A Novel technique for Detection of Edges in Images

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Abstract: **The areas of this work are in digital image process and telecommunication engineering, which are very wide fields. This work is intended to implement the edge detection for digital image, so that it may be carried out to a big contour identification of an image. Edge detection is one of the most fundamental operations in image processing and computer vision. It is defined as the process of locating the boundaries of objects or textures depicted in an image. Knowing the positions of these boundaries is critical in the process of image enhancement, recognition, restoration and compression. The edges of image are considered to be most important image attributes that provide valuable information for human image perception. The data of edge detection is very large, so the speed of image processing is a difficult problem. The conventional edge detection algorithms are highly sensitive to noise, time consuming & computationally complex. A high performance edge detection algorithm is proposed based on the segmentation properties such as similarity & discontinuity. In the similarity method, an image is divided into sub-parts which are similar to a set of established criteria. The method for discontinuity is to split up the image on the basis of sudden variations in intensity. In some of the traditional edge detectors, we may get thick edges or thin edges based on the calculation. Using Canny edge detector, we can very well get the thin boundaries of the object but the computational procedure is very difficult. In the proposed algorithm, we are calculating the similarity measure by using the formula S=P/No. If the ratio of S<=1 we get the thin edges or otherwise we get very thick edges. Experimental results indicate that the proposed edge detection algorithm achieves better performance than the conventional methods. Moreover, it is time efficient method & has a low computational complexity.**
Keywords: Edge, Edge Detection, Image Processing.

I. INTRODUCTION

Edge detection is a very important area in the field of computer vision. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. They can show where shadows fall in an image or any other distinct change in the intensity of an image. Edge detection is a fundamental of low-level image processing and good edges are necessary for higher level processing [1].

The problem is that in general edge detectors behave very poorly. While their behavior may fall within tolerances in specific situations, in general edge detectors have difficulty adapting to different situations. The quality of edge detection is highly dependent on lighting conditions, the presence of objects of similar intensities, density of edges in the scene, and noise. Since different edge detectors work better under different conditions, it would be ideal to have an algorithm that makes use of multiple edge detectors, applying each one when the scene conditions are most ideal for its method of detection. In order to create this system, you must first know which edge detectors perform better under which conditions [1].

In digital image, the so-called edge is a collection of the pixels whose gray value has a step or roof change, and it also refers to the part where the brightness of the image local area changes significantly. The gray profile in this region can generally be seen as a step. That is, in a small buffer area, a gray value rapidly changes to another whose gray value is largely different with it. Edge widely exists between objects and backgrounds, objects and objects, primitives and primitives. The edge of an object is reflected in the discontinuity of the gray. Therefore, the general method of edge detection is to study the changes of a single image pixel in a gray area, use the variation of the edge neighboring 1st order or 2nd order to detect the edge. This method is used to refer as local operator edge detection method.

Edge detection is mainly the measurement, detection and location of the changes in image gray. Image edge is the most basic features of the image. When we observe the objects, the clearest part we see firstly is edge and line. According to the composition of the edge and line, we can know the object structure. Therefore, edge extraction is an important technique in graphics processing and feature extraction [2].

The basic idea of edge detection is as follows: First, use edge enhancement operator to highlight the local edge of the image. Then, define the pixel "edge strength" and set the threshold to extract the edge point set. However, because of the noise and the blurring image, the edge detected may not be continuous. So, edge detection includes two contents. First is using edge operator to extract the edge point set. Second is removing some of the edge points from the edge point set, filling it with some another and linking the obtained edge point set into lines [3].

The four steps of edge detection are:

1. Smoothing: suppress as much noise as possible, without destroying the true edges.
2. Enhancement: apply a filter to enhance the quality of the edges in the image (sharpening).
3. Detection: determine which edge pixels should be discarded as noise and which should be retained (usually, thresholding provides the criterion used for detection).
4. Localization: determine the exact location of an edge (sub-pixel resolution might be required for some applications, that is, estimate the location of an edge to better than the spacing between

pixels). Edge thinning and linking are usually required in this step [4].

Paper is organized as follows. Section II describes the edge detection techniques. After that, the Soble edge detection is discussed in Section III. Section IV presents simulation results showing results of images tested and the results discussion. Finally, Section V presents conclusion.

