Real-Time Object Detection Using Different Edge Detection Technique

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Abstract - The process of using several arithmetic approaches to locate spots in a picture where the brightness is discontinuous. Edge detection is used in object detection. We have edge detection operators such as Prewitt, Canny, Sobel, & others. The ultimate outcome of edge detection is determined by factors such as the density of edges in the picture, as well as noise and light. When there is a shift in intensity from one pixel to another, edge detection decreases the complexity of image processing algorithms, resulting in a change in picture quality. Important structural features must be preserved during edge identification. The goal of glimpsing sharp changes in picture brightness is to document significant events and changes in the world's attributes. Discontinuities in picture brightness are expected to correlate to aspects like a discontinuity in the depth, discontinuities in surface orientation, changes in material qualities, and also variations in scene lighting given very generic assumptions for an image creation model.

Keywords - Edge detection,

1. INTRODUCTION

Whenever the image brightness fluctuates suddenly or, more formally, includes discontinuities, edge detection relates to the collection of mathematical algorithms for locating curvature in a digitized picture. Step detection is the task of locating jumps in one-dimensional signals, whereas change detection is the task of locating signal discontinuities spanning time. Edge detection is a crucial approach in image recognition, object tracking, and computer vision, notably in the disciplines of detection & differentiation and extraction.

2. PURPOSE

The Aim is to develop a MATLAB code which can detect objects from real-time images.We then apply different edge detection techniques on real-time images from the input camera and compare the results.

3. CONCEPT

Convolution is used for a variety of tasks, including computing derivatives, identifying edges, and applying blurring, among others, and it is accomplished using a "convolution kernel." A convolution operation is a very tiny matrix that contains a number and an anchor point for each cell.
The reference point is often used to determine the kernel's location in relation to the picture. It begins at the upper left corner of the image then proceeds through each pixel in turn. At each place on the picture, Kernels overlaps a few pixels. Each overlapping pixel is amplified and then added together. And the current position's value is set as the total. Convolution is the method of adding each picture element to its close neighbors and then weighing it by the kernel. It has something to do with a type of mathematical convolution.
The matrix in Convolution does not execute typical matrix multiplication and is indicated by * instead.

0	-2	0
-1	0 anchor	-1
0	-2	0

Table [1]

4. WORKING

There are two 3x3 matrices, one is kernel and another one is an image piece. In convolution, rows and columns of the kernel are flipped and then they are multiplied and then summing is performed. Elements which are present in the center of the matrix i.e. in [2,2] of the image will be a weighted combination of the image matrix and the weights will be given by the kernel. Similarly, all the other elements of the matrix will be weighted and then weights will be computed.

Convolution can be computed using multiple loops. But using for loops causes a lot of repeated calculation and also the size of the image and kernel increases. Using Discrete Fourier Transform technique calculating convolution can be done rapidly. In this technique, the entire convolution operation is converted into a simple multiplication. In convolution, the problem occurs when the kernel is near the edge or corners because the kernel is
two dimensional.

To overcome these problems the following things can be done:
1. Ones can be ignored
2. Extra pixels can be created near the edges.

Extra pixels can be created in the following ways:
1. Duplicate edge pixel.
2. Reflect edges
3. Pixels can be copied from the other end.

The technique of applying a filtering kernel to an image in the image space is known as convolution. Table [2] shows the basic steps:

1. Invert the Kernel both horizontally and vertically (centre of the kernel must be provided)
2. Move the kernel around the array, centred on an interesting place.
3. Multiply the kernel data by the number of overlapping regions.
4. The output should be summed or accumulated.

Example:

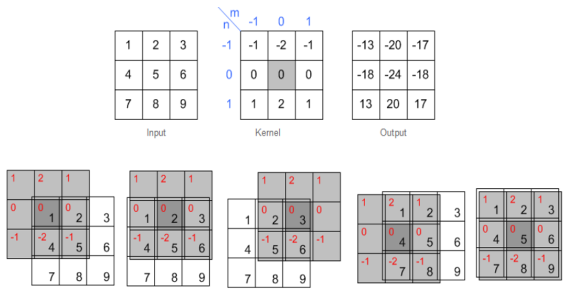


Table [2]

