An Automated Way of Vehicle Theft Detection in Parking Facilities by Identifying Moving Vehicles in CCTV Video Stream

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***Abstract*—Security of parked cars against theft is a long existing concern where image and video processing can offer solutions. The car owners or parking lot operators are worried about having the vehicles stolen from parking lots, so they use CCTV cameras in parking lots to detect theft. The increased use of CCTV and video surveillance indicates their success as theft deterrents but a major drawback of the system is that non-automated human monitoring of vehicles can have human errors or lapses due to human fatigue. This paper presents an automated way of detecting vehicle theft as it happens. This procedure is based on moving object detection using Canny Edge Detection method and eventually notifying the security personnel or the parking lot operator about the movement. The first step is to detect the edges through Canny method and then finding the edge change ratio to finally determine a movement. Canny is one of the modern Edge detection techniques and choosing this one over other methods is because of the double thresholding and its better performance, which makes the method described in this paper efficient and useful. This paper proves the effectiveness of the described method.**

Keywords— Object Detection, Object Classification, Video Surveillance, Image Processing, Edge Detection, Canny Operator

I. INTRODUCTION

Security and Surveillance of any particular area is a prime concern of an individual or a group of people to detect intrusion or any other unwanted phenomena. The use of CCTV is getting popularity because of the availability and increasing advancement of image processing from video. To detect a crime or intrusion, real time image processing can be an optimal solution. In many environments, the retrieval of the video or the purpose of using a video surveillance might be different. Depending on the nature of the need for the video surveillance, the image processing method varies.

Detection and tracking moving objects have various applications in the domain of machine vision such as: video compression, monitoring systems, industrial control and gesture-based computer interaction. Object tracking in video surveillance systems are widely used by security agencies to have real time monitoring and also to detect potential security threats by instant [2].

Moving object identification is the task of determining an object's physical movement for a specific area or region. From last few years, detection of moving object has gained much of popularity because of its vast area of applications such as video surveillance, robot navigation human motion analysis, event detection, , video conferencing, traffic analysis, anomaly detection and home and commercial security. Moreover, moving object detection is a very efficacious and consequential subject matter since it forms analytical and interpretative action for various complex processes such as object classification and tracking an object from video.

There are many methods of detecting images but this paper focuses on edge detection [5]. The edges of a particular object are detected and it will be extracted from the background. If the image contains some noise the image has to be gone through a filter, most likely a Gaussian filter. In the proposed system, the extraction of the edge of the object is done by Canny Edge Detection which can be used for object classification and detection of a complex video. The detection of an object's actual shape is not easy because issues like light variation, shadow and noise affect the quality of the video as well as the image. An individual image is nothing but a frame. In this proposed system, each frame is compared to a particular background image and subtracted from it to detect whether there is any change in the edges.

A system was proposed where parameters were chosen interactively to achieve the objective for the gradient and Marr-Hildreth images [12]. By comparing the Canny image with these images we can see significant improvement in detail of the principal edges and at the same time more rejection of irrelevant features in our proposed Canny result. All the edges form closed loops which gives 'spaghetti' effect is its serious drawback and thus the method gives irrelevant features. These irrelevant features are caused by zero crossing which can be recovered by Canny method through double thresholding [12]. The quality of the lines with regard to continuity, thinness and straightness is superior in the Canny image. Results stated above have made the Canny algorithm a tool of choice for edge detection.

Most of the apartments now a day have large parking area and the security of the parked cars have become a prior concern. We

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propose a system in which several video cameras are installed in different parking lots. The proposed computational model will capture and analyse one frame per second. The detected edges of the output should give a clear image of the moving object from the video [5]. As there will be several videos running simultaneously from different parking areas which will be monitored by human, so to avoid human error the monitor will give a notification if there is any movement detected after the video footage is processed.

II. Related work

A system was proposed which provides parking information to the users and guidance for parking by using video and image processing [1]. It incorporates the countdown of the number of parked vehicle and identifies the empty parking slots. To match this they used Prewitt operator for edge detection and according to the reference image, the percentage of matching, the information is sent to the incoming driver [2]. Face detection and face recognition can be used to check whether the driver is an authenticated driver or not. The photos of the drivers are captured in real time, there must be unequal illumination for which the background can have an effect in the system. DCT normalization and also background cancellation are used to eliminate this problem [2].