II. LITERATURE SURVEY

Chinu, Amit Chhabra [1], "A Hybrid Approach for Color based Image Edge Detection", IEEE International Conference on Advances in Computing, Communications & Informatics (ICACCI), Pp. 2443 – 2448, New Delhi, 2014.

In this paper a sequential hybrid approach is proposed to overcome all the limitations of existing edge detection algorithms. The operations performed by image edge detection algorithm can be computationally expensive and takes lots of execution time for processing the data. This research work also improves hybrid color based image edge detection technique by using the data parallelism approach. The comparison among sequential and parallel edge detection will be drawn based upon different parallel metrics. The experimental results have shown that parallel strategy achieves a performance gain of 68% as compared to sequential approach.

Shuai Wang, Shuifa Sun et-al [2], "Image Edge Detection Based on Rotating Kernel Transformation", 7th IEEE International Congress on Image & Signal Processing, Pp. 397 – 402, Dalian, 2014.

An edge detection algorithm based on improved Rotating Kernel Transformation, IRKT edge detection method (IRKTE), is proposed in this paper. The algorithm adopt the line detection approach RKT, and defines a new model of edge detection according to the direction difference between edge and smooth regions. Simultaneously, an accurate edge location approach based on edge normal direction is presented to overcome the wide width caused by a large scale kernel in IRKT. Furthermore, the improvement of previous IRKT with weight edge detection (IRKTEW) is proposed to improve the ability to resist the noise effectively. A series of experiments are carried out through the picture libraries with ground truth and the performance is analyzed with ROC curves. The experimental results show that the proposed method can effectively detect the edge under the strong noises, and the performance of edge detection is improved with the proposed approach.

Abin Jose & Chandra Sekhar Seelamantula [3], "Bilateral Edge Detectors", IEEE International Conference on Acoustics, Speech & Signal Processing (ICASSP), Pp. 1449 – 1453, Vancouver, 2013.

In this paper, we modify the bilateral filter to perform edge detection, which is the opposite of bilateral smoothing. The Gaussian domain kernel of the bilateral filter is replaced with an edge detection mask, and Gaussian range kernel is replaced with an inverted Gaussian kernel. The modified range kernel serves to emphasize dissimilar regions. The resulting approach effectively adapts the detection mask according as the pixel intensity differences. The results of the proposed algorithm are compared with those of standard edge detection masks. Comparisons of the bilateral edge detector with Canny edge detection algorithm, both after non-maximal suppression, are also provided. The results of our technique are observed to be better and noise-robust than those offered by methods employing masks alone, and are also comparable to the results from Canny edge detector, outperforming it in certain cases.

Madhulika, Divakar Yadav, Madhurima [4], "Implementing Edge Detection for Medical Diagnosis of a Bone in Matlab", 5th IEEE International Conference on Computational Intelligence & Communication Networks, 2013.

Edges of an image are considered a type of crucial information that can be extracted by applying detectors with different methodology. Edge detection is a basic and important subject in computer vision and image processing In this Paper we discuss several Digital Image Processing Techniques applied in edge feature extraction. Firstly, Linear filtering of Image is done is used to remove noises from the image collected. Secondly, some edge detection operators such as Sobel, Log edge detection, canny edge detection are analyzed and then according to the simulation results, the advantages and disadvantages of these edge detection operators are compared. It is shown that the canny operator can obtain better edge feature. Finally, Edge detection is applied to find crack in a bone of a hand. After experimentation, edge detection method proposed in this paper is Feasible.

III. EDGE DETECTION TECHNIQUES

There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories:

1. Gradient: The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image.
2. Laplacian: The Laplacian method searches for zero crossings in the second derivative of the image to find edges.