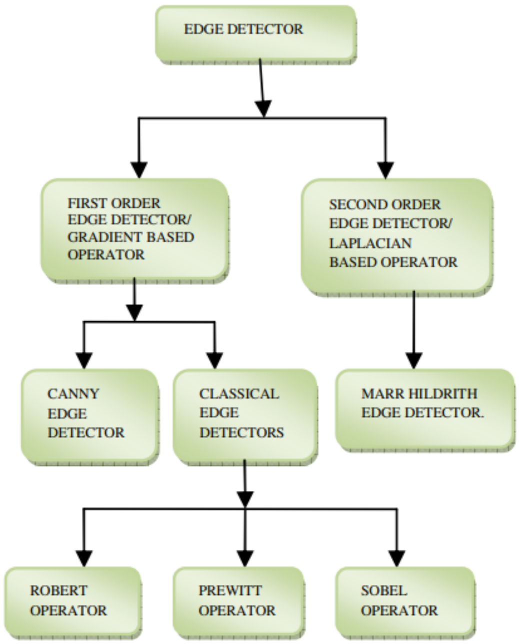
5. EDGE DETECTION TECHNIQUES

The edge depiction of a picture lowers the amount of data that must be examined while preserving vital information about the forms of objects in the picture. This visual analysis is simple to implement in a variety of object identification algorithms used in computer vision and other image analysis systems.

For picture segmentation, edge detection is a critical technique.Edge detection algorithms that transform original photos into edge images benefit from differences in subtle shading in the image. Edge detection approach for locating substantial changes in a greyscale image and determining the structural and geometrical features of scene objects in image processing, notably in computer vision.
Edge detection is the most often used approach for detecting substantial intensity level discontinuities.

Because it makes higher-level picture analysis simpler, edge detection is a prominent topic in the field. There have been three types of discontinuities in the grey scale: point, line, and edges. Spatial masks can identify all three types of discontinuities in an image.

For picture segmentation, there are several edge detection algorithms in the literature.
This section examines the most widely used discontinuity-based edge detection approaches.



Flowchart [1]

In image processing, there are two basic filtering methodologies:

1. Low Pass Filter (LPF): Low pass filtering is used to remove good spatial frequency distortion from digital images.

2. High Pass Filter (HPF): A high pass filter is the first step in most sharpening methods. Sharpening occurs when visual contrast between neighbouring regions is increased with minimum variation in brightness or darkness.

5.1 Low Pass Filter (LPF):

Low-pass filtering is the most fundamental of filtering procedures. A low-pass filter, often known as a "blurry" or "softening" filter, smooths out fast intensity variations. The most basic low-pass filter simply averages a pixel's eight closest neighbours. The pixel's original value is replaced as a result of this. Each pixel in the picture undergoes the same procedure.
The noise is affected more than the picture by the low-pass filter. Reduced noise allows for the detection of previously undetectable changes. As a result, a low-pass filter could be used to bring forth information that has been masked by disturbance.

0	1/8	0
1/8	1/2	1/8
0	1/8	0

Table [3]
Original Image:

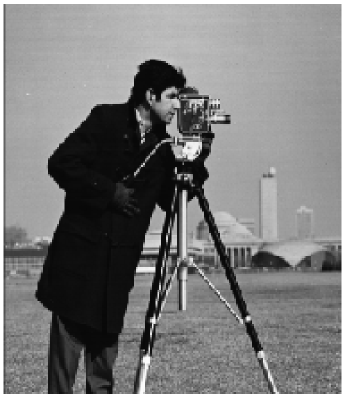


Figure [1]

After applying LPF filter:

Figure [2]

When the Low Pass Filter is applied to the image it smoothes the edges of the image by making them faint[2]. So to get dark and sharp edges we use the High Pass Filter.

5.2 High Pass Filter (HPF):

A high-pass filtration can be used to improve a picture's sharpness. In contradiction towards the low-pass filtering, these filters bring out fine features of the image. High-pass filtering is identical to low-pass filtering, with the exception that it uses a more powerful convolutional layer(s).. Notice the negative indications for the neighbouring pixels in the Table [4] example below. Nothing happens if the intensity does not vary. However, if that unit is darker than its Neighbours, it is enhanced.

0	-1/4	0
-1/4	2	-1/4
0	-1/4	0

Table [4]

Original Image:

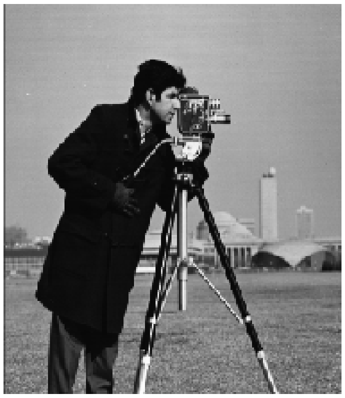


Figure [3]

After applying HPF filter:

Figure [4]

Small, weak features can also be dramatically magnified when using high-pass filter. An image that has been over-processed will appear grainy and artificial, and defining feature will be surrounded by dark donuts. While high-pass filtering may typically improve a picture by sharpening detail, using it excessively might actually damage image quality.