There are several tracking methods and their classification into discrete category aims on significant and effective tracking methods [3]. Video indexing module contributes in the video surveillance indexing and its retrieval framework for the prevailing the challenges like human limitations and vast storage of data [4]. The proposed video indexing module consists of the following components: foreground extraction, blob detection, background modelling, blob analysis, blob representation, and feature extraction, blob indexing. Risha describes the process of finding the edges of a moving object in the video. Identifying the moving object is the first task, the resultant output may contain noises, which can be eliminated through morphological operation [5]. After the elimination of the noise to a large extent, the system gives a perspicuous image of the moving object. In this paper, they applied optical flow method to detect a moving object, morphological operation and gradient edge detection techniques [5].

In response to poor noise problem, this paper presents an improved algorithm based on Canny Edge Detection [6]. The concept of gravitational field intensity has been introduced by the authors to replace image gradient. They developed the gravitational field intensity operator by using the concept [6]. There are two flexible threshold assortment methods found from the mean of image gradient magnitude and standard deviation to achieve robustness to noise. Aziz proposes a fast and robust method for detecting and tracking moving objects is presented [7]. This method is based on mobility edge through fixed edges. The results show that the proposed method, further to its efficiency, is able to overcome challenges such as brightness variations and background changes over time.

The appropriate result of the determination of substantial shape of moving object from a video sequence is critical. It becomes more complex to find the physical shape of a moving object because of many challenges like light variation, change in the illumination intensity, shadow effect, camouflage and bootstrapping issues. A system was developed to diminish the effects mentioned above which describes the classification of the traditional approaches for moving object detection [8].

A methodology is developed to detect and classify the objects like classification between human and vehicle in different weather conditions [9]. The system uses a static camera which is capable of accurately detecting and tracking more than one object despite occlusions and other interactions. They presented the result by experimenting on real life sequences and applying them in online using the algorithm. Mandar P. Pathrikar et.al. described video security system which monitors a premise to detect unwanted intruder [10]. A plurality of cameras located about the premise, supply video images of scenes to a processor located which processes the images to detect the motions in a scene and classify the source of motion.

The study of the related work gave us the motivation to work with image processing to increase the security in the parking area. The authors or the researchers mentioned above, have contribution to different security systems utilising various image processing methods. From this study, we found that the Canny method would be the optimal one to use for edge detection. Moreover, one idea that has arisen from these related researches is that none of them have worked for the purpose to reduce the human error caused by fatigue or illness of the security personnel who is responsible to monitor the whole CCTV video stream. However, the usual intention of CCTV system fails because of the proper maintenance of the monitoring by the security personnel in the control panel. So, our paper objectifies to the purpose to reduce the human error or to help the security personnel by notifying him about the missing car as soon as the car starts moving when it is already parked for a certain period of time and thus he can take action immediately.

III. Methodology

There are many edge detection techniques in image processing such as:

(1) Roberts Edge Detection,

(2) Sobel Edge Detection, and

(3) Prewitt edge detection

These techniques are used for comparison. Modern edge detection techniques includes Canny method and Marr-Hildreth algorithm.

In computer vision, another modern edge detection method, the Marr–Hildreth algorithm is fundamentally based on detection of the edges of continuous curves depending on the instantaneous brightness variation. The operation of the Marr- Hildreth method is simple but uses zero crossings which are detected from the

filtered output of the edges. It is operated by the convolution of the image with the Laplacian of the Gaussian function. But the reason of choosing the Canny method over Marr-Hildreth is the accuracy of the edges, lower error rate, better noise reduction and most importantly, the double thresholding.

Canny Edge Detection is a technique to obtain information pattern of different objects and also minimize the amount of data [5]. The specifications for which made this method more useful includes:

1) Capturing the maximum number of edges found in the image meaning that the detection of edges can be done with a low error rate.

2) Accurate centre can be assigned from the edge operator by the edge point detected

3) Image noise is eliminated as the edge is marked only once so does not create false edges.

The Canny Edge Detection methodology can be subdivided into following steps.

A. Noise Filtering

The image should be gone through a Gaussian filter to reduce the noise which is produced by the false edges. One dimensional Gaussian distribution has the following form:

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \quad (1)$$

where σ is standard deviation of the distribution. Two dimensional Gaussian distribution includes the y component and has the following form:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (2)$$

