Edge Detection Technology using Image processing in Matlab

Divyang Goswami
M.Tech Scholar, Digital Communications
Marudhar Engineering College,
Bikaner, Rajasthan, India
goswamidivyang@gmail.com

***Abstract*—** An edge may be defined as a set of connected pixels that forms a boundary between two disarrange regions. Edge detection is a method of segmenting an image into regions of conclusion. Edge detection plays an very important role in digital image processing and practical aspects of our life. In this report, we studied various edge detection techniques as Robert, Sobel and Canny operators. On comparing them we can see that canny edge detector performs better than all other edge detectors on various aspects such as it is flexible in nature, doing better for noisy imageand gives sharp edges , low probability of detecting false edges etc

Keywords- *Edge Detection, Image Processing, Matlab.*

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I. Introduction

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness can changes sharply or more formally, has discontinuities. Any points where image brightness changes sharply are typically organized into a set of curved line segments into termed edges. The same problem of finding breaks in 1D signal is known as step detection and the problem of finding signal discontinuities over time is known as change detection in image processing. Edge detection is a important basic tool in image processing where machine vision and computer vision particularly in the areas of feature detection and feature extraction.

Digital image is composed of a finite number of components, each of which has a special place or position and value. These components are cited to as picture elements, image elements, and pixels .Image processing is any form of signal processing for which image is the input, such as a photograph and the image processing output may be whether an image or, a set of characteristics or parameters associated to the image Edge can also be defined as in binary images as the black pixels with one nearest white neighbour. Edges include large amount of important information about the image. The changes in pixel intensity describe the boundaries of objects in a picture. Feature detection and Feature extraction are the main areas of image processing, where Edge detection is a important tool. Image edge detection trades with drawing out of edges in an image by recognizing high intensity variations in the pixels. This action discovers outlines of an object and boundaries between objects and the back part of the image.

Detection of edges for an image may help in image segmentation, data compression, and for image reconstruction and so on. Variables involved in selection of an edge detection operator include edge orientation, noise environment and edge structure. Edge detection is difficult in noisy images, since both the noise and the edges include high-frequency essence. Attempts to reduce the noise consequence are blurred and distorted edges.

Edge detection is used mainly to extract the information about the image e.g. image sharpening and enhancement, location of object present in the image, their shape, size. Depending upon variation of intensity / grey level, various types of edges are shown in Figure 1.

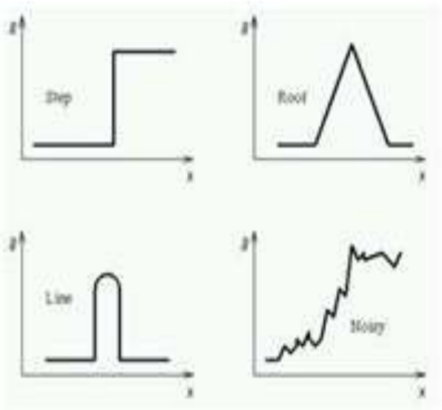

Fig 1 Typical Edge Profile

II. Literature Survey

An edge may be defined as a set of connected pixels that forms a boundary between two disjoints regions. Edge detection is basically, a method of segmenting an image into regions of discontinuity. Edge detection plays an important role in digital image processing and practical aspects of our life. I am giving some research papers related to it.

Sunanda Gupta ,Charu Gupta and S.K Gupta in their paper— Edge detection is important part of image processing for object detection. So it becomes extremely important to have a good understanding of edge detection algorithms. An edge is the real or imagined line that marks the limit and divides of plane, object or appearance from other places or things. This means that if the edges in an image can be identified accurately, all of the objects can be located and basic properties can be measured. This paper introduces a classification of most important and commonly used edge detection algorithms, namely Sobel, Robert, Prewitt, Laplacian of Gaussian, Canny, Ant colony Optimization [1].

