Volume 5, Issue 5, May 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Evaluating the Shortcomings of Edge Detection Operators

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Abstract— Edge detection is the procedure of identifying and tracing sharp discontinuities in an image. The discontinuities are sudden changes in pixel intensity which describe boundaries of objects in a scene. The reason for that is that edges form the outline of an object. A benefit could be the linking a thing and the backdrop and shows the boundary between overlying objects. Image edge detection also decreases the amount of data and filters out inadequate information, while maintaining the important structural properties in an image. Edge detection is found in various fields like image analysis and pattern recognition. This paper describes the various edge detection techniques along with discussing their advantages and limitations. The techniques discussed here are Roberts operator, Sobel operator, Prewitt's cross operator, Laplacian, Laplacian of Guassian and Canny's edge detection.

Keywords— Edge Detection, Canny Edge Detection, Laplacian of Guassian, Laplacian,operators for detection.

I. INTRODUCTION

An edge is an area of significant change in the image intensity/contrast and edge detection is locating areas with strong intensity contrasts. Edge recognition could be the term for some mathematical methods which target at classifying points in a image at that your image intensity varies sharply or, has discontinuities. Moreover, edges are a important confined changes of intensity in an electronic digital image..Edge detection is very helpful in case there is noise free images. But in case there is noisy images it is just a challenging task. Noisy images are corrupted images. Their parameters are difficult to analyze and detect. Edge detection is just a fundamental tool found in most image processing applications to acquire information from the frames as a precursor step to feature extraction and object segmentation. There is some curled make segments identified as edges. It's found in picture segmentation, object detection, information hiding, image coding and so on. Thus apply an edge detection algorithm to a graphic may ease the sum total of data to be processed and may straighten out information that possibly will be regard as less related while preserving the key structural properties of an digital image. If edge detection step be successful, the consequent task of interpreting the information contents in original image may be easy.

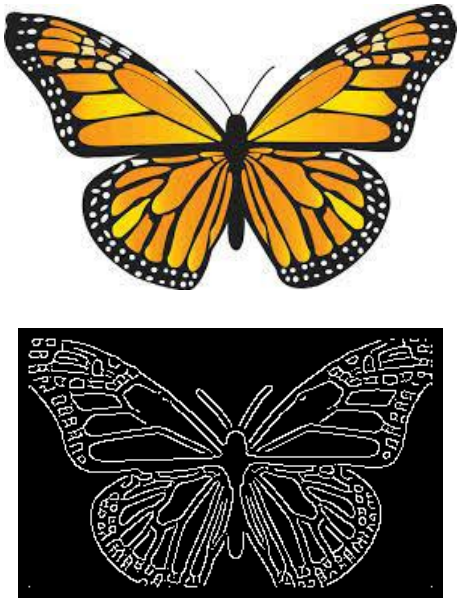

Fig. 1 Edge detection

II. EDGE DETECTION TECHINQUES

Edge detection techniques convert images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending. Consequently of the transformation, edge image is obtained without encountering any changes in physical qualities of the key image [4]. Variables active in the choice of an advantage detection operator include:

A. Edge orientation

The geometry of the operator determines a characteristic direction in which it's most sensitive to edges. Operators may be optimized to consider horizontal, vertical, or diagonal edges.

B. Noise environment

Edge detection is difficult in noisy images, since both the noise and the edges contain high-frequency content. Attempts to lessen the noise result in blurred and distorted edges. This results in less accurate localization of the detected edges. Operators applied to noisy images are generally larger in scope, so they can average enough data to discount localized noisy pixels [5].

C. Edge structure

Not absolutely all edges involve an action change in intensity. Effects such as refraction or poor focus can lead to objects with boundaries defined by a gradual change in intensity. The operator must be chosen to be attentive to this type of gradual change in those cases. Newer wavelet-based techniques [6] actually characterize the type of the transition for every single edge in order to distinguish, for example, edges connected with hair from edges associated with a face.

D. Classical or Gradient based edge detectors (first order derivative)

The gradient method detects the edges by looking for the maxima and minima in the initial spatial derivative of the image [5]. Mathematically, the gradient of a two variables function (here the image intensity function) at each image point is 2D vector with the components given by the derivative in the horizontal and vertical direction. At each image point, the gradient vector points in the direction of largest possible intensity increase and along the gradient vector corresponds to the rate of change for the reason that direction.

