Advances in Optics and Computer Vision

Journal homepage: http://www.aocv.ir

AOCV

Image edge extraction based on weighted fusion of gray scale, color and texture using PSO

Moeen Kamali

Department of Computer, South Tehran Branch, Islamic Azad University, Tehran, Iran
Corresponding Author, Email: s.moeen.kamali@gmail.com

ARTICLE INFO

Article history:
- *Received: 2017-10-3*
- *Revised: 2017-12-16*
- *Accepted: 2017-12-28*
- *Available online: 2018-1-1*

Keywords:
edge detection
color image processing
texture
image fusion
PSO

ABSTRACT

The extraction of corner points is considered as one of the most important and fundamental stages of image processing. In addition to machine vision, image enhancement and image compression, it plays an essential role. Because the focus is in the first phase of image engineering, it will affect the subsequent stages of image analysis and picture comprehension. Therefore, the extraction of corner points, as the first action taken before classifying and identifying in the field of image processing, is one of the key operations in the field of image engineering. In this paper, it is attempted to identify corners in images using polynomials. experimental results and evaluations show the effectiveness of this method.

1. Introduction

Image edge detection is an important field that has been studied a lot. Edge detection can be achieved by different methods that each of them has its own advantages and disadvantages. Most of methods are in spatial and frequency domains. In spatial domain most of the time, the methods are based on gradients of gray level. In classic edge detection, Laplacian and Sobel methods can be named. Sobel uses first order and Laplacian uses second order derivative. Most of the time gradient methods end up with a filtering window that correlates with the image. One of most important problem of methods based on gray level gradient is when there is no equal light intensity in the image and the method doesn't find correct edges. One other important problem is cases that two objects beside each other have same surface material. In these cases, these methods fail to detect the edge. Most important method in spatial domain is canny that right now is an standard for edge detection [1]. In addition, there are frequency domain techniques that are based on Fourier transform. In these methods, edges are considered as high frequencies and edge detection is done by applying a high pass filter on the Fourier transform of the image. Frequency domain methods also have some disadvantages like spatial domain techniques.

Human vision can detect light intensity and color difference of objects. It has been a long time that imaging devices can capture color feature of images. It has been proven that all colors that are observable by human are some mixture of three main colors including red, green and blue. In computer systems, colored images are saved in these in three channels. There are some other digital systems like HSI and CMYK. All edge detection techniques that use color feature use methods in gray scale images with some fusion techniques. Most color edge detection methods use one of these systems. In RGB system, Gradient is applied to image in three channels separately and after that, a fusion method is applied. In HSI system, most of the time, gradient is applied in hue channel and for more accuracy gradient of intensity is also calculated and after that fusion is used to achieve the final image.

Another Important image feature that can be detected by human vision is texture. Texture is a pattern that is repeated one after another in an image or any other types of signal. Many techniques use texture feature to extract edges. There are some methods like range filters that use statistical information to find textures in an image. There is another innovative method named 'law'. This method presents five different one-dimensional filters that multiply with each other to make two-dimensional filters. These filters convolve with the image to make edge image.

