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Edge Detection on Noisy Image Frames Obtained from Video

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Abstract: One of the vital steps in digital image processing & image segmentation is Edge detection. Digital image processing is one of the most important tools in image processing and computer vision. Edge is a basic feature of the image, comprises rich information which plays a vital role for attaining the characteristics of image and also helpful in object recognition. Edge describes boundaries of actual image, which is a fundamental difficult in image segmentation. Edge detection is an image processing technique used for finding the boundaries of objects inside images. Detecting an edge in image declines the amount of data as well as screens out unwanted information, while keeping the important properties of an image. In this proposed methodology, traffic surveillance camera video is taken as the input which is converted into 2D image frames with noise. Canny edge detector with Sobel filter is used for edge and object detection in the image. Canny edge detection is one of the broadly used algorithms for optimal edge detectors. Sobel filter with 3×3 convolution kernels is used to eliminate noise in the image and used as a filter in many of the edge detection algorithms, for a range of applications: e.g. number plate recognition of vehicles and efficiently retrieve it in the string format. The proposed method using Canny edge detection with Sobel filter performs improved than all the other edge detection algorithms. The proposed algorithm attains 92% of accuracy in edge and object detection.

Keywords: Image processing, Edge Detection, Canny edge detection, Sobel filter, Noisy Images, Image frames, Video.

I. Introduction

Image processing has been developed essentially for two purposes. The first is for improved interpretation of images by humans and the second is for analysis, data storage, and transfer. Substantial improvements have been made to image processing. Image processing is used in several areas such as medical imaging and surveillance, security, retrieval and more. There are several uses in image processing such as feature extraction, object detection, image analysis, where they have image segmentation as a pre-processing. Edge detection is an important stage in dissimilar image processing operations like pattern recognition, feature extraction, and computer vision [1]. It is an extensively used operation in image processing and plays a very significant role in identifying and splitting geometric shapes in the image. The edges always contain vital information from the image. The objects in the image are divided by the edges of the image. Thus it can be said that one of the most important steps in machine vision is edge detection.

The edge detection identifies and locates sharp discontinuities and variations in an image. These discounters are the alterations in the intensity of a pixel that may state the boundaries of an object in an image or the boundary among different regions of an image. Numerous computer vision applications, such as edge-based obstacle detection, edge-based vehicle recognition, or edge-based target recognition initiate with these object bounders. The image processing application usually includes detection of the edges of a vehicle followed by vehicle type classifications. During the detection of vehicles, a well-known edge detection algorithm such as Canny is considered between other existing options [2].

Currently, video cameras are progressively used for surveillance, monitoring, and activity recording. These cameras produce high resolution image and video data at large scale. Processing such large scale video streams to

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extract required information with time constraints is a most challenging task. Traditional methods do not offer scalability to process big scale data [3]. In order to certify safety measures on roads of India, the identification of traffic rule violators is highly wanted but challenging job due to several difficulties such as occlusion, illumination, etc. In this paper we propose an end to end framework for detection of violations, notifying violators, and also storing them for analyzing and producing statistics for enhanced decision making regarding traffic rules policy. Once violations detected, vehicle numbers are attained of respective violators and violators are notified. Thus an end to end autonomous system will support imposing strong regulation of traffic rules.

II. Related Work

Ehsan Akbari Sekehravani et al., 2020, proposed a novel method that increases the accuracy of the Canny edge detection algorithm for noisy images. The proposed method used median filter for reducing the noise in edges once they are detected by the Canny edge detection algorithm. Outcomes presents that this proposed method can absolutely overwhelmed noise disorders, preserve the edge useful data and similarly improve the edge detection precision. Experimental outcomes have shown that with the proposed method, edges in noisy images can be detected efficiently and better in edge and detail detection than standard Canny algorithm [4].

