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A Study of Edge Detection Methods

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Abstract
Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. Good edges are necessary for image segmentation but in general quality of edge detection is highly dependent on intensity of image, the presence of objects of similar intensities, density of edges in the scene, and noise. Since different edge detectors work better under different conditions, comparative evaluation of different methods of edge detection makes it easy to decide which edge detection method is appropriate for image segmentation. Edge detection is approach used for segmenting images based on local changes in intensity. Choice of an edge detection method is based on characterisitics of problem being studied. This paper present an overview of different edge detection methods .

***Index terms* – Image, Image segmentation, Edge , Edge detection, Edge detectors**

1. Introduction

Interpretation of image contains different Information of scene, such as objects, shape, size, colour, and orientation, but discrimination of the objects from their background is the first essential task that should be performed before any interpretation. Edge is basic feature of image. Edge detection is a process that detects the presence and location of edges constituted by sharp changes in intensity of an image. The edge representation of an image drastically reduces the amount of data to be processed, yet it retains important information about the shapes of objects in the scene. An important property of the edge detection method is its ability to extract the accurate edge line with good orientation, The performance of an edge detection method is always judged subjectively and individually dependent to its application.Image segmentation depends only on the problem to be studied and edge detection method depends on the best criteria selection for image to be processed.

Related work

(i) Edge Detection Methods

Edge is part of an image that contains significant variation. The edges provide important visual information image intensity is often proportional to scene radiance, physical edges are represented by changes in the intensity function of an image .The most common edge types are steps, lines and junctions. Edge detection process detects outlines of an object and boundaries between objects and the background in the image. Sobel edge detector is a simple and effective approach, but sensitive to noise, it indicates that one of the possible ways to find the ―ideal operator size is to look for the largest one that does not originate a significant decrease on the output value, when compared with the output value of the immediately smaller operator.

(ii) Classical Methods

Classical edge detectors have no smoothing filter, based on a discrete differential operator. The Sobel operator is the most known among the classical methods. The Sobel edge detector applies 2D spatial gradient convolution operation on an image. Popular works in this category include the algorithms developed by Sobel, Prewitt, Kirsch, Robinson, and Frei-Chen.

(iii) Gaussian Based Methods

Gaussian-based edge detectors are developed based on some physiological observations and important properties of the Gaussian function that enable to perform edge analysis in the scale space.
Marr [9] proposed an edge detector based on Gaussian filter, by using Laplacian of Gaussian (LOG) function as filter. LOG is an orientation-independent filter that breaks down at corners, curves, and at locations where image intensity function varies in a nonlinear manner along an edge. There are advantages in its output.
Yuille [10] proved that with the Laplacian, the Gaussian function is the only filter in a wide category that does not create zero-crossings as the scale increases.
Canny [3] proposed a scheme for combining the outputs from different scales. Canny‗s edge detection causes the algorithm to be slightly more sensitive to weak edges, but more susceptible to

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spurious and unstable boundaries wherever there is an insignificant change in intensity [2].

(iv)Multi-Resolution Methods

Multi-resolution methods based on repeating edge detection for several scales of the Gaussian filter to achieve a quality performance.

Schunck [11] proposed an algorithm for the detection of step edges using Gaussian filters at multiple scales. But loses a lot of important details which may exist at smaller scales [2].

Witkin [12] proposed the study of edge detection as a function of scale, and led to algorithms that combine edges for better edge detection.

Bergholm [13] proposed an algorithm which uses the Gaussian filter and combines edge information moving from a coarse-to-fine scale, called edge focusing, To avoid blurring process is to start with edges detected at the coarse scale and gradually track or focus these edges back to their original locations in the fine scale [2].

Lacroix [14] proposed scheme to avoid the problem of splitting edges is by tracking edges from a fine-to-coarse resolution. Only validated edges are then tracked through the scales. It avoids the problem of splitting edges, but introduces the problem of localization error as it is the coarsest resolution that is used to determine the location of the edges.

Williams and Shah [15] proposed a scheme to find edge contours using multiple scales. It specifies the number of scales to be used and the relationship between these scales, but not the best way to choose the value of σ and under what conditions [2].

Goshtasby [16] proposes an algorithm that works on a modified scale-space representation of an image. The major problem is the need for a considerable amount memory to store the three-dimensional (3D) edge images [2].