2. Related Works

There are a lot of works and papers in field of image edge detection. Some important works are mentioned in this part. Claudia Gonzalez et al. introduced a paper named optimization of interval type-2 fuzzy systems for image edge detection [1]. This paper presents the optimization of a fuzzy edge detector based on the traditional Sobel technique combined with interval type-2 fuzzy logic. The goal of using interval type-2 fuzzy logic in edge detection methods is to provide them with the ability to handle uncertainty in processing real world images. However, the optimal design of fuzzy systems is a difficult task and for this reason the use of meta-heuristic optimization techniques is also considered in this paper. For the optimization of the fuzzy inference systems, the Cuckoo Search (CS) and Genetic Algorithms (GAs) are applied. Hanhoon Park et al. introduced a paper in 2011 named 'adaptive edge detection for robust model based camera tracking' [2]. Krit Somkantha et al. published a paper in 2011 named 'boundary detection in medical images using edge following algorithm based on intensity gradient and texture gradient features' [3]. Patricia Melin et al. worked on paper 'named edge detection method for image processing based on generalized type-2 fuzzy logic' [4].This paper presents an edge-detection method that is based on the morphological gradient technique and generalized type-2 fuzzy logic. Ruijin Jin et al. introduced a work named 'improve multiscale edge detection method for polarimetric sar images' [5]. Olivia Mendoza et al. worked on 'interval type-2 fuzzy logic for edge detection in digital images' [6]. Fabio Baselice et al. introduced a method named 'edge detection using real and imaginary decomposition of sar data' [7]. Very basic work been introduced in 1986 by researcher named canny. The paper is named 'a computational approach in Edge detection [8]. Another work in edge detection is 'a new edge detection algorithm for image corrupted by white Gaussian noise' by Qinghang He et al [9]. A method about color edge detection named 'color edge detection based on fusion of hue component and principal component analysis' by Tao lei et al. a different edge detection method used neural network as a supervised learning method to find edges. This work is done in a paper named 'research on the improvement of image edge detection algorithm based on artificial neural network' [10].this work is done by Jinan GU et al. another work is 'edge detection by color invariants' by Jun Chu et al [11]. Another research about image processing is done in 2013 named 'unsupervised edge detection and noise detection from single image' by Kuna Ray [12]. Another important work is in field of color edge detection is 'color edge detection based on data fusion technology in presence of Gaussian noise' by Yang Ou et al [13]. Another work on fusion of edge image is 'feature fusion method for edge detection of color images' by Ma Yu et al [14]. One other good work on image edge by using fuzzy logic is 'a new fuzzy approach for edge detection' [15]. An important research on edge detection is a work by Tian Qie et al in 2011 named 'an auto adaptive edge detection algorithm for flame and fire image processing' [16]. One other important work about edge detection problem is 'a new measure intuitionistic fuzzy set theory and application to edge detection' by Tamalika Chaira et al [17]. Another important method used fuzzy logic in enhancement step of edge detection. This work is 'the fast multilevel fuzzy edge detection of blurry images' by Jumbo Wu et al [18]. Another work is about 'edge detection in noisy images by neuro fuzzy processing' by Emin Yuksel [19]. Different works is using of ant colony optimization in edge detection named 'an ant inspired algorithm for detection of image edge features' by s. Ali Etemad [20]. Another work is 'canny edge detection enhancement by general auto regression model and bi-dimensional maximum conditional entropy' by Hao Fei et al [21]

3. Weighted fusion of grayscale, color and texture using PSO

In this part, the synthetic method about edge detection is explained. The base idea of this research is about using three important aspects or features of the image, including grayscale, color and texture. Human vision can use all features to detect objects in the image. Generally, the method introduced in this paper is implemented in seven steps.

1) *Receive the image and make a grayscale version of it*
2) *Use a Gaussian filter to soften and reduce image noise*
3) *Use canny edge detection method as grayscale method*
4) *Implementing the color edge detection method. The method implements gradient in three different channels and uses averaging method to get final color image.*
5) *Implementing texture edge detection using law filters and choosing appropriate edge image*
6) *Implementing image fusion using weighted averaging*
7) *Threshold and make final edge output*

In this research as input, both colored and grayscale images are needed. Gray image can be obtained from colored image. In next step, image noise should be reduced and get soften using Gaussian filter. This helps to find true edges and makes the probability of finding false edges less. Next step is to detect edges by the gray level method using canny. This method first finds the gradient of the image. Basic operator that is used in canny algorithm is Sobel but other operators can be used too. After that, canny uses non-maximum suppression to make the edges as thin as possible. The most important point is, not to threshold any output result of edge detection methods. In the next level, color edge detection is implemented. It is a simple but very accurate method in edge detection. First, Kuwahara filter is implemented in the color image. This method can be used in different ways and different systems and this algorithm is performed on grayscale images, but a modified version of it can be used in HSI system. Because of some ambiguity

problem, this method couldn't be done in the RGB system. It has claimed that this method reduces the effect of noise without removing any edge in the image. After that in every red, green and blue channel of image Sobel is implemented. After that, a weighted average is used to fuse results using the below equation.

