A COMPARATIVE ANALYSIS OF EDGE DETECTION TECHNIQUES USED IN FLAME IMAGE PROCESSING

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ABSTRACT

This paper presents a review over the detection of edges by taking a flame as an input image. The identification of flame edge is the process of locating a boundary between those areas where a thermochemical reactions take place. The determination of flame edges is necessary for early fire detection, fire analysis and the estimation of various flame parameters. Edge detection is an important process which aims to identify and locating the sharp intensity changes in an image. Generally, Edges are find out by reducing the unwanted or unnecessary data from an image, while preserving and maintaining it's important structural properties. The study has been done on various edge detection methods such as Sobel, Robert's cross, Prewitt, Laplacian of Gaussian (LoG), Canny edge detection & the technique which is based on Local Binary Pattern (LBP). The study also explores various advantages and disadvantages of existing edge detection techniques.

Keywords*: *Canny, Edge Detection, Flame, Local Binary Pattern, Sobel.

I. INTRODUCTION

There has been increasingly use of fire detection in power generation industries since many years. These industries continuously monitoring different types of flame to obtain geometric properties such as shape, size, location etc. and luminous properties such as brightness, nonuniformity etc. These properties are achieved if the closed and continuous contour or boundary edges of flame can be detected properly [7]. Edge detection is very important area in many applications in the field of image processing such as image enhancement, compression, watermarking, registration, retrieval, recognition and morphing. Edges are mainly occur over the boundary between two areas which are different from each other. Edges contain many points and each point occur where the brightness of image changes sharply and abruptly. These points are organized into set of curved line segments called edges [1]. Edges are used to find changes in local of intensity from an image. Edges are of different types which are a) Step edge, b) Line edge, c) Ramp edge, and d) Roof edge.

1.1 Step edge

It is a perfect transition from one segment to another segment. The intensity of image changes abruptly from one value to different value on the opposite side, called step edge.

1.2 Line edge

When the segment of an image is very narrow, then it has two edges in close proximity. This type of arrangement is called a line edge.

1.3 Ramp edge

In case of ramp edges, it allow for a smoother transition between segments. It is used for modelling the blurred edges created from sampling a image containing objects not aligned to the pixel grid.

1.4 Roof edge

when two nearby ramp edges resulting in a line structure, called roof edge. Edge detection is define as a process which identifying the fine & abrupt discontinuities over an object of an image. The abrupt changes occur in the intensity of pixel are the discontinuities which are able to characterize the object boundaries in an image. Edges detection mainly depends upon object intensity, noise, blur, illumination in an image. Edge detection plays an important pre-processing step for object recognition and object detection. The lighting conditions, the presence of objects of similar intensities, density of edges are the quality measures of edge detection [2].

The edge detection methods structurally incorporate three operations: smoothing, differentiation and thresholding. Smoothing is done for reducing the noise. Differentiation includes in evaluating the desired derivatives of an image. Thresholding is used to determine edges where some pixels are remove as noise and some pixels are retained.

II. REVIEWS OF EDGE DETECTION TECHNIQUES

The main purpose of studying various edge detection techniques is to overcome the problems which are encountered during the analysis of edges of an image. The problems such as missing true edges, fake edges, malfunctioning at the corners and curves etc. In general, all edge detection techniques are either gradient based or gaussian based [1].

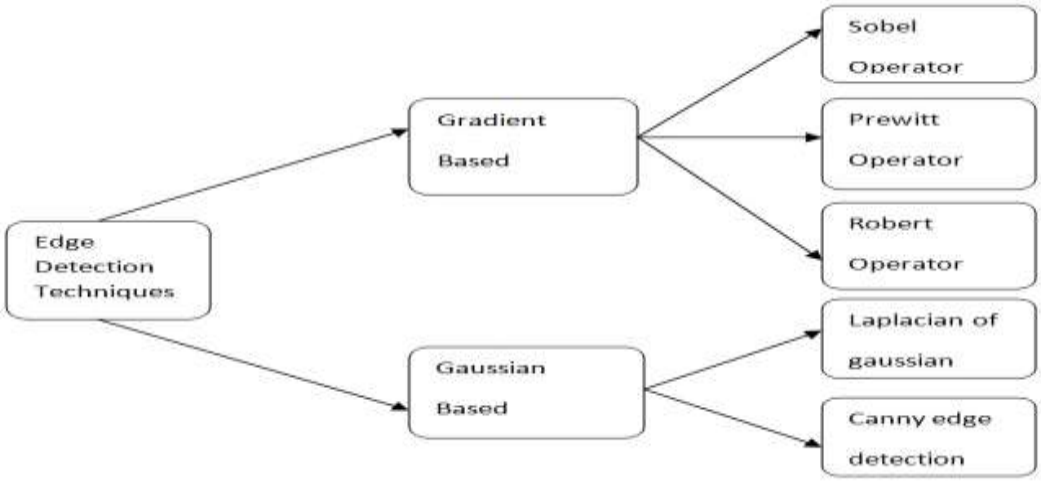


Fig. 1: Various Edge Detection Techniques [1].