There are many other edge detection techniques in image processing such as Roberts, Sobel, Prewitt, Canny and LoG edge detection.
In this section we will see each of these techniques in detail.

5.3 Roberts Edge Detection

$$\frac{\partial f}{\partial x} = f(i, j) - f(i+1, j+1)$$

$$\frac{\partial f}{\partial y} = f(i+1, j) - f(i, j+1)$$

The Roberts edge detection delivers a simple, fast 2-D spatial gradient calculation. This approach highlights high spatial frequency areas, which frequently correlate to edges. The most typical application of this technology is to give the operator a grayscale image that matches the output. Every pixel value in the output represents the estimated entire magnitude of the input image's spatial gradient at that place.

-1	0
0	+1

G_x

0	-1
+1	0

G_y

Table [5]

Original Image:

Figure [5]

After applying Robert edge detection:

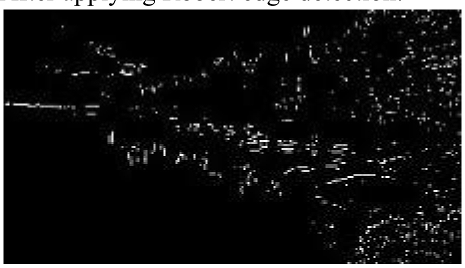


Figure [6]

5.4 Sobel Edge Detection

The Sobel technique of image segmentation edge detection uses the Sobel approximations to the derivation for discovering edges. At the spots at which gradients have become the steepest, it appears before the edges. The Sobel approach emphasises regions of high spatial frequencies that correlate to edges by performing a 2-D spatial gradient quantification on a picture.
The operator, at the very least, is made up of a set of 3x3 convolution kernels, as shown in the table below. One kernel is just 90 degrees rotated from the other. The RobertsCross operator is pretty similar to this.

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

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

G_x

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

G_y

Table [6]

Original Image:

Figure [7]

After applying Sobel edge detection:

Figure [8]

5.5 Prewitt Edge Detection

Prewitt edge detection is the accurate method for estimating the size and direction of an edge. Despite the fact that different gradient edge detection requires a lengthy calculation to determine the direction first from magnitudes in the x and y directions,

For eight directions, using gradient-based edges detection gets calculated in the 3x3 neighbourhood. All eight convolution masks have been computed. Then, for the purpose of the biggest module, one complication masking is chosen.

Prewitt detection is considerably easier to implement in terms of computing than Sobel detection, but somehow it generates noisier results.

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

G_x

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

G_y

Table [7]

Original Image:

Figure [9]

After applying Prewitt edge detection:

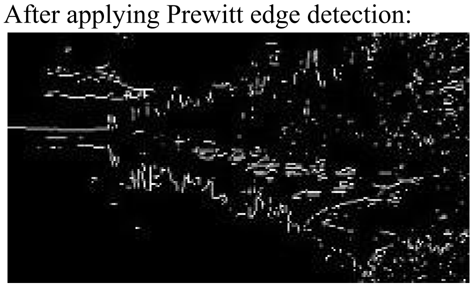


Figure [10]

5.6 LoG edge detection

The second-order derivative of an image f(x,y) is the Laplacian of Gaussian (LoG).

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

It has two effects: it smooths the image and calculates the Laplacian, resulting in a double-edged image. Determining the zero crossings within the dual edges is the next step in recognizing edges. The mask below is typically used to digitally implement the Laplacian function.

0	-1	0
-1	4	-1
0	-1	0

G_x

-1	-1	-1
-1	8	-1
-1	-1	-1

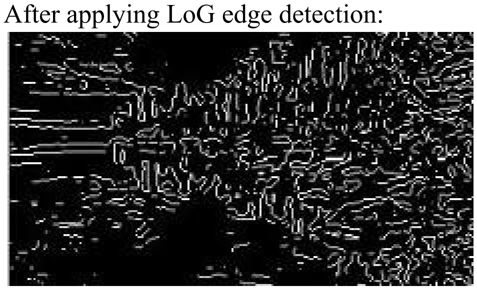
G_y

Table [8]

Original Image:

Figure [11]

After applying LoG edge detection:



[12]

5.7 Canny Edge Detection

One of the most used edge detection algorithms is Canny. It discovers edges by first removing noise from the picture before looking for edges. Canny is a crucial technique. By using the propensity to detect the edges and a serious threshold value, the Canny technique is a superior approach that does not affect the attributes of the boundaries in the image.
The Canny operation, unlike Roberts & Sobel, is not very sensitive to noise. The Canny detector would be excellent if it functioned effectively.