Jeong [17] proposed a scheme that automatically determines the optimal scales for each pixel before detecting the final edge map. It does result in reduced performance when it comes to detecting straight lines in vertical or horizontal directions and also has the disadvantage of low-speed performance [2].

Deng [18] proposed an adaptive Gaussian filtering algorithm for edge detection. The major drawback is that it assumes the noise is Gaussian with known variance. In practical situations, however, the noise variance has to be estimated, but it is very computationally intensive [2].

Bennamoun [19] determined the optimal scale and threshold, of the hybrid detector, by deriving a cost function which maximizes the probability of detecting an edge for a signal and simultaneously minimizes the probability of detecting an edge in noise [2].

(v) Nonlinear Methods

These methods includes edge-detectors that leave the linear territory in search of better performance. Nonlinear methods based on the Gaussian filter and images convolved with Gaussian filter for a smoothing purpose.

Perona [20] proposed a scale space representation of an image based on anisotropic diffusion. This is achieved by making the diffusion coefficient in the heat equation a function of space and scale.

(vi) Wavelet Based Methods

Wavelet transform (WT) is defined as the sum over the entire of rows and columns of the image intensity function multiplied by scaled and shifted versions of the mother wavelet function.

Heric [4] presented an edge detection algorithm using Haar wavelet transform. They chose Haar wavelet as the mother wavelet function

Shih and Tseng [5] combined a gradient-based edge detection and a wavelet based multi-scale edge tracking to extract edges.

(vii)Statistical Methods

Konishi [6] formulated the edge detection as a statistical inference. This statistical edge detection is data driven. Edge detection is formulated as a discrimination task specified by a likelihood ratio test on the filter responses.

Bezdek [7] described edge detection as a composition of four steps: conditioning, feature extraction, blending, and scaling. They found that understanding the geometry of the feature extraction and blending functions is the key to using models based on computational learning algorithms such as neural networks and fuzzy systems for edge detection.

Santis [8] proposed a statistical edge detection algorithm using a linear stochastic signal model derived from a physical image description. The advantage of this method is that it exploits the estimated local signal characteristics and does not require any overall thresholding procedure.

(viii) Machine Learning Based Methods

Lu [23] proposed a fuzzy neural network system for edge detection and enhancement by recovering missing edges and eliminating false edges caused by noise. Based on constraint satisfaction and the

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competitive mechanism, interconnections among neurons were determined in the Hopfield neural network.

Zheng [24] presented an edge detection algorithm that employs estimations of image intensity derivatives produced by least square support vector machine (LS-SVM). The performance is near to the Canny method, but faster computation.

(ix) Line edge detectors

Most of line edge detectors are limited to thinning algorithms, and designed for binary images and a few for grey images.

Giraudon[21] proposed an algorithm for detecting a line at a negative local maximum of the second derivative of the image, rather than a zero-crossing of the first derivative.

Koundinya [22] proposed an algorithm based on combinatorial search. This algorithm is used to locate lines that maximize an ad-hoc confidence measure. The confidence measure of a candidate pixel is proportional to the number of pixels in its vicinity having a different grey intensity than the candidate pixel.

(x) Coloured Edges' Methods

Koschan [25] proposed a scheme based on review of techniques for the detection and classification of edges in colour images. The techniques used for this can be subdivided on the basis of their principle procedures into two classes: monochromatic-based techniques and vector-valued techniques.

(xi)Contextual Methods

Yu [26] suggested an adaptive edge detection approach based on context analysis.

Kang [27] proposed an edge detection algorithm based on maximizing an object function.

Chao [28] presented an edge detection algorithm using Hopfield neural network.

Methods of Evaluation

Evaluation of an edge detector is based on criteria or references that describe the characteristics of the edges.

Subjective evaluation, is performed using human as subject, cannot be used to measure the performance of detectors.

Objective evaluation is performed using certain models of edges that should be detected, used to measure the performance of detectors. Performance measure is a combination of three factors: non-detection of true edges, detection of false edges, and localization error. Subjective and objective evaluations can be used together to evaluate edge detectors. This combination inspired by psychological methods, is based on statistical analysis.It is suggested that the evaluation methods should take into account model of the edges, specification of the detector and characteristics of the image.

Conclusion

This paper reviews wide range of methods of edge detection for image segmentation. Different edge detection methods can be implemented as per the need of segmentation of image . In future we plan to design a novel method of edge detection and object recognition.

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