Phusit Kanchanatripop et al., 2020, proposed an adaptive edge detection technology for images based on discrete algorithm along with standard Canny operator. At First, based on the associated literature research, the traditional sub-pixel edge detection method is demonstrated. Then, Canny operator is used for detection, the edge model of the quadric curve is renowned using discrete data, and the adaptive image edge parameters are attained using one-dimensional gray moment. The research outcome displays that the accuracy of feature detection is 99%, which can be applied to work out image edge detection at assured level [5].

Khalid Alshalfan et al., 2020, proposed a technique that distinguishes among contrast colors and detects edges based on the threshold value. In this method, median filters is used to remove noise in the image, then calculated the high and low threshold values to create a chain of edge between start and week edge. The technique was studied on three well known databases Pascal, Corel, and Berkeley. At last, the outcomes were estimated with qualitative and quantitative assessment tests. The outcomes were inside the range of entropy [6].

Nati Ofir et al., 2020, proposed a method for faint edge detection that works in a linear complexity, by training the network on a dataset of binary image.Even though their method is orders of magnitude faster, they still achieve greater accuracy of detection under numerous challenging scenarios. In addition, they show that their method to performing multi-scale pre-processing of noisy images using U-net advances the ability to perform other vision tasks under the existence of noise. They show it on the difficulties of noisy objects classification as well as classical image de-noising. They display that multi-scale de-noising can be carried out by a novel edge preservation loss. From their experiment, they achieve high-quality results in the three aspects of faint edge detection, noisy image classification as well as natural image de-noising [7].

M F V Ruslau et al., 2019, The authors conducted edge detection in the image by means of outlining the right edge detection method to recognize edges in noisy images. The results showed that, deprived of filtering the image, in noisy edge, the LoG operator was capable to identify edges and decrease noise improved than Canny. Based on the consequences then discussion, it can be decided that at the noisy image, the LoG operator is capable to decline noise improved than the Canny Operator. To achieve good edge detection outcomes, it should be noted about the choice of threshold and the appropriate standard deviation for all edge type [8].

III. Proposed Methodology

Edge detection plays a vital role in image segmentation for object recognition. Elementary features of an image & boundary of the image are incorporated in edge. Proposed method uses Canny edge detection algorithm with Sobel filter for edge detection. Proposed methodology endures the following process:

a) Pre-processing
b) Conversion to Grayscale
c) Blurring grayscale image
d) Edge Detection
    i) Filtering
    ii) Finding gradients
    iii) Non-maximum suppression
    iv) Double thresholding
    v) Edge tracking by hysteresis
e) Object Detection

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a) Pre-processing

Traffic surveillance video is used as an input in this research. As like any videos, there are noises existing in the input video. Pre-processing is the first step to make the input video to next stage. In this stage, input video is divided into image frames for further processing. Each image frame is consecutively numbered and stored in one folder. The output of pre-processing (image frames) would be obtainable for the next stage to perform complicated video sequence processing tasks on the input video data.

b) Conversion to Grayscale

Output of pre-processing process, which are image frames are altered into grayscale for further image processing. Image is a group of pixels and every pixel is defined by three dissimilar colors; Red, Green & Blue (RGB). Colored images are transformed into gray-scaled image in this process.

c) Blurring grayscale image

Converted grayscale images are blurred to get significant edges and to ignore noise. In this research, Gaussian blur is performed on the gray-scaled image. Blurring process eradicates some of the noises in image before further processing. Gaussian blur is categorized by the sigma parameter. A sigma of 1.4 is used in this instance and was determined through trail & error.

d) Edge Detection (Canny Edge Detection Algorithm)

Canny edge detection algorithm is one of the usually used image processing algorithm which detect edges in a robust manner. Canny edge detection is not very prone to noise unlike other edge detection algorithms. It is one of the most vital methods to find the edges by separating noise from input images. It is a much improved method because it draws out the features in an image without disturbing image features.