2.1 Gradient based techniques

The gradient based edge detections look for the first derivative of an image where the maxima and minima are occur. These techniques used sobel, prewitt and robert's cross operator for finding the edges.

2.1.1 Sobel Operator

Sobel operator applies two dimensional spatial gradient measurements on an image and also highlight spatial component that belongs to edge. The operator contains a two 3×3 convolution mask to calculate the gradient between two directions (i.e. row and column orientation). For obtaining gradient component in each direction,

the mask is used over an image separately i.e. G_x and G_y. The Sobel Operator uses the common masks which are given by G_x and G_y [3].

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

G_x

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

G_y

The magnitude of gradient is given by: $|G|=\sqrt{G_x^2 + G_y^2}$

The gradient angle is given by: $\tan^{-1}(G_y / G_x)$

2.1.2 Prewitt Operator

The prewitt operator estimates the magnitude and orientation of edges same as sobel operator. It is used for calculating horizontal and vertical edges with 3×3 convolution mask P_x and P_y respectively. The common mask is given by P_x and P_y [4].

-1	0	1
-1	0	1
-1	0	1

P_x

1	1	1
0	0	0
-1	-1	-1

P_y

2.1.3 Robert Operator

The Robert operator is similar to sobel & prewitt and performs two dimensional gradient measurements on an image. It thus highlight region which are related to high spatial frequency of edges. The operator contains pair of 2×2 convolution mask. These masks are prepared in the manner that they give maximally response to an edges which are at 45 degree running to the grid of the pixel. The common mask is given by R_x and R_y [2].

1	0
0	-1

R_x

0	-1
1	0

R_y

The gradient magnitude is given by: $|R|=\sqrt{R_x^2 + R_y^2}$

The orientation of angle is given by: $\tan^{-1}(R_y / R_x)$

2.2 Gaussian Based Techniques

The main purpose of this technique is to detect the zero crossings in the second order derivative of an image to find edges. The Gaussian based techniques are Laplacian of Gaussian (LOG) and Canny edge detection.

2.2.1 Laplacian of Gaussian

The laplacian of Gaussian performs two dimensional isotropic estimation of the 2nd spatial order of an image. It highlights the region of fast changes in intensity that is used in the detection of edges. The laplacian of Gaussian uses Marr-Hildreth for estimating the second derivative of an image i.e. called LoG operator. [1].

It is a second derivative and defined as :

$$\nabla^2 f = \frac{d^2 f}{dx^2} + \frac{d^2 f}{dy^2} \quad (1)$$

The pixel intensity value L(x, y) of the laplacian of an image is given by:

$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2} \quad (2)$$

The common mask of the laplacian of Gaussian is given by L_x and L_y which are given below [1]

1	1	1
1	-8	1
1	1	1

L_x

-1	2	-1
2	-4	2
-1	2	-1

L_y

2.2.2 Canny edge detection

It is well known and commonly used image processing tool which is used to detect edges in a very robust manner. This method is used to find edges by separating noise from image and extract information from the image without disturbing its feature. There are some points which are to be kept in mind for improving the above said method of edge detection. These points are low error rate, well localization of edge points and one response per edge [1].

The algorithms of canny edge detection are in following steps:

Step 1 Smoothing: First of all, Smoothing is done by convolving the image with Gaussian filter to remove noise from the image. The number of steps must be followed in order to implement canny edge detection algorithm. The suitable mask is taken for smoothing with the image. When the width of the mask is larger, than the detection sensitivity to noise will be lower [1].

Step 2 Finding Gradients: After removing the noise from an image by smoothing, the next step is to find the edge strength by taking the gradient of the image. By taking horizontal and vertical gradient of an image for this purpose, this method applies respective sobel kernel mask in both horizontal and vertical direction. It uses a couple of 3×3 convolution mask that approximate the x-direction gradient and y-direction gradient [5].

Step 3 Non Maximum Suppression (NMS): It is applied over the image to find every maxima in the gradient direction that is preserve as edges and deleting everything else. Finally, it will provide thin edges in an output image [5].