An edge has the 1D shape of a ramp and calculating the derivative of the image can highlight its location. Suppose we have the following signal, with an edge shown by the jump in intensity Fig. 1 below [5], [6]:

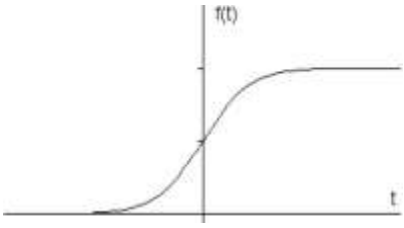

Fig 1 Intensity graph of a signal

If we take the gradient of this signal (which, in one dimension, is just the first derivative with respect to time t) we get Fig. 2 [2], [5]. Clearly, the derivative shows a maximum located at the centre of the edge in the original signal. This method of locating an edge is characteristic of the "gradient filter" family of edge detection filters and includes the Sobel method. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. As mentioned before, edges will have higher pixel intensity values than those surrounding it. So once a threshold is set, you can compare the gradient value to the threshold value and detect an edge whenever the threshold is exceeded.

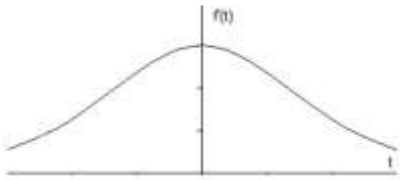

Fig 2 First derivative of the signal

Furthermore, when the first derivative is at a maximum, the second derivative is zero. As a result, another alternative to finding the location of an edge is to locate the zeros in the second derivative. This method is known as the Laplacian and the second derivative of the signal is shown in Fig. 3 [7]:

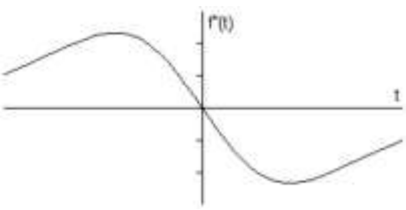

Fig 3 Second derivative of the signal

The process of edge detection attenuates high fluctuations in color, i.e. dramatic change in intensity [8]-[10]. Matlab includes the built-in function edge designed for edge detection. It supports the following types of edge detectors: Sobel, Prewitt, Roberts, Log (Laplacian), Canny and Zerocross.

IV. PROPOSED EDGE DETECTION

Edge detection is the process of localizing pixel intensity transitions. The edge detection has been used by object recognition, target tracking, segmentation, and etc. Therefore, the edge detection is one of the most important parts of image processing. There mainly exist several edge detection methods: Sobel, Prewitt, Roberts and Canny. The basic similarity of image intensity values are considered here for detecting the edges. The principal techniques in the similarity class are based on sub-grouping an image into regions which are similar to a set of absolute intensity difference.

Assuming that E notates a group of pixel values of the m x n (7x7 or 9x9) moving kernel window in the input image. Using the absolute intensity difference (Diff), the list L is partitioned into two sub lists E1 & E2 delimited by the middle edge pixel " xm " where m = 1,2,….n. Then firstly calculation of the median should be done. Here the xm is the median value for the filtering window. The proposed edge detection method is purely based on the extraction of key points on the detected edges of the object. The active key points are extracted & selected based on some constraints which will be discussed in the subsequent chapters. If the extracted edges are very thick, it is very easy to identify & select the active key points on the detected edges of the object. If the extracted edges are very thin, it may not be identified & selected as key points for recognizing the objects. The proposed algorithm is the framework to develop a unified framework that incorporates both the tasks in a coupled manner. Hence, the proposed algorithm is in the context of edge detection by demonstrating their applicability in object recognition.

Proposed Algorithm:

Step 1: Take a moving window of size mxn (7x7 or 9x9) around the pixel x.

Step 2: Calculate the median from the pixels of the kernel that to be placed as the middle element of the kernel.

Step 3: For each & every pixel in the window, calculate the absolute intensity difference with the median value.

Step 4: Calculate the average of the absolute intensity difference (Diff).

Step 5: To identify the edge pixels, fix the similarity neighborhood by using the following condition :

if ((xi <= (x_{mn} + Diff)) && (xi >= (x_{mn} – Diff)))

c[i,j] = 1 else c[i,j] = 0

Step 6: Edge pixels & non-edge pixels are categorized using the value c[i,j].

if (c[i,j] = 1) then

The pixel belongs to edges.

else

The pixels are non-edge pixels.

Step 7: Some times, thick edges are identified. i.e., the edge pixel array can also consists of other pixels that satisfy the condition in the image. The similarity measure is calculated by using the formula

S = Diff/No

where No is the similar number of pixels,

Diff is the absolute intensity difference & S is Similarity measure.

Step 8: If the ratio of (S <= 1)

Thin edges are identified

else

Very thick edges are identified.

