accurately and suppress the less significant edges.

Methodology

Face detection is the first step in any automated system that solves problems such as face tracking, face recognition, and facial expression recognition. Detection rate and the number of false positives are important factors in evaluating face detection systems. The core objective of this research work is to find out the best edge detection algorithm among Canny, Mar-Hildreth. The methodology of the research work is as follows:

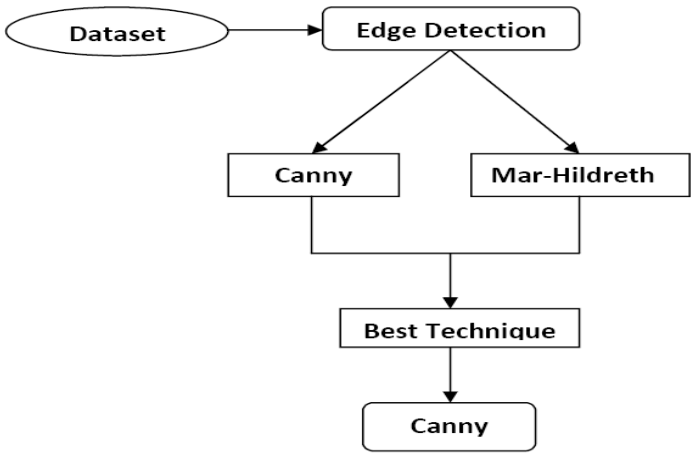

Fig 1: System Architecture of Edge detection

A.DATA SET

To compare the edge detection methods, different size of facial images are collected and the data set is created. This dataset consists of 23 different faces. Confusion matrix is used to analyze the performance of the edge detection method.

B. EDGE DETECTION

Edges are boundaries between different qualities. Edge also can be described as discontinuities in image intensity from one pixel to another. The edges for an image are always the significant characteristics that offer an indication for a higher frequency. Finding of edges for an image may help for image segmentation, data compression, and also help for well equivalent match, such as image reconstruction and so on.

Canny Edge detection algorithm

The Canny edge detector is widely considered to be the standard edge detection method in the diligence. Canny saw the edge detection problem as a signal processing optimization problem, so he build up an objective function to be optimized. The resolution to this problem was a rather complex exponential function, but Canny found a number of ways to approximate and optimize the edge-searching problem. The steps in the Canny edge detector are as follows:

1. Smooth the image with a two dimensional Gaussian. Computation of a two dimensional Gaussian is costly in

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most cases, so it is estimated by two one dimensional Gaussians, one in the x direction and the other in the y direction.
2. Take the gradient of the image. This proves changes in intensity, which signifies the presence of edges. This really gives two outcomes, the gradient in the x direction and the gradient in the y direction.
3. Non-maximal suppression- Edges will occur at points the where the gradient is at a maximum. Therefore, all points not at a maximum should be suppressed. To facilitate this, the magnitude and direction of the gradient is computed at each pixel. Then for every pixel verify if the magnitude of the gradient is greater at one pixel's distance away in either the positive or the negative direction perpendicular to the gradient. If the pixel is not larger than both, suppress it.

The general algorithm for the Canny edge detector is as follows:

The algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.

2. Finding gradients: The edges should be marked where the gradients of the image has largE magnitudes.

3. Non-maximum suppression: Only local maxima should marked as edges.

4. Double thresholding: Potential edges are determined by thresholding.

5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

Marr-hildreth Edge detection algorithm

Marr–Hildreth algorithm is a method of detecting edges in digital images that is continuous curves where there are strong and rapid variations in image brightness. The Marr-Hildreth edge detector is a gradient based operator which uses the Laplacian to take the second derivative of an image. The idea is that if there is a step difference in the intensity of the image, it will be represented by in the second derivative by a zero crossing. The Marr–Hildreth edge detection method is simple and operates by convolving the image with the Laplacian of the Gaussian function, or, as a quick approximation by Difference of Gaussians. Then, zero crossings are identified in the filtered result to obtain the edges.

The Marr–Hildreth operator, however, suffers from two main drawbacks. It produces responses that do not correspond to edges, so-called "false edges", and the localization error may be severe at curved edges. Today, there are much improved edge detection methods, such as the Canny edge detector which based on search for limited directional maxima in the gradient magnitude, or the differential approach that based on search for zero crossings of the differential expression that corresponds to the second-order derivative in the gradient direction (Both of these operations preceded by a Gaussian smoothing step.)

The general algorithm for the Marr-Hildreth edge detector is as follows:

1. Smooth the image using a Gaussian. This smoothing reduces the amount of error found due to noise.
2. Apply a two dimensional Laplacian to the image.
3. Loop through every pixel in the Laplacian of the smoothed image and look for sign changes. If there is a sign change and the slope across this sign change is greater than several thresholds, mark this pixel as an edge. Alternatively, you can run these changes in slope through a hysteresis (described in the Canny edge detector) rather than using a simple threshold.