B. Divya, Dr. T. K. Shanthi, T. K. Sethuramalingam, Ebin Ephrem Elavathingal, Edge detection in an image is an major issue in image processing. Many hidden objects can be identified using edge detection which gives major clue in identifying actual truth behind the images. In this paper, double thresholding method of edge detection along with canny edge detector is used to identify the small objects in an images. Here threshold plays a major role which extracts the clear image from unclear picture.[2]

Ranjeet Kumar Nigam, N. P. Waghmare, A. K. Gupta The forensic identification of ballistics specimens relies on the detection, recognition and ultimate matching of markings on the surfaces of cartridges and projectiles made by the firearms. The feature extraction from the images is always a very important step in automated examination system. The edge detection refers to the process of identifying and locating sharp discontinuities in an image which helps in pattern recognition. The edge detection of ballistics specimens like, the firing pin mark, head stamp mark and striation on cartridge case the positive identification is based mainly on the image segmentation and feature extraction of the proposed area. Thus, applying an edge detection algorithm to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplifiedIn this paper we have compared different techniques of Gradient-based and Laplacian based edge detection on the cartridge case image with MATLAB tool.[3]

Hankyu Moon, Rama Chellappa, and Azriel Rosenfeld, propose an approach to accurately detecting two dimensional (2-D) shapes. The cross section of the shape boundary is modeled as a step function. We first derive a one-dimensional (1-D) optimal step edge operator, which minimizes both the noise power and the mean squared error between the input and the filter output. This operator is found to be the derivative of the double exponential (DODE) function, We define an operator for shape detection by extending the DODE filter along the shape's boundary contour. The responses are accumulated at the centroid of the operator to estimate the likelihood of the presence of the given shape. This method of detecting a shape is in fact a natural extension of the task of edge detection at the pixel level to the problem of global contour detection. This simple filtering scheme also provides a tool for a systematic analysis of edge-based shape detection. We investigate how the error is propagated by the shape geometry. We have found that, under general assumptions, the operator is locally linear at the peak of the response. We compute the expected shape of the response and derive some of its statistical properties. This enables us to predict both its localization and detection performance and adjust its parameters according to imaging conditions and given performance specifications. Applications to the problem of vehicle detection in aerial images, human facial feature detection, and contour tracking in video are presented. [4].

Rashmi, Mukesh Kumar, and Rohini Saxena in their paper, an edge may be defined as a set of connected pixels that forms a boundary between two disjoints regions. Edge detection is basically, a method of segmenting an image into regions of discontinuity. Edge detection plays an important role in digital image processing and practical aspects of our life. .In this paper we studied various edge detection techniques as Prewitt, Robert, Sobel, Marr Hildrith and Canny operators. On comparing them we can see that canny edge detector performs better than all other edge detectors on various aspects such as it is adaptive in nature, performs better for noisy image, gives sharp edges , low probability of detecting false edges etc. [5].

III. EDGE DETECTION ALGORITHM

We define image edge detection as the analysis of the real or imagined line that marks the limit and divides of image appearance from other places or things in a digital image.

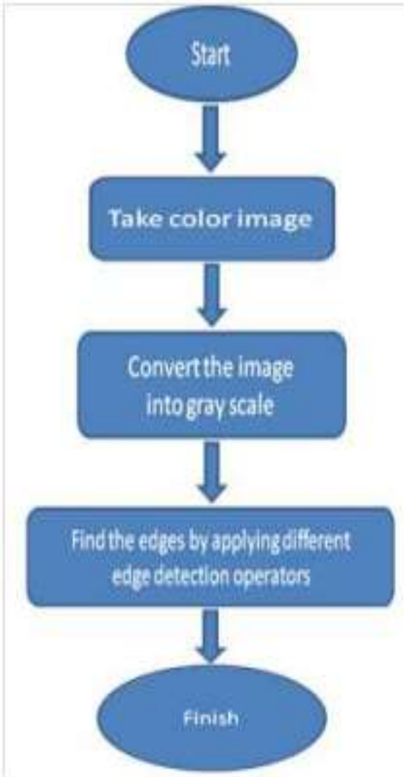

Fig.2 Flow Chart of Edge Detection

It is a series of actions whose purpose is to recognize points in an image where clear and defined changes occur in the intensity. This action is necessary to realize the meaning of the content of an image and has its applications in the evaluation of image and machine vision. The end usage of discovering clear and defined changes in image intensity is to represent the bottom line events and changes in the material properties of the world. Causes of Intensity

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alteration normally represent two types of events: one is geometric events and other is non-geometric events.

Step 1-Take a color image.
Step 2 -Smoothing: Annihilate as a noise as accessible, without wrecking genuine edges.
Step 3- Enhancement: the quality of edges is increased by applying differentiation.
Step 4- Threshold: Apply edge define magnitude threshold to determine which edge pixels should be retained and which should be discarded as noise.
Step 5- Localization: As certain the postulate the edge bearings.
Step 6- Evaluation with the algorithms.
Step 7- Get the detected image after edgedisclosure .