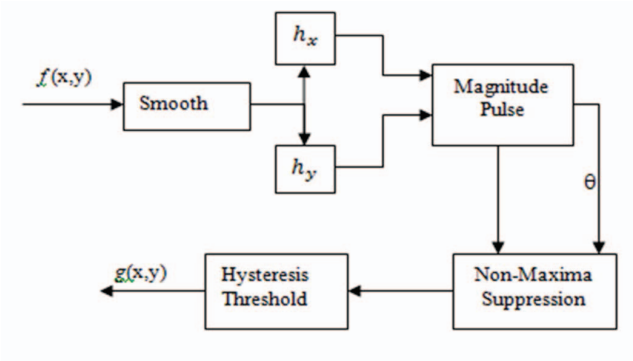

Fig. 1. Block Diagram of Canny Edge Detection

B. Determination of Intensity Gradient

An intensity gradient of Canny grayscale image is found where a sharp change is detected in the intensity. The canny algorithm finds the edges by determining the gradients of an image. The magnitudes of a gradient can be obtained as Euclidian distance by using Pythagoras law shown in (3). It is applicable for the reduction of evaluation complexity.

$$|\mathbf{G}| = \sqrt{(G_x^2 + G_y^2)} \quad (3)$$

where GX and GY indicates the x and y components of gradients respectively. The direction of the edges can be found by applying (4).

$$\theta = arctan\,|\frac{G_x}{G_y}| \quad (4)$$

C. Suppression of Spurious Results

Spurious response corresponds to the noise that is created from false edges. This response must be eliminated through an edge thinning technique. This technique is the application of non-maximum suppression. The calculation of gradients cannot give a clear gradient value. To have the accurate response, non-maximum suppression basically terminates the gradient values to 0 excluding local maxima which specifies the exquisite change in the intensity.

The edge strength of the current pixel is checked in both positive and negative direction and the value will be preserved if it is larger than other in mask having same direction, other values will be supressed.

D. Determination of Potential Edges

Double threshold application is required to dictate potential edges. From the non-maximum suppression, it is strong edge pixels are preserved meaning that the pixels with lower gradient value are simply filtered out. If the edge pixel falls above the upper level, then it is marked as strong edge pixel, if lies above the lower level then it is marked as lower edge pixel but if falls below the lower level then the value of the pixel will be ignored.

E. Determination of Actual Edges

Tracking edges using Hysteresis can be done finally by suppressing all the weak edges and only preserving the edge pixel. The weak point can also be preserved only if one strong edge pixel is connected with a blob.

IV. SYSTEM ARCHITECTURE

The proposed methodology in this paper is an approach to detect the movement of a vehicle based on edge detection technique. It is a branch of image processing used in moving object identification. Edge detection method is developing modern techniques to allow a system to have the finest performance and the Canny Edge Detection technique aims to offer efficiency to the expected results. It provides accuracy in detecting the edges and yielding better quality of lines.

The system presented in this paper allows an automated way to detect a movement of a vehicle which is already parked by the driver and for a certain period of time the car is not supposed to move from the parking lot. In this span of time CCTV camera is capturing the real time video and providing the video to a security personnel who is responsible to monitor in the control panel. To

avoid the human error usually caused by fatigue of unconsciousness, there will be a notification of the movement of vehicle to the security personnel to discern an immediate action against possible theft detection. On one hand, this system in computationally inexpensive and user friendly. On the other hand, once the network has been setup, the prediction of potential threat and taking action against the theft is quite fast and efficient.

The proposed system module is executed through performing the following steps.

A. Video Input

A real time video signal is captured by a closed circuit camera and this video signal will go through various computational module so that the image acquisition can be done. In the first step it is needed to extract the images from the video for further analysis. Parking monitoring applications must have real time video surveillance and uninterrupted video signal to access an efficient and systematic approach for continuous observation.

B. Reading Frames

Frames can be obtained periodically from a video and converted into images. A video is a bunch of image taken in very quick time, typically 30 image per second. The proposed computational model will capture and analyse 1 frame per second. At run time, the video automatically extract the images which are segmented to frames analogous to the surveillance area having the static camera. Each frame is then classified to resize the scaling of the image to be processed.

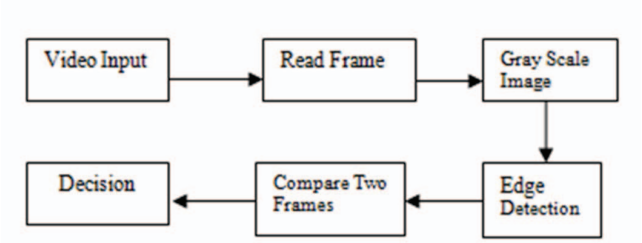

Fig. 2. Computational Workflow

C. Gray-scale Image

The extracted frames from the video corresponding to the parking lot are in RGB form. To determine the edges each frame should be converted into the Gray-scale form first. Gray-scale image carries only intensity information and each pixel is a single sample. Though the Canny method givers similar results for both RGB and Grayscale, to avoid the complexity, the described methodology is preferring Gray-scale images to achieve better results for edge detection.