Step 9: Get the output image framed by using the detected edge pixels which forms the boundaries of the object.

V. SIMULATION RESULTS AND DISCUSSION

A number of researchers have considered the problem of measuring edge detector performance. The proposed detector is compared with other edge detectors such as Log, Sobel, Prewitt & Robert cross. The performance of the edge detector is analyzed. The general-purpose evaluation is difficult to define while evaluation based on a specific application reduces the generality of the evaluation method. The performance evaluation measure should be well quantified & generally applicable one. Real (noisy) images should be used for evaluation. These features are then passed on to the recognition system for recognizing 3D objects. In fact, it is very difficult to set the criteria for measuring the performance of the edge detector. Even then, the following criteria can be used to evaluate the performance of the edge detector in the literature. They are;

- Probability of false edges;
- Probability of missing or lapsed edges;
- The error in estimating the edge angle;
- The mean square distance of the edge estimate from the true edge
- The algorithm's tolerance to distorted edges & other features such as corners & junctions

These characteristics are assessed for comparing the quality of edges of the objects. The Pratt's Figure of Merit evaluates edge location accuracy by the displacement of detected edge points from an ideal edge & the Pratt figure of merit for various edge detectors are shown in the Table 1 for the ideal capsicum image in Fig. 4. The Figure of Merit is defined by;

$$R = \frac{1}{I_N} \sum_{i=1}^{I_A} \frac{1}{1 + \alpha d^2}$$

where $I_N = \max(I_I, I_A)$

I_I = number of ideal edge points

I_A = number of actual edge points

d = displacement of actual edge points from ideal edge

α = scaling constant.

We have tested the proposed edge detector in different images. We have shown the Pratt figure of merit for the artificially added noisy image in Fig.6.1 & the real world noisy image in Fig.6.3. The table 6.1 & table 6.2 shows the comparison results of Pratt figure of merit of the proposed edge detector with other edge detectors for the artificially added noisy image capsicum.jpg & the real world noisy image juice-bottle.jpg.

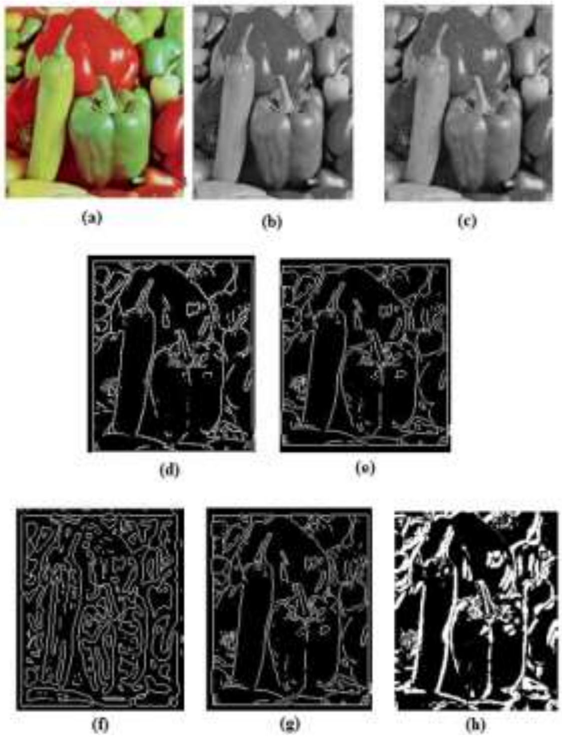

Figure 4: (a) Original image (b) Gray scale image (c) Salt & Pepper added Noisy image (d) Robert cross edge detector (e) Prewitt edge detector (f) Log edge detector (g) Sobel edge detector (h) Proposed edge detector

Detector	Pratt's FOM
log	0.39591
Prewitt	0.36943
Sobel	0.36866
Robert	0.30024
Proposed Method	0.425