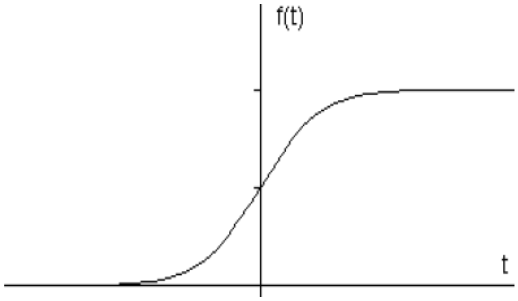

Fig. 2 1-D signal [8]

If we take the gradient of this signal (which, in one dimension, is just the first derivative with respect to t) we get the following Figure 3

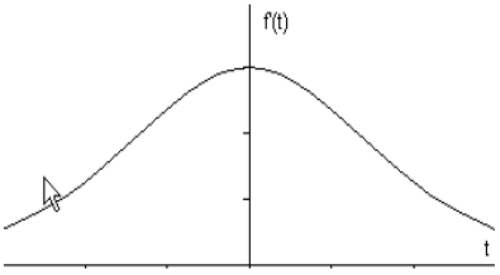

Fig.3 First derivative of 1-d signal [8]

The different types of operators used for this type of edge detectors are described in the following subsection.

1) *Robert's Operator*: It had been invented by Larry Roberts in his 1962 Stanford Thesis. In Robert cross algorithm the horizontal and vertical edges bring out individually and chances are they assembled for the resulting edge detection. The Roberts operator performs an easy, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights elements of high spatial gradient which often correspond to edges. In its most frequent usage, the input to the operator is a grey-scale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image when this occurs [9].

In theory, the operator contains a set of 2×2 convolution masks as shown in Figure 3.One mask is merely the other rotated by 90° ;.That is very similar to the Sobel operator.

$$Gx = \begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix};\ Gy = \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix}$$

Fig. 4 Roberts Cross convolution masks

These masks are made to respond maximally to edges running at 45° to the pixel grid, one mask for each of the two perpendicular orientations. The masks may be applied separately to the input image, to make separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*) [10]. These can then be combined together to get the

absolute magnitude of the gradient at each point and the orientation of this gradient.Robert's operator has the main advantage of providing an easy approximation to the gradient magnitude and is able to detect edges run over the vertical axes of 45 degree and 135 degree. However, its accuracy is low because as the gradient magnitude of the edges decreases, which most likely decreases the accuracy. Also Robert's cross kernel are relatively small, they are highly susceptible to noise in the detection of the edges and their orientations. The escalation in the noise to the image will ultimately degrade the magnitude of the edges.

2) *Sobel operator:*It had been invented in 1970 [11]. The Sobel operator performs a 2-D spatial gradient measurement on a picture and so emphasizes elements of high spatial gradient that correspond to edges. Typically it's used to get the approximate absolute gradient magnitude at each point in an input gray-scale image.

In theory at the very least, the operator contains a set of 3×3 convolution masks as shown in Figure 4 [10]. One mask is merely the other rotated by 90° ;.That is very similar to the Roberts Cross Operator.

$$\mathrm{Gx} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix};\ \mathrm{Gy} = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Fig.5 Sobel convolution masks

These masks are made to respond maximally to edges running vertically and horizontally relative to the pixel grid, one mask for each of the two perpendicular orientations. The masks may be applied separately to the input image, to make separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to get the absolute magnitude of the gradient at each point and the orientation of this gradient. Advantage of Sobel operator is that, sobel kernals are more suitable to detect edges over the horizontal and vertical axes. Disadvantage of the Sobel operator, it places focus on pixels that are closer to the center of the masks.