D. Edge Detection

This step is to be executed to find the edges of the object. Edge detection technique is used for the identification of points in an image where brightness can change sharply or orderly having discontinuities. An edge is the arrangement of the curved lines arranged in a typical manner where the brightness changes sharply. The detection of edges becomes difficult due the light variations, illumination effects and the speed of the moving object [5]. Using Canny Edge Detector itself presents better performance against these obstacles as it goes through double thresholding. The edges of the objects whether it is moving or in static state, is to be detected through Canny operator. To track the boundary of an object and also the foreground and background edge feature, edge detection is used.

E. Comparison of Two Consecutive Frames

The proposed module will compute the edge change ratio between two consecutive frames. From the difference between current frame and previous frame, a moving object can be detected. Gaussian mixture model and median filter is used in recursive background modelling where frame differencing is done. Moving object detection can be perceived by differencing the consecutive frames [5]. A reference frame is the frame which is temporarily selected as referral for the adjacent frames with dynamic pattern.

To get the expected results, subtraction of the consecutive frames from the reference frame is done by the subtraction operator. It is an effective method for detecting the gray level changes in the consecutive frames [5]. The algorithm has three parts which includes the selection of optimum reference or background, then performing the arithmetic subtraction operation and finally selection of an appropriate threshold.

F. Decision

Finally the model takes its decision by using all the value of edge change ratio and detects if the object having any movement. In a parking lot under video surveillance a static camera is used to capture the real time video and from the video, notification of a movement is provided to the security personnel by using the method described above.

V. Implementation of Algorithms

For the implementation and validation of the proposed approach, Python version 2.7, Anaconda 3- 4.3.1, Jupyter Notebook 5.1.0 are used. Python is a dynamic programming language which has code readability and also Jupyter notebook provides an online sharing platform and interactive computational environment which made this software to be chosen.

A. Algorithm for Moving Object Detection:

The algorithm for implementation includes various steps but the principal stage uses the multi-phase edge detector which is known as Canny Operator. Intensity of the gradient is used for finding the derivative of Gaussian filter and the filter is based on the derivative obtained.

The purpose of using this filter is to reduce the amount of noise present in the image. The potential edges should be gone through a thinning process using the elimination of non-maximum pixels. The final step is to use a hysteresis thresholding to obtain the edge pixel on the gradient magnitude.

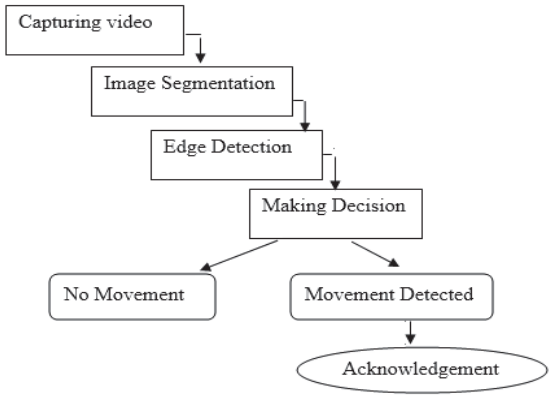

Fig. 3. Work Breakdown Structure

B. Steps involved in the algorithm

1) Reference Image is captured and the RGB image is converted into Grayscale

2) The Canny Image is obtained for the Reference frame

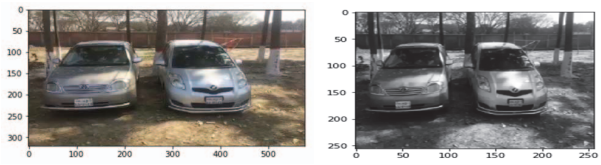

Fig. 4. Reference Image Extracted from the video and Grayscale conversion

3) Consecutive frames are subtracted from the Reference Image for further processing

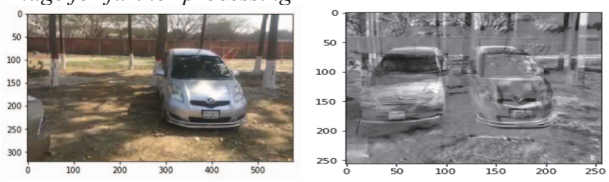

Fig. 5. RGB to Grayscale conversion of the first frame where movement of the car started

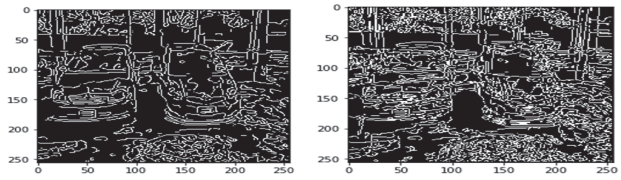

Fig. 6. Reference frame and the adjacent frame when the movement started are converted to Canny Image

4) Edge change ratio is found for all frames using the following formula:

edg_chng_ratio
=abs(im1_cnyim2_cny).sum()/im1_cny.sum()
=1.5821461609620722,
Where,
edg_chng_ratio= Edge change ratio
abs=Absolute value
im1_cny= Reference Image converted into Canny
im2_cny= Current Image converted into Canny
Sum= Arithmetic Summation

5) As the Canny method shows better performance due to its double thresholding, two threshold levels are needed to be defined.