Table 1: Pratt's FOM for Figure 6.1

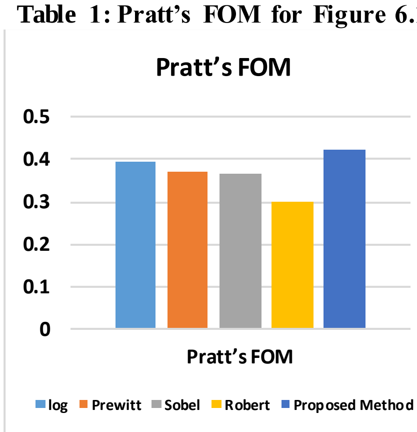

Figure 5: Result Comparison Pratt's FOM for Table 1

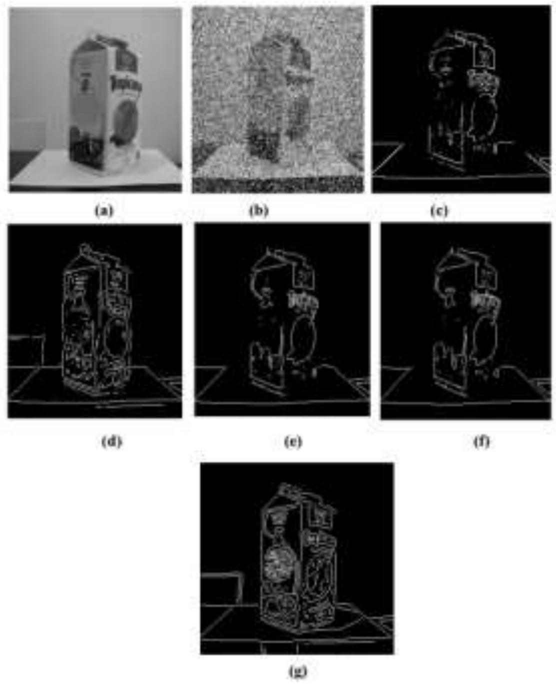

Figure 6: Comparison results of various edge detectors of the juice-bottle.jpg image (a) Original image (b) Noisy image (c) Robert cross edge detector (d) Log edge detector (e) Sobel edge detector (f) Prewitt edge detector (g) Proposed edge detector

Detector	Pratt's FOM
log	0.372
Prewitt	0.302
Sobel	0.343
Robert	0.349
Proposed Method	0.402

Table 2: Pratt's FOM for Figure 6

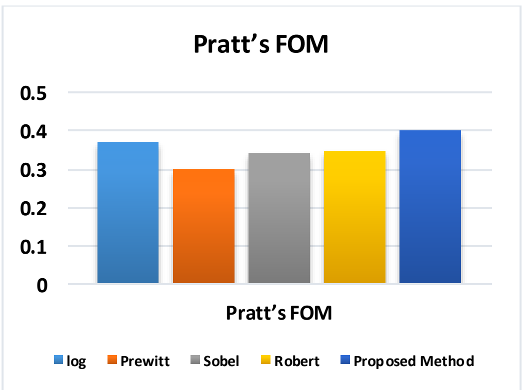

Figure 7: Result Comparison Pratt's FOM for Table 2

These edge detection operators can have better edge effect under the circumstances of obvious edge and low noise. There are various edge detection methods in the domain of image edge detection, each having certain disadvantages. As edge detection is a fundamental step in computer vision, it is necessary to point out the true edges to get the best results from the matching process. That is why it is important to choose edge detectors that fit best to the application. In both images, the proposed edge detector gives a better result than the other detectors. In the artificially added noisy image, the proposed edge detector gives 3% better results than log edge detector, 10% better than prewitt edge detector, 5.8% better than sobel edge detector & 5.3% better than Robert cross edge detector.

VI. CONCLUSION

The conventional edge detection algorithms are highly sensitive to noise, time consuming & computationally complex. A high performance edge detection algorithm is proposed based on the segmentation properties such as similarity & discontinuity. In the similarity method, an image is divided into sub-parts which are similar to a set of established criteria. The method for discontinuity is to split up the image on the basis of sudden variations in intensity. In some of the traditional edge detectors, we may get thick edges or thin edges based on the calculation. Using Canny edge detector, we can very well get the thin boundaries of the object but the computational procedure is very difficult. In the proposed algorithm, we are calculating the similarity measure by using the formula S=P/No. If the ratio of S<=1 we get the thin edges or otherwise we get very thick edges. Experimental results indicate that the proposed edge detection algorithm achieves better performance than the conventional methods. Moreover, it is time efficient method & has a low computational complexity.

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