Smooth by Gaussian

$$S = G_\sigma * I \qquad G_\sigma = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Compute x and y derivatives

$$\nabla S = \left[\frac{\partial}{\partial x} S \quad \frac{\partial}{\partial y} S \right]^T = \left[S_x \quad S_y \right]^T$$

OriginalImage:

Figure [13]

After applying Canny edge detection:

Figure [14]

6. EXPERIMENTAL RESULTS

On the basis of performance of different edge detection approaches, such like Sobel, Robert, Prewitt, Log, and Canny Edge Detection are presented in this section.
The edge detection approaches were developed in MATLAB and evaluated with an image goal in order to build a tidy adaptive threshold by extracting the image's main edge characteristics.

Edge Detection On Still Image:
Look at figures [15],[16] they show the original picture and the image generated using various edge detection algorithms.

Image No. 1:

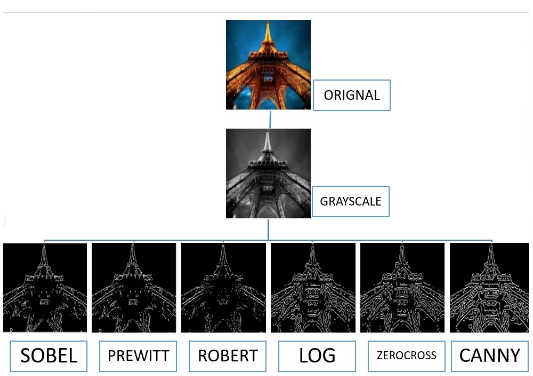


Figure [15]

Image No. 2:

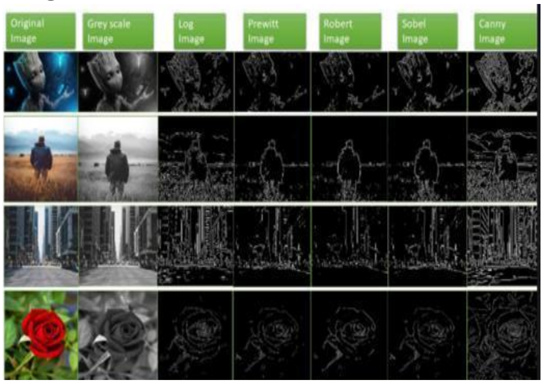


Figure [16]

The results of Roberts, Sobel, and Prewitt differed from the rest. The edge map generated by LoG and Canny is nearly identical. The Canny result is clearly superior to the other outcomes, as seen in the graph.

Techniques	Pros	Cons
Sobel, Prewitt, Robert	Simpler to implement, while detection of edges and their orientation.	Highly sensitive to image noise and inaccurate results.
Laplacian of Gaussian (LoG)	Covers a wider area around the pixels, meanwhile finds correct places of the edges.	High chances of finding false edges and localization errors on the curve edges.
Canny	Good edge detection in noisy images, while improving signal to noise ratio (SNR).	Complexity in computation, false zero crossing and time consuming.

Table [9]

Table [9] shows that the LoG & Canny edge detection create almost identical edge maps. Because different edge detectors function better under different situations, Canny's solution is superior to all others for a given picture. Despite this, there are several edge detection strategies in the literature, as it is a difficult problem for researchers to detect the precise picture minus distortion from the input images.

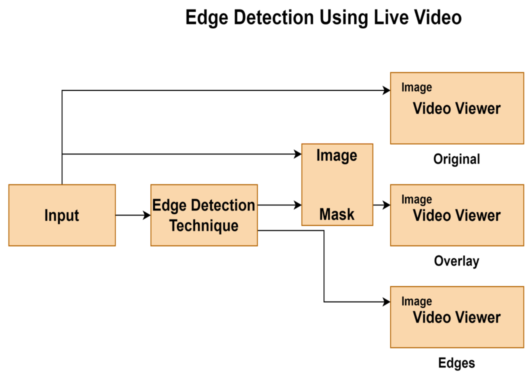
In the above section we applied different edge detection techniques on still images and got the best technique for edge detection.
Now let's apply the same techniques on the real time images which will be detected by a web camera and compare its results.

7. Edge Detection On Real-Time Image:

The term "real-time image processing" refers to the use of digital computers to process images in real time. It is the application of computer algorithms to real-time picture processing. It is a widely used technique for image data operations such as feature extraction, pattern identification, segmentation, picture morphology, and so on.