3) *Prewitt's operator :*It had been invented in 1970 [11]. The Prewitt edge detector is a proper method to estimate the magnitude and orientation of an edge. Although differential gradient edge detection requires a rather time intensive calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response. The Prewitt operator is restricted to 8 possible orientations, however experience shows that a lot of direct orientation estimates aren't a lot more accurate. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions as in Figure 5. All of the eight convolution masks are calculated. One convolution mask is then selected, namely that with the largest module[9].

$$\mathrm{Gx} = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix};\ \mathrm{Gy} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Fig. 6 Masks for the Prewitt gradient edge detector

Advantage of this operator is that it generally does not place any focus on pixels that are closer to the center of the masks. Disadvantages are Senstivity to noise and Inaccurate.

E. Laplacian based edge detection(Second Order Derivative)

It looks for zero crossings in the 2nd derivative of the image[12] to find edges. An advantage has usually the one dimensional shape of a ramp and calculating the derivative of the image can highlight its location. Further-more , when the very first derivative are at maximum, the 2nd order derivative is zero. Consequently, another alternative to obtain the location of an advantage is to locate the zeros in the 2nd order derivative.

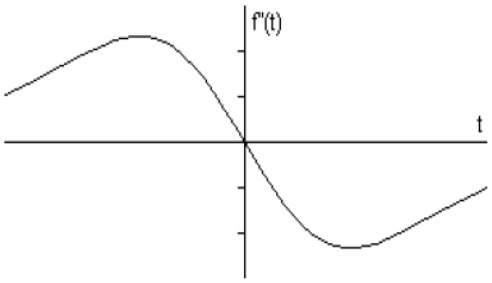

Fig. 7 2nd derivative of 1-d signal[8]

If the very first derivative is maximum then its second derivative will certainly be zero. This phenomenon give rise to alternate method for edge detection which is called Lalpacian. Hence, we could detect the edges by looking for zero crossings in the 2nd derivative, Figure 6 shows second derivative of the signal.

$$\begin{bmatrix} z_1 & z_2 & z_3 \\ z_4 & z_5 & z_6 \\ z_7 & z_8 & z_9 \end{bmatrix} \quad \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

General Mask Mask 1 Mask 2

Advantages of Laplacian operator are: Laplacian is employed to find perhaps the pixel is on the dark side or light side of an advantage, Role of Laplacian in segmentation due to its zero crossing property means points where in actuality the

intensity of the image changes rapidly. Disadvantages of Laplacian operator are: Laplacian is unacceptably sensitive to noise, Magnitude of the Laplacian produces double edges, Laplacian is unable to detect edge direction.

1) *Laplacian Of Gaussian* :It absolutely was invented by Marr and Hildrethin 1980[17] .The Laplacian is really a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of a graphic highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is usually applied to a graphic that has first been smoothed with something approximating a Gaussian Smoothing filter to be able to reduce its sensitivity to noise. The operator normally has a single gray level image as input and produces another gray level image as output.

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 8 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 2 & -1 \\ 2 & -4 & 2 \\ -1 & 2 & -1 \end{bmatrix}$$

Fig. 8 Three commonly used discrete approximations to the Laplacian filter.

Because these kernels are approximating another derivative measurement on the image, they're very sensitive to noise. To counter this, the image is usually Gaussian Smoothed before applying the Laplacian filter. This pre-processing step reduces the high frequency noise components ahead of the differentiation step. Actually, since the convolution operation is associative, we could convolve the Gaussian smoothing filter with the Laplacian filter to begin with, and then convolve this hybrid filter with the image to accomplish the required result. Doing things in this way has two advantages: Since both the Gaussian and the Laplacian kernels are generally much smaller compared to the image, The LoG (`Laplacian of Gaussian')[13] kernel can be pre-calculated in advance so only one convolution needs to be performed at run-time on the image.

Laplacian of Gaussian has the advantages to Finding the right places of edges , Testing wider area round the pixel and Disadvantages are: Malfunctioning at the corners,curves and where in actuality the gray level intensity function varies and it doesn't locating the orientation of edge due to using the Laplacian filter.