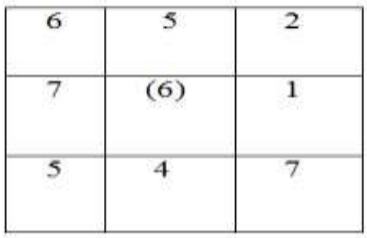
Step 4 Double Thresholding: This type of thresholding is used to determine the potential edges. The canny edge detector uses the hysteresis to do thresholding. In double thresholding, there are two types of thresholding level i.e. low threshold and high threshold. When the value of edge pixel is stronger than the high threshold then they marked as strong; An edge pixel is said to be a strong if its value is greater than high threshold and weak, if its

value is less than low threshold. Weak edge pixel must be suppressed and consider only strong pixel as well as those pixel whose value lies between low and high threshold (if they are connected to strong edge pixel)[5].

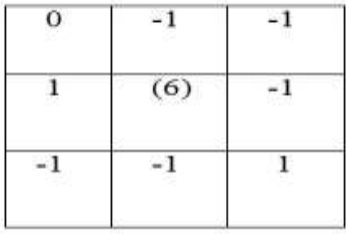
III. LOCAL BINARY PATTERN (LBP)

LBP is a gray scale texture classification operator computed from the neighbour of particular pixel which is to be analysed. This particular pixel is considered as a central pixel and the analysis is done by describing the relationship of the central pixel with its neighbouring pixel. It was first introduced by "Ojala" in the year 1996. The LBP mainly act as an unified approach to the existing statistical and structural models of texture analysis.

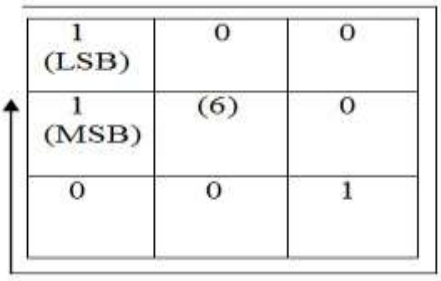
There are many other applications, such as localization of shape, recognition of face and recognition of dynamic texture. The image texture is represented by building the histograms after the identification of LBP pattern of each pixel. Due to its flexibility, the LBP method becomes applicable for different types of problems. Some extension and modification of LBP have been applied to improve its robustness and power of discrimination [6].



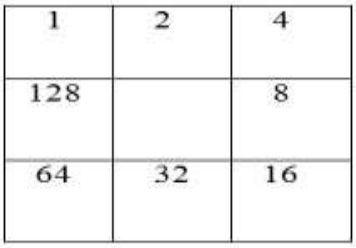
(i) 3×3 window with (6) as a Central pixel



(ii) Subtraction of central pixel from its neighbour



(iii)Assume (-) sign as 0 Other as 1



(iv) Weight Matrix

LBP Code = 10010001

$(10010001)_2 = (145)_{10}$

Fig. 2: Computation of LBP pattern

From the figure 2, it is clearly seen that if the value of the neighbouring pixel is lower than the value of central pixel, then it is assigned as 0, otherwise it is assigned as 1.Then the 8 bit LBP code is obtained by arranging 1's

& 0's in their respective positions according to their weights given by fig 2(iv). Then the central pixel is replaced by the decimal equivalent of obtained LBP code.