IV. EDGE DETECTION METHODOLOGIES

Edge detection makes use of differential operators to detect changes in the gradients of the grey levels. It is further divided into two main categories:
1) First Order Edge Detection
2) Second Order Edge Detection

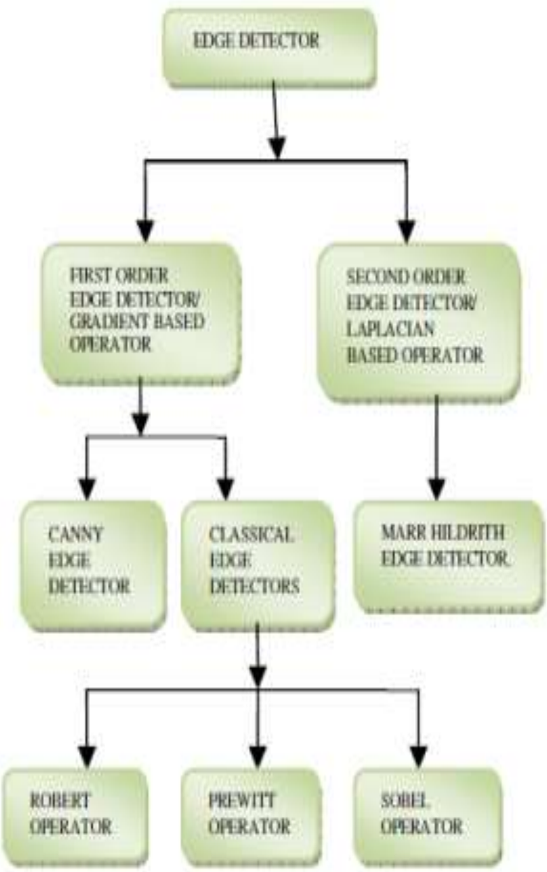

Fig.3 Types of Edge Detector

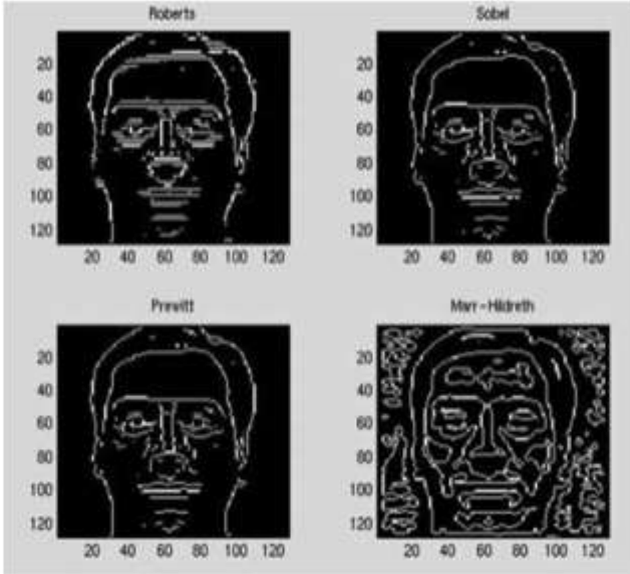

Fig.4 Various Edge Detection Techniques

4.1 Robert operator

The Roberts operator performs a simple quick to the compute 2-D spatial gradient measurement on the image. It will highlight regions of high gradient which often correspond to edges. In its most usage the input the operator is a greyscale image is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point.

How It Works

In theory, the operator consists of a pair of 2×2 convolution masks as shown in Figure 4.2. One mask is simply the other rotated by 90°. This is very similar to the Sobel operator.

0	+1
-1	0

GX

+1	0
0	-1

GY

It is gradient based operator. It firstly computes the sum of the squares of the difference between diagonally adjacent pixels through discrete differentiation and then calculate approximate gradient of the image.