F. Optimal Edge Detection

1) *Canny Edge Detector*:It was first produced by John Canny for his Master's thesis at MIT in 1983 [15], and still out performs lots of the newer algorithms which were developed. Canny saw the edge detection problem as a sign processing optimization problem, so he developed an objective function to be optimized. The effect of the Canny operator is decided by three parameters --the width of the Gaussian kernel utilized in the smoothing phase, and the top of and lower thresholds used by the tracker [15]. The situation with this sort of classical edge detection approach is that the low threshold generates false edges, but a high threshold misses important edges. Firstly it needs that the image be smoothed with a Gaussian mask, which lessens significantly on the noise within the image. Then the image is explain to you the Sobel algorithm, and this technique is hardly suffering from noise. Lastly, the pixel values are chosen based on the angle of the magnitude of the pixel and its neighboring pixels[18].

III. RELATED WORK

Yang, Hao et al. [1] combined original algorithm with Otsu adaptive threshold algorithm and a fresh fast algorithm for edge detection. This fast algorithm can directly obtain the suitable step gray threshold and detect the edge. The detection time was significantly shortened while ensuring the detection results. This algorithm also calculates the error brought on by edge model. Experimental results showed that the improved algorithm can detect the image edge more effectively and the sub-pixel location was more accurate after compensating, the detection effects were satisfied. Wan-she, Li et al. [2] studied the edge detection algorithm on the edge of the location and anti-noise capability, they selected Log operator, Canny operator and wavelet transform edge detection algorithm to detect image edge by using Matlab software. Simulation results reveal that, three edge detection operators possessed different capacity in the edge location and suppress noise. Wavelet transform can provide the edge information of different scales. The experimental result showed that, since wavelet transform have a multi-scale feature and localization characteristic, it could accurately detect the edge points, In the meantime ,it could overcome preferably noise-sensitive problems which arise from Log operator and Canny operator. Zhu, Shihu et al. [3] deeply studied the edge detection ways of the noisy images and concentrates on the mathematical morphology methods. By analyzing and studying the idea of mathematical morphology, the paper constructed edge detection operations and analyzes the specialties of those operations and the structure elements. The new method of edge detection centered on multi-structure elements morphology and image fusion is proposed. By simulation and comparing with the traditional edge detection operations, the proposed method not only will effectively get rid of the image noise, but also can effectively maintain good edge information. Qiang, Wang et al. [4] proposed a micro-vision positioning centered on edge detection of micro-structure parts, a pixel-level edge points detection method centered on limit local entropy. 2-3 pixel were extended in the gradient direction to both parties from the edge points to construct the 3 cubic spline interpolation function of edge transition zone. Using function derivation to obtain the floating value of sub-pixel coordinates, then, sub-pixel coordinate was located according to the positioning principle of directional sub-pixel coordinates. Finally, the fine grinding standard gauge block and LIGA micro-spring were taken as example, using traditional gradient edge detection and the method proposed in this paper to realize image edge detection, and achieve the width measurement. The results showed that the edge positioning accuracy of the method proposed in this paper is greater than the traditional gradient edge detection method. And if the pixel level edge positioning accuracy or sub-pixel edge positioning accuracy are higher compared to positioning accuracy required of micro-assembly systems (5μm). Kaur, Beant et al. [5**]** studied the need of edge detection is to obtain the discontinuities comprehensive,