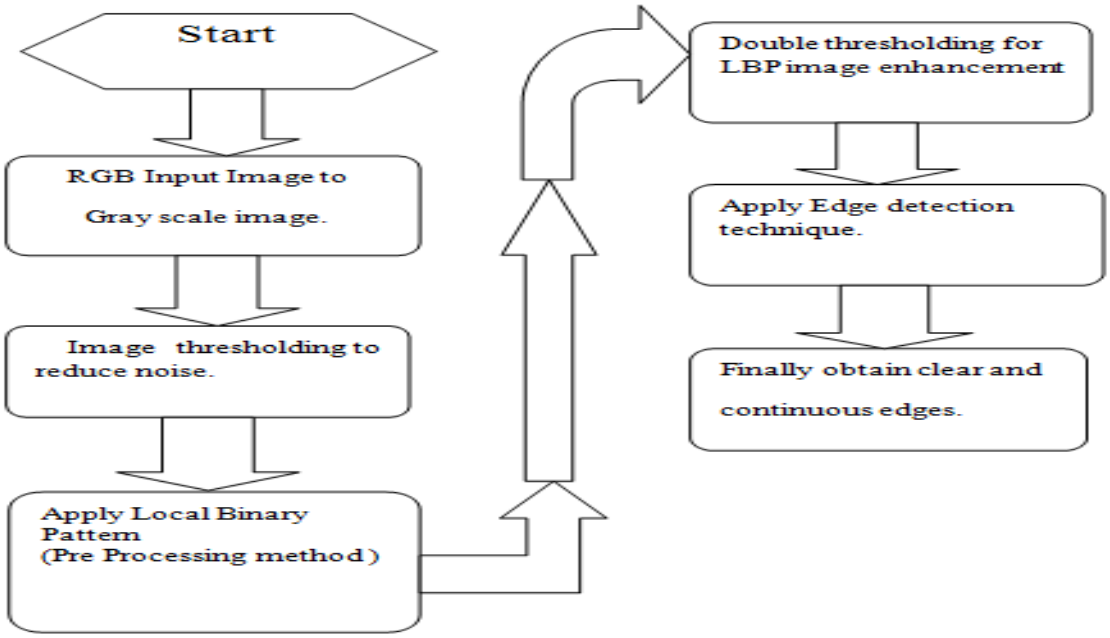


Fig. 3: The flowchart for edge detection using LBP [7].

IV. ADVANTAGE AND DISADVANTAGE OF TECHNIQUES [1]

Techniques	Advantages	Disadvantages
Gradient Based Techniques	1) It is simple, quick and easy to compute.	1) These are more sensitive to noise.
	2) Edges are detected along with their orientation.	2) The detection of edges are inaccurate.
Gaussian Based Techniques		
1) Laplacian of Gaussian	1) Due to the approximation of gradient magnitude, the cross operation detection of edges and their orientation is simple.	1) The edge magnitude degrades as noise increases due to detection of edges and their orientation.
	2) The characteristics are fixed in all direction.	2) At the corners and curves, malfunctioning are varies.
2) Canny edge detection	1) Signal to noise ratio is improved.	1) Complex and time consuming computation.
	2) Better detection in noise condition.	2) False zero crossing.

V. EXPERIMENTAL RESULTS

In this paper, flame image is considered to study various edge detection techniques:

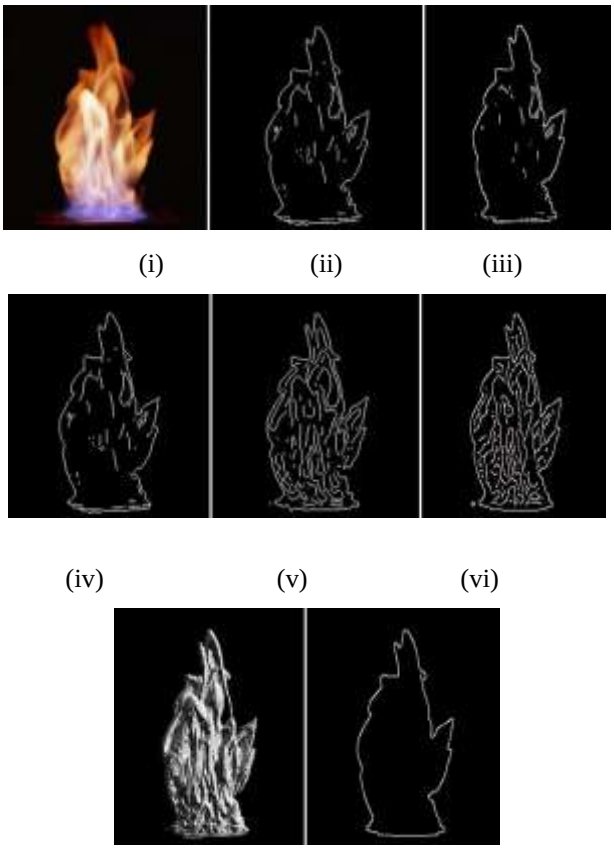


Fig. 4: Comparison of different edge detection methods (i) Original Image, (ii) Sobel method, (iii) Robert method, (iv) Prewitt method, (v) LoG method, (vi) Canny method,(vii) LBP Image, (viii) Edge detection after applying LBP.