$$Synthetic\ image = 0.3R + 0.59G + 0.11B \quad (1)$$

The coefficients of this equation are inspired from a concept named perceived luminance. This is one of the accepted models of perceived luminance. It can be understood from the formula that the human eye is more sensitive to green color and least sensitive to blue color. For texture edge detection, law filters are used. The filters are as follows:

$$Level\ [+1\ \ +4\ \ 6\ \ +4\ \ +1] \quad (2)$$
$$Edge\ \ [-1\ \ -2\ \ 0\ \ +2\ \ +1] \quad (3)$$
$$Spot\ \ [-1\ \ \ 0\ \ 2\ \ 0\ \ -1] \quad (4)$$
$$Wave\ [\ -1\ \ +2\ \ 0\ \ -2\ \ +1] \quad (5)$$
$$Ripple\ [+1\ \ -4\ \ 6\ \ -4\ \ +1] \quad (6)$$

These filters make twenty-five of two-dimensional filters by applying product operator to them. By convolving these filters with image, twenty-five edge images can be obtained. The best edge image should be selected and this work can be done by different methods. The method has been used, will be explained in the next part. Now weighted averaging is used to fuse result of edge images. The equation is:

$$AverageImage = (a \times ColorEdge + b \times CannyEdge + c \times TextureEdge)/(a + b + c) \quad (7)$$

As shown in the equation, there are tree a, b and c coefficient or factors that need to get values. In the first step, simply averaging is used just by setting all factors to one. Experiments show good and satisfying results. However, it is assumed that better results can be achieved by finding right factors. It is assumed that there is no info from edge results. Best choice to find best factors is Particle Swarm Optimization. PSO is a computational intelligence algorithm that is made to work on un-modeled data and works well with continuous numbers. As initiation, this algorithm spreads particles in the problem space and after that in a loop for every particle, resultant velocity is calculated and its summation of position of best particle, and best personal velocity of particle in previous steps. After that particle should move to that resultant velocity. Equation of Velocity and movement has shown below:

$$V_i(t) = w * V_i(t-1) + c_1 * rand_1 * \left(P_{i.best} - X_i(t-1)\right) + c_2 * rand_2 * \left(P_{g.best} - X_i(t-1)\right) \quad (8)$$

$$X_i = X_i(t-1) + V_i(t) \quad (9)$$

To use PSO, a fitness function is required. This function is defined by dividing the count of 'and' operator with the ground truth image to count of 'xor' operator with ground truth image. Equation of fitness function is defined as follows:

$$fitness = \frac{count\ of\ and(image, groundTruth)}{count\ of\ xor(image, groundTruth)} \quad (10)$$

Ground Truth images are edge images that the human expert detects edges. To train the algorithm ground truth of the image is needed to find best coefficients. Meaning of the above equation is to maximize the count of matched edge pixels with ground truth and minimize mismatch with ground truth image. Ground Truth images are used to obtain best factors for weighted averaging but in real there is no ground truth image to train factors. The idea is that factors that are obtained are mostly dependent on the edge detection method instead of being dependent on image. In the image database two-hundred train images being used to train the algorithm. So, each of them has their own factors. We use each of them for all images and the one that has best mean result for all images is chosen. Now they will be called, chosen factors. Now chosen factors should be tested on test images. Results are shown in the next section. thresholding is not a parameter of our problem and is not discussed in this research and a known method named Otsu is used for all compared methods. Otsu is fisher method that is implemented on image histogram. The goal of this method is to maximize variance between classes and minimize inner class variance.

4. Experimental Results

To test the research, a database is needed. Database chosen for this research is ground Truth database that made by university of Berkeley.1 This database consists two groups of images and their ground Truth. There are two groups of train and test images and each of them consists of two hundred images.

System configuration for testing this research is: Processor: intel Core i3-3217U CPU @ 1.80 GHz, Installed memory (RAM): 8/00 GB, System Type: Windows 10 64-bit Operating System. Time consumption of methods distinguished in table below:

Table 1 time consumption of methods

Method Name	*Time Consumption(seconds)*
Chosen Factors	*6.12*
Canny	*5.656*
Color Edge Detection	*0.643*
Texture Edge Detection	*0.438*
Sobel	*0.105*
Laplacian	*0.084*
Prewitte	*0.142*
Roberts	*0.192*

To test the method both statistical and intuitive ways are used. Based on the fitness function introduced in last

[1] *https://www2.eecs.berkeley.edu /Research/Projects/CS/vision/grouping/resources.html*

section, method introduced is compared with result of classic and fused methods. Table of distinguishing methods is as follows. First of all, 'and' operator of methods output with Ground Truth are distinguished. Then 'xor' operator and 'and/xor' are checked:

Table 2 AND operator of result with ground truth

Method name	And operator
Chosen Factors	752.125
Canny	336.468
Color Edge Detection	571.6
Texture Edge Detection	355.455
Sobel	765.36
Laplacian	913.225
Prewitte	573.39
Roberts	526.7

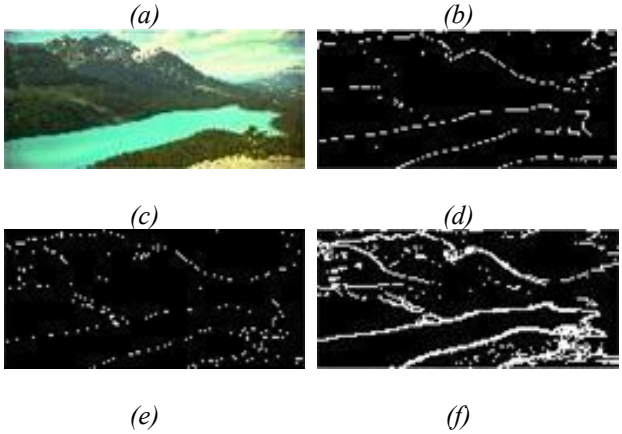
Table 3 XOR operator of result with ground truth

Method name	Xor operator
Chosen factors	14962.755
Canny	8418.7
Color edge detection	13495.965
Texture Edge Detection	24827.295
Sobel	26062.95
Laplacian	35919.745
Prewitte	15739.895
Roberts	16306.23

Table 4 AND/XOR operator of result with ground truth

Method name	And/Xor operator
Chosen factors	0.050266
Canny	0.047913
Color edge detection	0.042467
Texture Edge Detection	0.014317
Sobel	0.029366
Laplacian	0.025424
Prewitte	0.03641
Roberts	0.032301

As shown in the tables, experimenting of chosen factors shows better and satisfying results and can be used as an enhancing method for edge detection. The goal of the method based on a fitness function defined in the previous section is to maximize the ratio of matching pixels to un-matching pixels. As in table number (4) is shown the goal is achieved. In the next part, methods are distinguished intuitively.



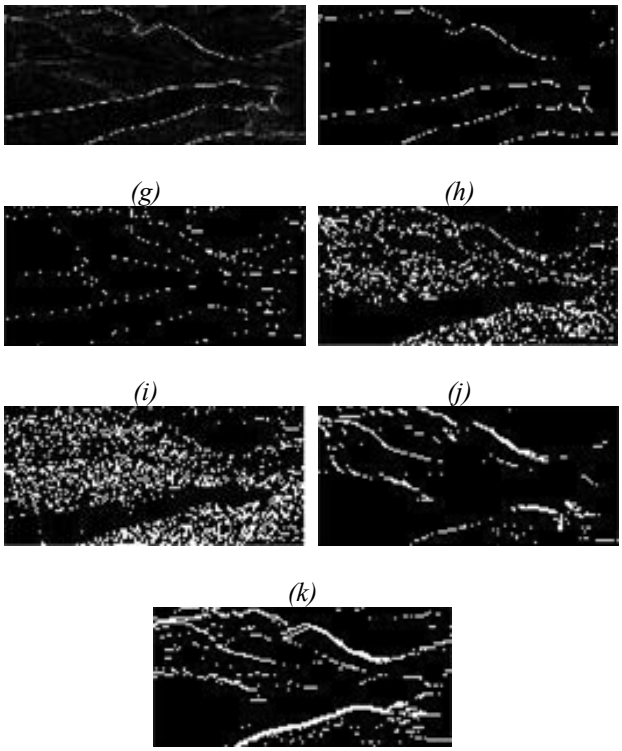


Figure1. output images a) input image b) color edge c) canny edge d) texture edge e) mean image f) chosen factors image g) ground Truth h) sobel edge i) laplacian edge j) prewitte edge k) Roberts edge

5. Conclusion

A synthetic method introduced in this paper and results shows better quality than previous classical methods. To check better results, other methods of edge detection can be checked to see the effect on the result. One important low point of this method is that the method has higher calculation complexity than classical methods.

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