The input image is convolved with the default kernels of operator and gradient magnitude and directions computed. It uses following given 2 x2 two kernels:

$$D_x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad \text{And} \quad D_y = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

These masks are designed to respond maximally to edges at 45° to the pixel grid one mask for each of the two perpendicular orientations. The masks is applied separately to the input image to produce the separate measurements of the gradient component in each orientation (call *Gx* and *Gy*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is defined by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

although typically, an approximate magnitude is computed using:

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$$|G| = |Gx| + |Gy|$$

which is much quicker to compute. The angle of orientation of edge giving rise to the dimentional gradient (relative to the pixel grid orientation) is given by:

$$\theta = \arctan(Gy/Gx) - 3\pi/4$$

In this case, orientation 0 is taken to mean that the direction of maximum contrast from black to white runs from left to right on the image, and other angles are measured anticlockwise. Often, the absolute magnitude is the only output the user sees the two components of the gradient are conveniently computed and added in a single pass over the input image using the pseudo-convolution operator shown in figure 5

P1	2	P
P3	4	P

Fig: 5 Pseudo-Convolution masks used to quickly compute approximate gradient magnitude

Using this mask magnitude is given by:

$$|G| = |P_1 - P_4| + |P_2 - P_3|$$

4.2 Sobel Operator Edge Detector

Common Names: Sobel, also related is Prewitt Gradient Edge Detector

Brief Description

The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial gradient that related to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input greyscale image.

How It Works

In theory at least, the operator consists of a pair of 3×3 convolution masks as shown in Figure 4.4 One mask is simply the other rotated by 90°. This is very similar to the Roberts Cross operator.

Gx

-1	0	+1
-2	0	+2
-1	0	+1

Gy

+1	+2	+1
0	0	0
-1	-2	-1

Fig 4.4 Sobel Convolution Mask

These masks are designed to respond maximally to edges running vertically and horizontally relative to pixel grid one mask for each of the two perpendicular orientations. The masks can be applied separately to the input image to the produce separate measurements of the gradient component in each orientation call these *Gx* and *Gy*. These can be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is defined by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Although typically, an approximate magnitude is computed using:

$$\theta = \arctan(Gy/Gx) - 3\pi/4$$

which is much quick to compute.

The angle of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$|G| = |Gx| + |Gy|$$

black to white runs from left to right on the image, and other angles are measured anticlockwise from this. Often, this absolute magnitude is the only output the user sees --- the two components of the gradient are conveniently computed and added in a single pass over the input image using the pseudo-convolution operator shown in Figure 4.5

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

Figure6 Pseudo-convolution masks used to quickly compute approximate gradient magnitude

Using this mask the approximate

$$|G| = |(P_1 + 2\times P_2 + P_3) - (P_7 + 2\times P_8 + P_9)| + |(P_3 + 2\times P_6 + P_9) - (P_1 + 2\times P_4 + P_7)|$$

4.3 Canny Edge Detector

The Canny operator was designed to be an optimal edge detector (according to particular criteria --- there are other detectors around that also claim to be optimal with respect to slightly different criteria). It takes input image a grey scale image and produces as output, an image showing the positions of captured intensity discontinuities.

How It Works

The Canny operator works great in a multi stage process. First,all the image is smoothed by Gaussian convolution. Then using a simple 2D first derivative operator like (somewhat like the Roberts Cross) is applied to the smoothed image to highlight regions of the image with high first spatial derivatives. Edges gives rise to all ridges in the gradient magnitude image. The algorithm tracks along the top of these ridges and sets to zero all pixels that are not actually on the ridge top so as to give a thin line in the output this all process called as *nonmaximal suppression*. The tracking process shows hysteresis controlled by two thresholds: *T1* and *T2* with *T1* > *T2*. Chasing can only begin at a point on a ridge greater than *T1*. Chasing then continues in both directions out from that point until the height of the ridge falls under *T2*. This hysteresis helps alot to ensure that noisy edges are not broken up into multiple edge fragments.

Fig: 7 Canny Edge Detector

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Canny Edge Detector Flow Chart