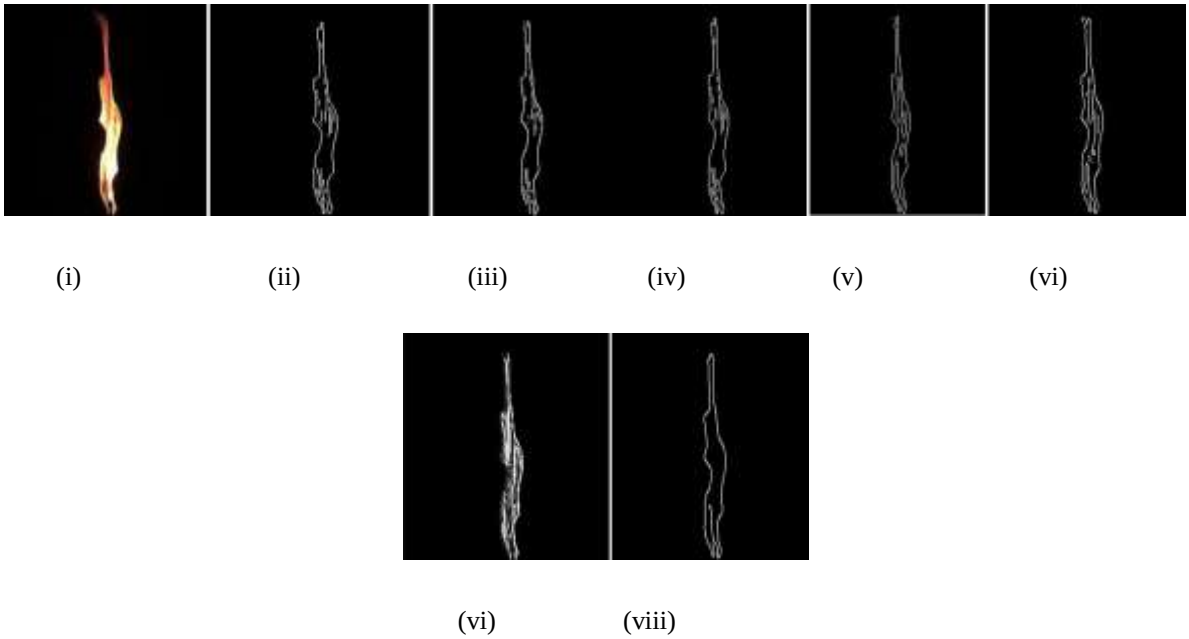
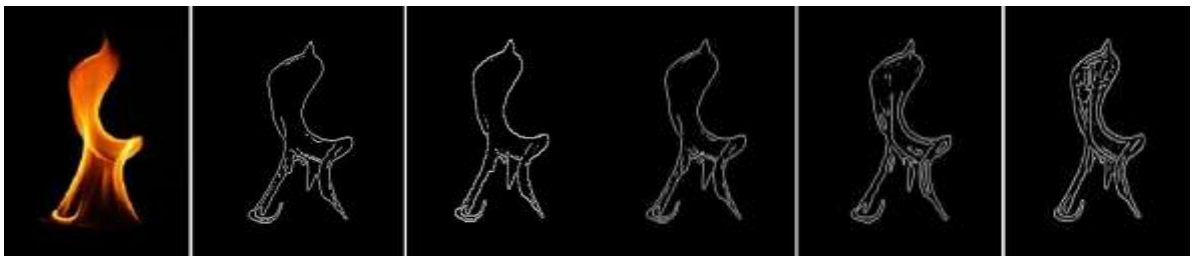
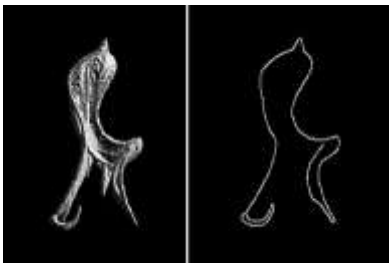


Fig. 5: Comparison of different edge detection methods (i) Original Image, (ii) Sobel method, (iii) Robert method, (iv) Prewitt method, (v) LoG method, (vi) Canny method,(vii) LBP Image, (viii) Edge detection after applying LBP.



(i) (ii) (iii) (iv) (v) (vi)



(vii) (viii)

Fig. 6: Comparison of different edge detection methods (i) Original Image, (ii) Sobel method, (iii) Robert method, (iv) Prewitt method, (v) LoG method, (vi) Canny method,(vii) LBP Image, (viii) Edge detection after applying LBP.

VI. CONCLUSION

The main aim of this paper is to present a review on various edge detection techniques. The sobel, Robert and Prewitt can compute the edges along their orientation easily but the detection of edges are inaccurate and more sensitive to noise. Canny edge detection in comparison to sobel, Robert and Prewitt is complex, it's computation is time consuming and detection of edges is immune to noise. But after analysis of different types of edge detection techniques, it is concluded that the detection based on Local Binary Pattern gives better results in comparison to Canny edge detection. Experimental results proved that clear, continuous and uninterrupted edges are obtained through LBP which is necessary for the estimation of various parameters of a flame.

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BIOGRAPHICAL NOTES

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