Edge detection in this technique is optimized with regard to the succeeding criteria:

- Increasing the signal-to-noise ratio of the gradient
- Edge localization for certifying the accuracy of edge
- Reducing many responses to a single edge

Working method of canny edge detection algorithm can be separated into 5 different steps:

1) Eliminate image noise and smooth the image by applying Gaussian filter. In this research, Sobel filter is used instead of Gaussian filter.
2) Find the image's intensity gradients.
3) Spurious responses to edge detection are rejected by applying non-maximal suppression.
4) Potential edges are resolute by applying double threshold.
5) Edge tracking by hysteresis: Detected edges are definite by hiding all the other edges that are not strong and not even linked to any strong edge.

The steps in proposed Canny edge detection method are discussed below:

(i) Filtering: Sobel filter is one of the usually used filters in many of the edge detection algorithms for a range of applications: e.g. number plate recognition of vehicles and effectively retrieve it in the format of a string. In order to reclaim the edge image and abstract the rectangular area in the original image which represents the number plate, Sobel filter is applied on a pre-processed image. Sobel filter is used together with Canny edge detection algorithm to display the vertical and horizontal groove pattern in the edge. To find the intensity gradient of the edges in the image, Sobel filter is performed on both the X and Y dimensions. The Sobel filter compute the derivative of the curves that fits the gradients among light as well as dark areas in an image, and then it finds the top of the derivative which is considered as the location of an edge pixel. The operator contains a pair of 3×3 convolution kernels as given in Figure 1. One kernel is just the other revolved by 90°.

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

s(Gx)

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

s(Gy)

Figure 1. 3x3 Convolution kernels of Sobel operator

In order to get maximum response from the edges running vertically and horizontally relative to the pixel grid, the kernels are designed as one kernel for all of the two perpendicular orientations. The Sobel kernels are applied to the given image which produces distinct measurements of the gradients in each direction x and y (call these s(Gx) and s(Gy)). These gradients can be joined together to find the absolute magnitude of the gradient at every point as well as the orientation of the gradient.

(ii) Finding gradients: The edge strength and direction has to be recognized by taking the gradient of the image after

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eliminating noise. This is attained by applying Sobel filter on the pre-processed image and the approximate absolute gradient magnitude is found at every pixel. This can be calculated by using the equation (1),

$$s(G) = s(Gx) + s(Gy) \qquad \ldots (1)$$

Where,s(G)is gradient of pixel using Sobel

s(Gx)is gradient of pixel in x-direction using Sobel

s(Gy) is gradient of pixel in y-direction using Sobel

Where s(Gx), s(Gy) are shown in above Figure 1

The angle of orientation of the edge (relative to the pixel grid) giving growth to the spatial gradient is assumed by the equation (2),

$$\text{Theta } (\theta) = \arctan (s(Gy) / s(Gx)) \qquad \ldots (2)$$

Where Theta (θ) is the direction of edge to trace

(iii) Non-maximum suppression: It refers to elimination of pixels, but seems too far from any edge. By using the edge direction which is calculated in the beyond step (ii) we move along the edge and disregard the pixel that does not belongs to the edge. Edge lines that are thinner are the output. The resolution of this step is to transform the "blurred" edges in the image of the gradient magnitudes to "sharp" edges. This is done by conserving all local maxima in the gradient image, and removing everything else. The algorithm is for every pixel in the gradient image:

a) Round off the gradient direction θ to the nearest 45◦, consistent to the use of an 8-connected neighborhood.
b) Edge strength of the current pixel and the edge strength of the pixel in the positive & negative gradient direction are matched. i.e. if the gradient direction is north (theta = 90◦), then relate with the pixels to the north as well as south.
c) If the edge strength of the current pixel is largest; reserve the value of the edge strength. If not, suppress (remove) the value.

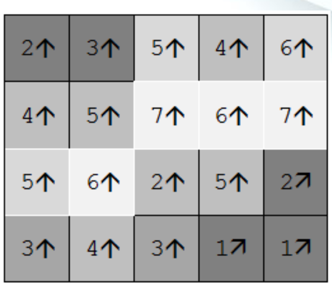

Figure 2. Non- maximum suppression

(iv) Double thresholding: The fixed edge pixels after the non-maximum suppression step are clean and clear with their strength pixel-by-pixel. Many of these will be accurate true edges in the image, but some may be due to noise or color variations for example due to rough surfaces. The simplest way to identify these would be to use a threshold, so that only certain valued stronger edges are conserved. Canny edge detection algorithm uses double thresholding which removes the discontinuities in the edge lines. Stronger edge pixels than the high threshold are considered as strong; weaker edge pixels than low threshold and the edge pixels between the two thresholds are considered as weak.