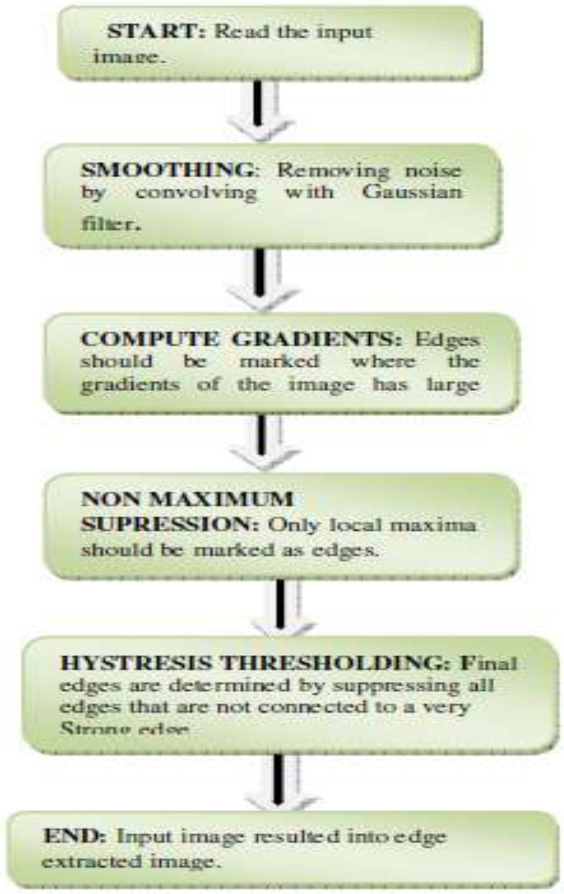

Fig 8. Flow Chart of Canny Edge Detector

- Canny Edge detector is advanced algorithm derived by Marr and Hildreth.
- It is an optimal edge detection technique as provide good detection ,clearly response and good localization.
- It is widely used in current image processing technique improvements.

Differences of Various Edge Detection Technique

Parameter	Robert	Sobel	Prewitt
Speed	Fast	Slow	Slow
Threshold Value	20	150	180
Standard Deviation	8	15	20
Kernell Size	2x2	3x3	3x3
Noise Sensitivity	Very High Sensitive	High Sensitie	Lower then Sobel
Edges Quality	Not good	Good	Good
Optimal Edge Detection	No	No	No

Applications of Edge Detections:

- In Biomedical Applications like Endoscopy, CT Scan, MRI Machines Etc.
- Detection of Aircraft in Radar.
- Concealed weapon Detection using X Ray Technology.
- Image Editing Tools or Software.
- 2D and 3D animations.
- Face Detection Technique using Sharp Edge Canny Detection
- Cable insulation layer measurement
- Edge detection of river regime
- In Automatic Multiple Faces Tracking System and Detection.

Major Advantage of canny edge detection algorithm

On analyzing all these edge detection techniques , it is found that canny gives optimum edge detection .Following are the some points throwing light on the advantages of canny edge detector as compared to other detectors discussed in this paper:

1. Less Sensitive to noise:

As compared to classical operators like Robert, Sobel and Prewitt canny edge detector is low sensitive to noise. By uses Gaussian filter which suppress noise at a great extent as compared to above filters. LoG operator is also very high sensitive to noise as differentiate twice in comparison to canny operator.

2. Remove streaking problem:

The classical operators' like Robert uses single thresholding technique but it results in the form of streaking. Streaking means if the edge gradient just above and just below the set threshold limit it removes the useful part of connected edge, and leave the disconnected the final last edge. To overcome from this type of drawback canny detector uses 'hysteresis' technique which uses two threshold values (T Low) and (T High) as discussed above in canny algorithm.

3. Adaptive in nature:

Classical operator has fixed kernels so cannot be adapted to a given image.The performance of the canny algorithm depends on variable or adjustable parameters like (Sigma) which is the standard deviation of Gaussian filter and threshold values (T low) and (T High). Smaller the value of (Sigma) results smaller Gaussian filter in turns results in fine edges. Therefore, user can changes these parameters and can improve the result of canny algorithm.

4. Good localization:

LoG operators cannot able to find edge orientation while canny operator provides edge gradient orientation, which results into good localization.

V. Conclusion

In this paper, we have studied and evaluate different edge detection techniques. We seen that canny edge detector gives better result as compared to others with have some positive clear points. It is very less sensitive to noise and resolved the problem of all streaking and provides good localization and distinguish sharper edges as compared to others.

It is consider as optimal edge detection technique hence lot of work and improvement on this algorithm has been done and further improvements are possible in future as an improved canny algorithm can detect edges in color image without converting in gray image, improved canny algorithm for automatic extraction of moving object in the image guidance.

It finds practical application in Runway Detection and Tracking for Unmanned Aerial Vehicle, in brain MRI image ,cable insulation layer measurement , Real-time facial expression recognition, edge detection of river regime, Automatic Multiple Faces Tracking and Detection .Canny edge detection technique is used in license plate reorganization system which is an important part of intelligent traffic system (ITS), finds practical application in traffic management, public safety and military department. It also finds application in medical field as in ultrasound, x – rays etc.

The edge detector performance criterion and methods of evaluation provides us a good understanding on possible ways of finding out the effectiveness of each developed detection model. Till the improved algorithms pointed out in section 8 are proved partially effective in precise ramp edge detection and reduction of noise-induced edges.

VI. REFERENCES

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