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Experimental Results

A. Accuracy measure

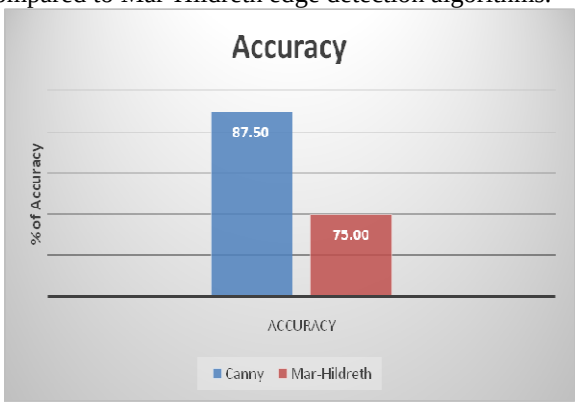
The following table shows the accuracy measure of various edge detection algorithms. A confusion matrix is a specific table layout that allows visualization of the performance of an algorithm. Each column of the matrix represents the instances in a predicted class, while each row signifies the instances in an actual class. A table of confusion, is a table with two rows and two columns that reports the number of false positives, false negatives, true positives, and true negatives.

From the analysis, accuracy measures of edge detection algorithms from the Table 1, Canny edge detection algorithm performs well when compared to Mar-Hildreth accuracy measures namely confusion matrix.

Table 1: Confusion matrix

Algorithms	Confusion matrix	
	Accuracy (in %)	Matrix
Canny	87.5%	6 1 0 1
Mar-hildreth	75%	3 0 2 2

From the graph, it is observed that Canny edge detection algorithm attains high percentage of accuracy when compared to Mar-Hildreth edge detection algorithms.



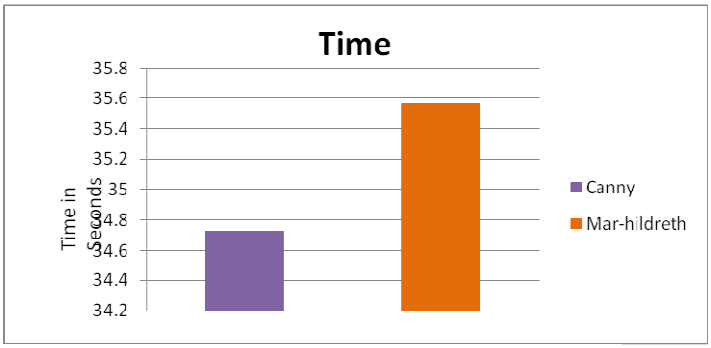
Graph 1: Accuracy measures

From the analysis, accuracy measures of edge detection algorithms from the Table 2, Canny edge detection algorithm outperforms well when compared to Mar-Hildreth.

Table 2: Execution time of Edge detection algorithm

Algorithms	Time
Canny	34.7
Mar-hildreth	35.5

From the graph, it is observed that Sobel edge detection detects edge in fewer seconds than Robert and Prewitt.



Graph 2: Execution time for edge detection algorithm

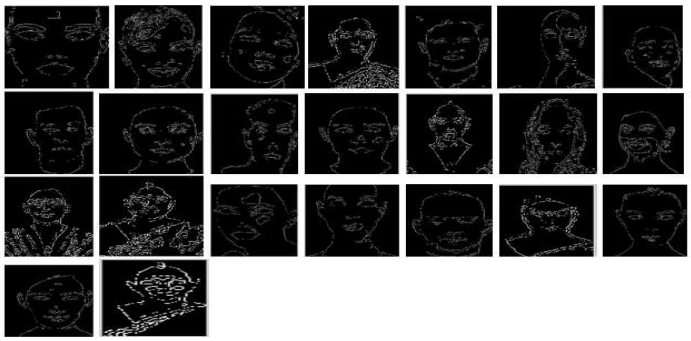


Fig 2: Mar-Hildreth edge detection

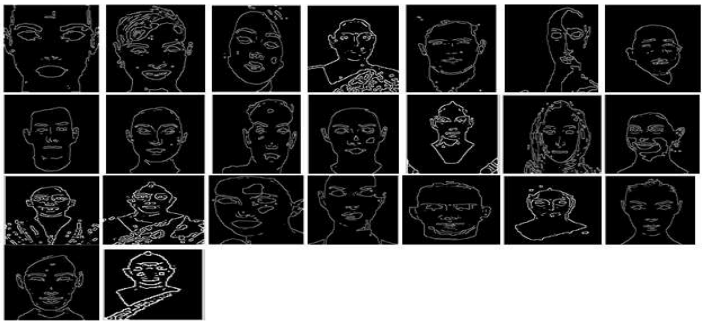


Fig 3: Canny edge detection

Conclusion

Edge detection method has become an important tool in image processing. Since edge detection is the initial step in object boundary extraction and object recognition, it is essential to know the differences between different edge detection operators. In this research work, edge detection algorithms namely Canny and Mar-Hildreth are used to extract the outline shape which detects the human facial images from the given data set. From the experimental results shown, it is clear that the Canny edge detection algorithm performs well when compared to Mar-Hildreth edge detection algorithms.

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