Upper threshold: 1.59
Lower threshold: 1.57

6) The efficacy of the system is checked for all the frames.
if edg_chng_ratio > 1.57 and edg_chng_ratio < 1.59:
Where,
edg_chng_ratio= Edge Change Ratio

7) After going through all the steps, the system must be capable of making a decision whether a movement is detected or not.If the edge change ratio is found between 1.57 and 1.59, then the system would decide a movement detected.

8) Acknowledgement upon the decision is finally required whether an identification of a movement is to be checked. If a movement is detected, there will be an acknowledgement 'One car is moving or missing' otherwise there is be no message.

C. Pseudo code

```
load or stream the video
extract the first frame (as reference)
resize the reference frame
convert RGB to gray
convert gray to edge (canny)
for frame in video:
        resize the frame
        convert in RGB to gray
        convert gray to edge (canny)
        calculate edge change ratio
        if edge change ratio > lower threshold and
        edge change ratio < upper threshold:
                print the caution message
 end
```

VI. Experimental Results and Discussion

The procedure described in this paper is executed with two different experimental videos. These two videos have different background also light variation, illumination and shadow. In the video, there are two cars parked nicely in their allocated place and at each one second time interval, frame is checked to see whether there is a movement or not. There will be a movement detected only if the edge change ratio lies between the upper and lower

threshold value which is 1.59 and 1.57 respectively. If there is any movement detected, the system automatically shows a caution message 'One car is moving or missing' and if not, then there will be no change in the monitoring tool. The experimental results show the final frames when a movement was detected.

The output from video 1 is shown in Fig. 7.

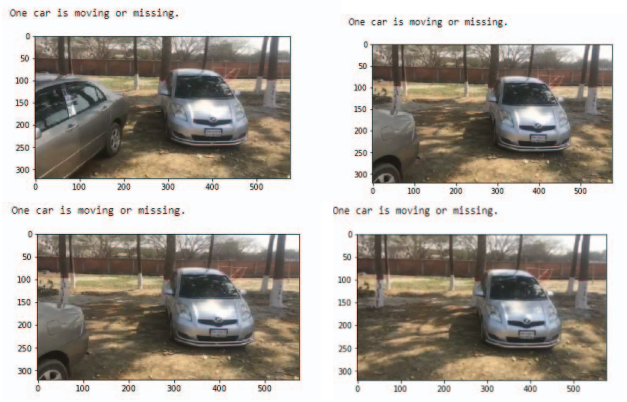

Fig. 7. Notification of movement dectection in four different situations for video 1

The output from video 2 is shown in Fig. 8.

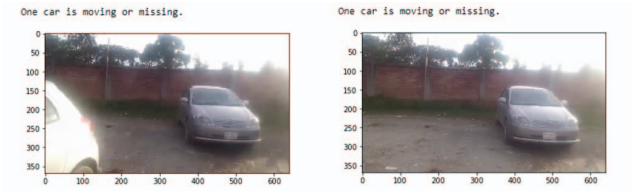

Fig. 8. Notification of movement dectection in two different situations for video 2

Parked vehicle theft detection and prevention system based on Video and Image processing for a particular time period is assessed through the proposed methodology. Experimental results of two different videos evince that, the security personnel has no longer need to monitor the static video and might not overlook a potential theft deterrent as he gets the notification of the movement of a car in a specific parking lot. If the edge change ratio changes by a very small value, the system indicates the car's movement as shown in Fig. 7 and Fig. 8 and hence the presented method proves its efficacy.

VII. CONCLUSION

In this paper an automated system to identify possible vehicle theft by moving object detection has been presented. The objective of this paper is to help reduce the amount of vehicle theft from the parking lots for a certain time period usually the night time. The described edge detection technique has been implemented to have the optimal performance in vehicle theft prevention because of its accuracy and cost effectiveness.

VIII. FUTURE WORK

The future implementation can be used in a range of applications like integrating GSM module, alarm or siren generation along with this system and also in home or commercial space security etc.

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