discontinuities in surface orientation, changes in material properties and variations in scene illumination. Remote sensing images are generally corrupted from noise. Mathematical morphology is really a new technique for edge detection. It's a principle and technique for analysis and processing of geometrical structures, centered on set theory. Mathematical morphology was originally developed for binary images, and later extends to grey scale functions and images. Simply the noise could be easily suppressed by mathematical morphology. So by using mathematical morphology the image could be enhanced and the edges could be detected. The result of edge detection using mathematical morphology will undoubtedly be in contrast to Sobel edge detector, Prewitt edge detector, laplacian of gaussian edge detector and Canny edge detector .Wang, Wei et al. [6] proposed an edge detection approach of SAR image predicated on edge localization with optical edge image of exactly the same scene. First, image association is done to the two images. Then, edge detection is taken up to the SAR image with the ROA detector and to the optical image with the Canny detector, respectively. Finally, the final edge result is obtained by deciding edge points in the SAR edge image predicated on edge localization with the optical edge image. The outcome of computer simulation are employed to confirm the validity of the proposed method. Edge localization is tough for edge detection of SAR images. However, the proposed method resolves the issue to some extent. Joshi, Shashidhar Ram et al. [7]proposed fusion of Haar wavelet and Prewitt operator and compares its performance with commonly used gradient edge detection algorithms and canny edge detection method in numerous conditions. Canny edge detection algorithm was implemented with adaptive parameters. Software packages for many edge detectors are developed in visual C#.net. It's been shown that canny edge detection algorithm with adaptive parameters performs better in almost all conditions in comparison to other operators in the expense of its execution time. Yasiran, Siti Salmah et al. [8] compared Sobel, Prewitt and Laplacian of Gaussian (LoG) edge detection techniques in segmenting the boundary of microcalcifications. The edge detection must satisfy the breast phantom scoring criteria before the segmentation phase is carried out. Then, all the edge detection techniques are implemented in the Enhanced Distance Active Contour (EDAC) model for the segmentation process. Results obtained from Area Underneath the Curve (AUC) of the Receiver Operating Characteristic (ROC) curve shows that the Prewitt edge detection has the greatest value of AUC, followed by the Sobel and LoG that have been 0.79, 0.72 and 0.71 respectively. Hou, Xianghua et al. [9] discussed Canny edge detection operator predicated on optimization algorithm which has advantages of large signal and noise ratio and high accuracy. Secondly, the welding image processing with Canny operator is described and for every step, detailed description and processing answers are given. Eventually, Canny operator edge detection answers are projected to 2-d histogram. The histograms of projection answers are compared with the qualified image histogram. Once the similarity is more than some threshold, they thought that the welding is qualified. Otherwise, it is recognized as as defective welding. Through the edge extraction and detection of lead-acid battery electrode welding that are done by welding robot, it could be seen that the recognition results meet the requirements of production line. Zhong, Weifeng et al. [10] used three algorithms of edge detection including: morphological edge detection, wavelet packet edge detection, edge detection combining morphological and wavelet packet. Experiments reveal that the edge detection combining morphological and wavelet packet can denoise and protect images has good practicality because of its relatively high measurement precision, which are of great value towards the engineering practice. Shang, Junna et al. [11] discussed an algorithm of edge detection predicated on mathematical morphology. Due to the characteristics of the fundamental morphology algorithm of image processing, the common edge detection algorithms with traditional morphological edge detection algorithm are analyzed and compared, and the characteristics of each, in addition to inadequateness were given here. Combined with geometric algorithms, placed on binary gray scale image edge detection, based on the classic edge detection algorithms and soft filtering properties, the morphology of the soft edge detection algorithm and optimization algorithm is put forward for the edge detection and image de-noising processing. Pirzada, Syed Jahanzeb Hussain et al. [12] compared edge detection centered on bilateral filtering with canny edge detection technique for satellite Images. Bilateral filtering based edge detection not merely generates well localized edges but in addition simultaneously reduces considerable noise from actual life images. The results show that the bilateral filtering based edge detection provide better edge maps than other comparable techniques. Wang, Xiufang et al. [13] proposed an algorithm of adaptive grayscale image edge detection centered on multi-scale and multi-form. The image is processed with different shapes and dimensions of structural elements, and the adaptively weights are calculated according to information entropy. And build a series-parallel type of edge detector. Eventually, they can get the final edge image after the fusion of every result from single element according to the series-parallel edge detector. The results of simulation show that in contrast to several conventional edge detection algorithms, the proposed algorithm can not merely filter nearly all of noise but in addition retain good edge details. Li, Zhonghai et al. [14] put forward an advantage detection algorithm which based on the law of gravity adaptive threshold. This algorithm is not merely has good effect for common image edge detection, but in addition for the noise of the image edge detection and great results have now been achieved. Based on the law of universal gravitation of physics, the author designs some sort of template which applied to edge detection. Then, designs some sort of dynamic adaptive threshold method can be used for edge detection because that a human visual system in light is preferable to the dark area have small noise sensitivity. This algorithm make up for the standard algorithm in the entire image only used an individual threshold. Through the experimental comparison, this paper algorithm can make dynamic adaptive threshold value. The algorithm has good inhibition effect found in image with salt and pepper noise and gaussian noise. it can extract image edge efficiently. Wang, Peizhen et al. [15] proposed a brand new algorithm pulse coupled neural network edge detection algorithm centered on multi-scale wavelet transform. Firstly, multi-scale wavelet is used to detect edge of smoothed plate image, and then pulse coupled neural network is employed to debar the fake edge, accompanied by binary calculation with K-means clustering algorithm. Ultimately, after thinning with the modified OPTA algorithm, edges with single pixel-width