(v) Edge tracking by hysteresis: Hysteresis is used to execute the final detection of edges. Weak pixels are studied and if they are related to a strong pixel candidate, they are considered to be edge pixels; enduring connected to weak pixel candidate is turned off.

e) Object Detection

Occurrence of an object in a video sequence and location in the image are determined by Object detection. Object detection can be categorized into soft detection & hard detection. When only the occurrence of an object is detected then it is termed as soft detection. When the occurrence& location of the object is identified then it is termed as hard detection. The process of finding an object of real-world in video sequences is called as Object detection. The Region of Interest (ROI) shows a nominated area from video sequences to split frame as shown in Figure 3. It gives more detailed information about an image deprived of changing the view angle. It is sometimes of interest to process single parts of an image, leaving other portion unaffected.

Figure 3. Object Detection with Region of Interest

STEPS INVOLVED IN PROPOSED METHODOLOGY

Step 1: Collect image frames from surveillance video

Step 2: Convert RGB image into grayscale image, if it is a color image

Step 3: Blur the grayscale image which helps in important edges extraction and ignore noise

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Step 4: Smooth the images and use Sobel filter to suppress the noise

Step 5: Calculate magnitude the gradients obtained

Step 6: Calculate directions of the gradients

Step 7: Make non-maxima suppression for the gradient to get better estimate of the magnitude values of the pixels in the gradient direction

Step 8: Get best high & low thresholds by iterative algorithm

Step 9: Detect and connect the edge with dual-threshold algorithm

Step 10: Refine the edge by hysteresis

Step 11: Using perfect edges resulted from canny edge detection and Sobel filter, the number plate details is found accurately without any noise

IV. Experimental Result

The proposed method for edge detection in noisy images attained from video of traffic surveillance camera was executed in MATLAB R2015a. Experimentations were implemented on the platform Intel(R) Core(TM) i5-4210U CPU at 1.70GHz, 4GB RAM, Microsoft Windows 10 Enterprise. The original images are shown in Figure 4, which is damaged by a noise illustrated in Figure 5, for executing the proposed method. Figure 5.shows the noisy images where the noise is obtainable in terms of white and black points. These white and black points are known as salt and pepper noise.

1. Converting video into image frames: The surveillance video given as an input is transformed into 'n' number of image frames as shown in Figure 4.

2. Grayscale Conversion: Convert the images to grayscale. In MATLAB the intensity values of the pixels are 8 bit as well as range from 0 to 255. The following Figure 5 shows the translation of RGB (original image frames) into grayscale image where the noise are obviously visible.

3. Blurring grayscale image frames: The grayscale image frames are blurred using Gaussian blur to get vital edges in the image and to eliminate noise before processing the image. Figure 6.shows the blurred grayscale image frames. A sigma of 1.4 is used in this instance.

4. Applying Sobel Filter: Gradients at every pixel in the smoothed image are determined by applying the Sobel operator. First step is to estimate the gradient in the x and y direction correspondingly by applying the kernels. Here we used 3x3 convolution method. The gradient in the x and y direction of the image frames are shown in the Figure 7.

5. Finding Magnitude of the gradients: The magnitude of the gradients is calculated by using the gradient of x & y. The magnitude of the gradients in the illustration is shown in Figure 8.

6. Non Maximal Suppression: Mostly, the image magnitude produced outcomes in thick edges; rather the final image should have thin edges. Hence, non-maximum suppression is performed to thin out the edges as shown in Figure 9.