It has uses in medical imaging, computer-assisted surgical diagnosis, locating objects in satellite photos, face and fingerprint identification, autonomous traffic management systems, and anatomical structure research, among other things. For extracting edges from digital pictures, many edge detection approaches have been developed.

Proposed method using live video acquisition uses the Image Acquisition Toolbox's Video Device block to import live visual data from a camera into Simulink.
The Image Acquisition Toolbox includes utilities for capturing pictures and video from PC-compatible imaging gear straight into MATLAB and Simulink. Automatically detect hardware, adjust equipment parameters, sample the collection, and record photos or video are all possible.



Flowchart [2]

8.Real time examples of edge detection:

1. Fingerprint recognition: When recognizing fingerprints, it's useful to preprocess the image by performing edge detection. In this case, the "edges" are the contours of the fingerprint, as contrasted with the background on which the fingerprint was made. This helps reduce noise so that the system can focus exclusively on the fingerprint's shape.

2. Medical imaging: Like fingerprint recognition, medical imaging is another field where computer vision systems can improve performance by eliminating noise and extraneous information and improve healthcare with AI. Medical images are susceptible to different types of noise during the data collection process. Applying edge detection makes it easier for computer vision systems to detect anomalies in medical images.

3. Vehicle identification: Consider one of the most cutting-edge computer vision use cases: self-driving cars. These systems depend on the ability to rapidly and automatically detect other vehicles on the road. This technology can help dramatically reduce the complexity of the images that self-driving cars need to analyze, while still preserving the recognizable shapes of other vehicles.

The real time image (i.e.captured from the camera) and the image obtained by using different edge detection techniques are given in figures [17],[18].

Image 1:

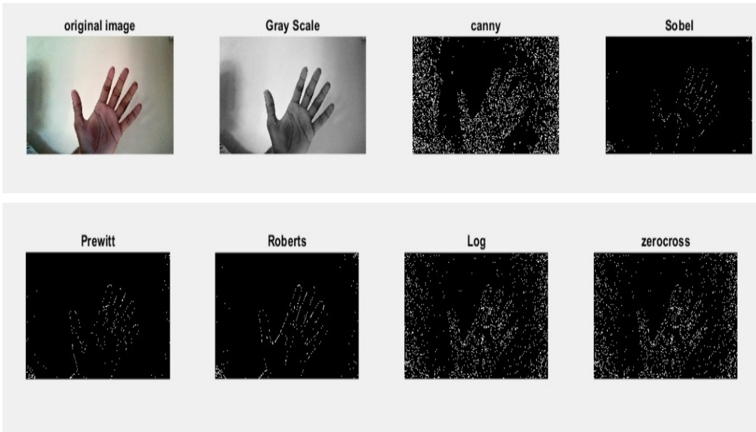


Figure [17]

Image 2:

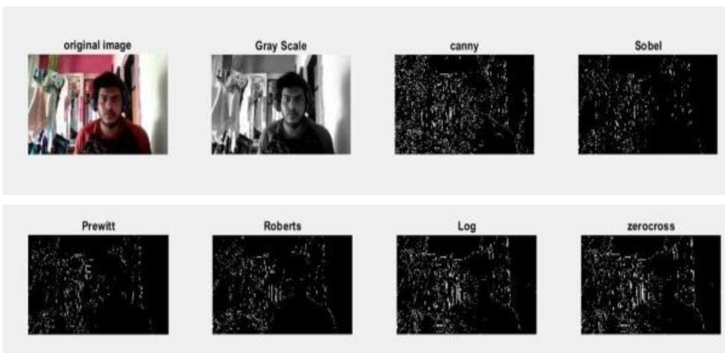


Figure [18]

From the Outputs Figure [17],[18] which we got, it is noticeable that LoG Technique works well compared to all the other edge detection techniques and methods.

Conclusion:

Feature extraction is an image analysis approach for detecting item boundaries inside pictures. The boundaries are detected by sensing brightness discontinuities. In the fields of image processing, object tracking, and machine vision, edge detection is utilized for picture segmentation and data extraction.

The features of many common operators have been studied and summarised. Each method has benefits and disadvantages in different regions, but experimental comparisons of multiple methods reveal which method is best for specific image. Even though all operators are generally similar in the case of a noiseless picture, we find that the canny edge operator delivers the best edge detection result in a noiseless image for practical applications. However, in noisy photos, such as Real Time Images, LoG edge detection has proven to be highly successful. There are still options for expanding the scope.

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