are obtained. By comparing the experimental results with those of non-subsample contour let transform, it is found that the proposed algorithm not merely ameliorates the situation of edge un-continuity due to non-subsample contour let transform, however the speed is improved. Lu, Jin-Yun et al. [16] presented a weld image edge-detection algorithm coupled with Canny operator and mathematical morphology. Pseudo-edges of Canny edge-detection Algorithm is eliminated by edge-detection operator based on the mathematical morphology, and weld center curve is obtained by local-region scanning. Relative to centered on Sobel operator and Prewitt operator, this algorithm inhibits the interference of noise on the edge and extracts the data of weld edge accurately. The typical error of weld center curve detected by this algorithm and actual weld center curve is decreased. On the basis of the advantages of both keeping Canny operator accurate location and high signal-noise ratio, this algorithm improves the performance of the Canny operator when it comes to inhibition of pseudo-edges and is suited to the process of image processing in welding seam tracking centered on vision sensor. Yadav, Divakar et al. [17] discussed several Digital Image Processing Techniques applied in edge feature extraction. Firstly, Linear filtering of Image was done is used to get rid of 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's 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. Suwanmanee, Siwa et al. [18] dedicated to the step of preprocessing in the part of edge detection techniques to detect red blood cells (RBCs) boundaries. The objectives of the study were to make a comparison between gradient based edge detection and zero-crossing based edge detection and to discover the right operator to use for edge detection of RBCs in capillary. Sobel, Robert, Prewitt and Canny were used as gradient based edge detectors whereas Laplacian of Gaussian was used as zero-crossing based egde detector. Their study used two criteria to consider the caliber of edge detector by eye judgment: the likelihood of a false positive and the likelihood of a false negative. It absolutely was unearthed that Canny and LOG are suitable to use as edge detectors for RBCs in microvasculature Waghule, Diplaxmi R., et al. [19]discussed a significant property of the edge detection method is its ability to extract the accurate edge line with good orientation. Different edge detectors work better under different conditions. Comparative evaluation of different methods of edge detection allows you to decide which edge detection method is acceptable for image segmentation. This paper presents an summary of the published focus on edge detection. Chhabra, Amit. et al. [20] proposed a sequential hybrid way of overcome most of the limitations of existing edge detection algorithms. The operations performed by image edge detection algorithm can be computationally expensive and takes a lot of execution time for processing the data. This research work also improves hybrid color based image edge detection technique using the data parallelism approach. The comparison among sequential and parallel edge detection is likely to be drawn in relation to different parallel metrics. The experimental results have shown that parallel strategy achieves a performance gain of 68% when compared with sequential approach. Pavithra, C et al. [21] proposed a canny edge detection algorithm rather than sobel operator to find the accurate edge detection; this edge detection algorithm is used to lessen the amount of data in the image. This process used to detect the real edge points and non edge points. It will maximize the real edge points and minimize the non edge points. These similarities to maximize the signal to noise ratio. The detected edges as close regarding real edges. The true edge shouldn't result as the detected edge. Employing a canny edge detection algorithm the visual perception of the image can be improved.

IV. CONCLUSIONS AND FUTURE SCOPE

In this paper, a survey of various edge detection techniques has been discussed along with discussing their advantages and limitations. From the survey, it has been found that none of the technique is better in all the fields for the edge detection. Edge detection techniques convert images to edge images benefiting from the changes of grey tones in the images. There are problems of false edge detection, missing true edges, producing thin or thick lines and problems due to noise etc. This paper has focused on edge detection using different well known edge operators. In near future we will use fuzzy templates to improve the segmentation criteria. Fuzzy will sharp edges in such a way so that we can achieve better edge detection. However noise issue will also be considered to make algorithm more robust.

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