7. Double thresholding: Edge pixels stronger than the high threshold are considered as strong and the edge pixels weaker than the low threshold and the edge pixels between the two thresholds are considered as weak. The result on the test image frames is shown in Figure 10.which is the resultant image of canny edge detection.

8. Object Detection: From the resultant image of canny edge detection, the vehicle number is identified from the number plate. Subsequently, we are using Sobel filtering; the rectangular part in an image can be identified accurately. The object detection of the test image frame is shown in the Figure 11.

(a) Frame 1 (b) Frame 2 (c) Frame 3

Figure 4. Original image frames obtained from traffic surveillance video

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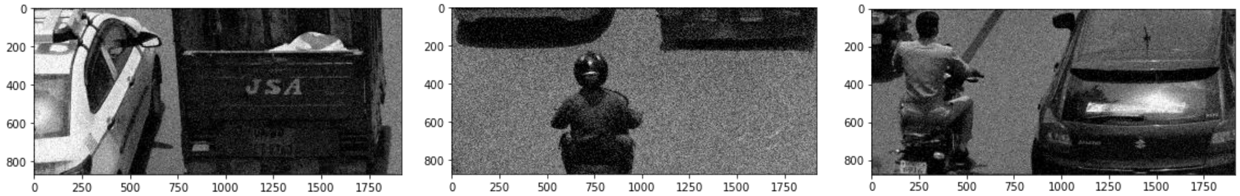
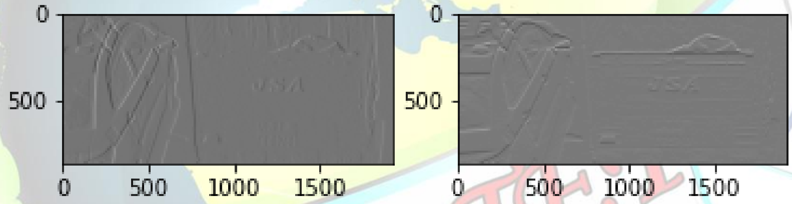


(a) Frame 1 (b) Frame 2 (c) Frame 3

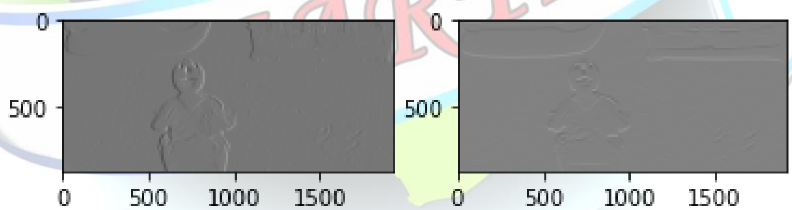
Figure 5. Converted grayscale image with noise

(a) Frame 1 (b) Frame 2 (c) Frame 3

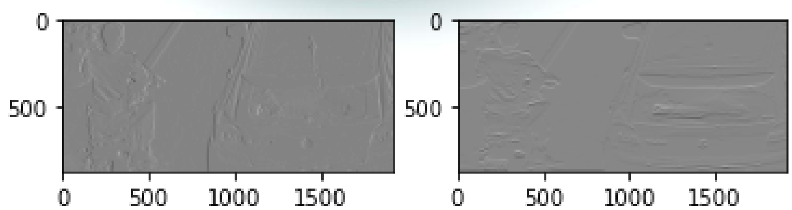
Figure 6. Grayscale image is blurred to extract edges and ignore noise



(a) Frame 1 (x and y gradients)



(b) Frame 2 (x and y gradients)



(c) Frame 3 (x and y gradients)

Figure 7. Sobel Filter in x and y direction

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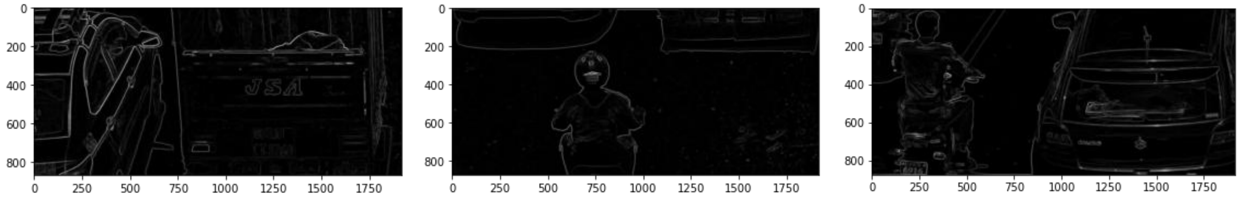
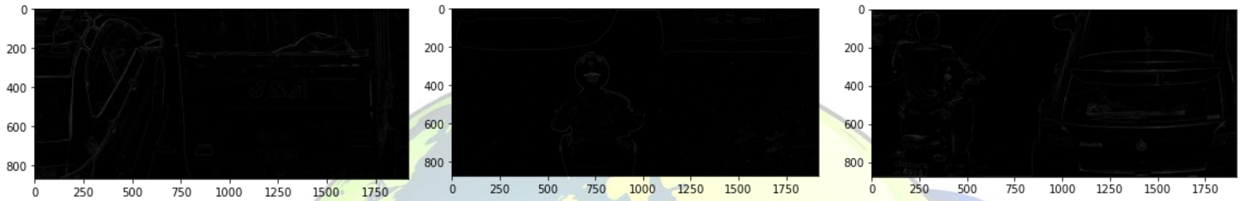


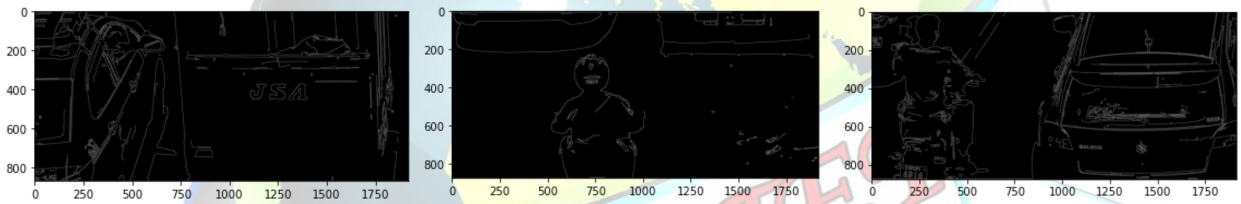
(a) Frame 1 (b) Frame 2 (c) Frame 3

Figure 8. Magnitude of the gradients



(a) Frame 1 (b) Frame 2 (c) Frame 3

Figure 9. Non-Maximal Suppression



(a) Frame 1 (b) Frame 2 (c) Frame 3

Figure 10. Result of Canny Edge Detection

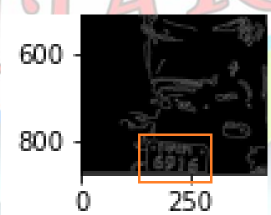


Figure 11. Object Detected

Result: From the outcomes it is clear that by using the Sobel filter for edge detection and object detection attains better result than the canny edge detection which uses Gaussian filter for smoothing. The object detection using Canny edge detection and Sobel filter attains 92% of accuracy.

V. Conclusion

Edge detection is a vital task in image segmentation for object detection. Edge comprises elementary features of an image and also describes the boundary of the image. Detection of edges classifies boundaries and objects; therefore it is extensively used for image segmentation. In the proposed model, image frames are composed from the traffic surveillance camera with noise. Canny Edge detector is the optimized edge detector and it targets to result in good accuracy in edge detection. Proposed method uses both canny edge detection for edge detection and uses Sobel filter in order to eliminate any noise. This Sobel filtering smoothens the input image and gives enhanced output. Canny edge detection algorithm uses the 3x3 Sobel kernel on the gradient operation step which gives the most effective result. The experimental outcome shows that edges and objects are accurately identified in the proposed method. Object detection attained 92% of accuracy by using canny edge detection and Sobel filter. This method can be improved by detecting the edges in a color image without converting it into a grayscale image.

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