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Towards a Real Time Road Moving Object Detection and Tracking System

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Abstract—Road moving object detection and tracking present an important role for highway traffic surveillance control management and traffic planning. In this work, we propose a new application in an Advanced Driver Assistance System (A.D.A.S) in order to participate in the reduction of the significant number of road accidents. Road moving object detection and tracking in a traffic video is a difficult task. Hence, in this work we present a new system in order to monitor the outside car risks by detecting and tracking of different road moving objects. This developed system is based on computer vision techniques. The system aims to solve this problem by using Haar like features and Background Subtraction technique. Experimental results indicate that the suggested method of moving object detection can be achieved with a high detection ratio.

Keywords-* *ADAS; Computer Vision; Object detection; Object Tracking;

I. Introduction

Traffic accidents are the major problem in which millions of people die. To prevent the people from this problem, one solution is to increase the significant application of video-based supervision system which is traffic surveillance.

With the rapidly growing number of road traffic accidents, visual surveillance has become a necessary area of research. It becomes heavy for human operators to monitor for long durations. In order to identify important events in real-time and in an avid manner, an intelligent visual surveillance system is proposed to assist the human operators.

Over the past few years, important researches have been conducted in the field of Advanced Driver Assistance Systems (ADAS), and autonomous vehicles devoted to vision-based vehicle detection for increasing safety in on-road environment [1, 2].

The attempt to develop technologies related to the detection or prevention of moving object while driving represents a serious challenge in the choice of accident preventing approaches.

The fact of giving strong and dependable vehicle detection for visual sensors still remains a difficult step as a result of the diversity of shapes, dimensions, and hues portraying the on road vehicles.

Furthermore, the road infrastructures and close-by objects may give introduction to complex shadowing and scene disarray which will lead to the reduction of the complete visibility of vehicles making their observation crucial.

Moving object detection by definition refers to the fact of identifying the physical movement of an object in a given region or area. Over most recent couple of years, moving article recognition has gotten a lot of fascination because of its extensive variety of uses and applications such as video surveillance, human motion analysis, robot route, anomaly identification, traffic analysis and security.

The moving object detection can also be influenced by all parts of the on road environment which is hard to control e.g. varieties in light conditions, out-of-control backgrounds and unexpected interactions among traffic members.

So, for this serious risk, we propose to develop a system which controls the road moving object in a real time and alerts driver in critical moment, when they are exhausted, in order to reduce car accidents.

The rest of the paper is based on four major points as follows: The second section reviews some related works dealing with the moving detection approaches while the third deals with the proposed moving approach detection method. The fourth section presents the experimental results in this work. Finally, the conclusion and some suggests for future researches.

II. RELATED WORKS

In this part, we are concentrating on recent works to control the road moving objects (pedestrian, cars, pets, etc.) with assumptions whether car technologies are going to help reducing the road accidents number or not. According to literature, there are multiple categories of technologies that can detect and track moving object.

A. Object Detection

Moving object detection has turned into a focal subject of exchange in field of PC vision because of its extensive variety of utilizations like video surveillance, observing of security at airport, law authorization, automatic target identification, programmed target distinguishing proof, marine observation and human action acknowledgment [3]. A few routines have been proposed so forward for object detection, out of which Background Subtraction, Frame differencing, Temporal Differencing and Optical Flow [4] are broadly utilized customary systems (Fig.1).

Considerably, moving object detection turned out to be testing undertaking because of number of components like element foundation, Optical flow, Temporal differencing, Background subtraction, Frame differencing

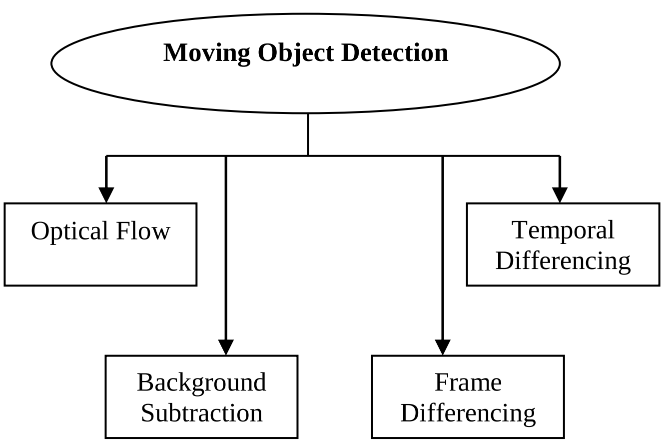


Fig.1 Classical techniques of Moving Object Detection

A.1 Optical Fow

The clustering processing is done according to optical distribution characteristics of images. It detects the moving object from the background. However, according to the large quantity of calculation and the sensitivity to noise, it makes unsuitable for real time applications [5].

A.2 Background Subtraction

The background subtraction technique is seen as to the most reliable and adequate method for moving objects detection. Background subtraction functions as following: first; it initializes a background model, then it contrasts between current frame and presumed background model which are obtained by comparing each pixel of the current frame with assumed background model color map. On the off chance that contrast between colors is more than threshold, pixel is thought to be fitting in foreground [6]. Execution of traditional background subtraction technique for the most part gets influenced when background is dynamic, brightening changes or in vicinity of shadow. Various strategies have been produced to redesign foundation subtraction strategy and to beat its downsides. Diverse systems for foundation subtraction as looked into by Piccardi et al. [7] are: Concurrence of image variations, Eigen backgrounds, Mixture of Gaussians, Kernel density estimation (KDE), Running Gaussian average, Sequential KD approximation and temporal median filter.

A.3 Frame Subtraction

The difference between two consecutive images is taken to determine the presence of moving objects. The calculation in this method is very simple and easy to develop. However, it is difficult to obtain a complete outline of moving objects.

A.4 Temporal Differencing

It is worth noting that utilizing pixel-wise contrast technique among two progressive edges [8]. Conventional worldly contrast system is adaptable to moving objects in the scenes. Yet, results corrupt when moving object moves gradually because of minor distinction between successive edges, article is lost. Also, trailing locales are recognized wrongly as moving item (phantom locale) due to quick development of article, furthermore inaccurate detection will come about where items save uniform regions [9].

B. Object Tracking

Tracking objects in video traffic is an important and fast growing step for tracking the moving objects in advanced driver assistance systems. The object tracking in video sequence of surveillance camera becomes a challenging and demanding exercise for researchers to improve recognition and tracking performances [10].

To track the physical representation of moving objects (e.g., cars) and determine it in dynamic scene, we need to fix the position, valuate the motion of these blobs and pursue their movements between two of consecutive frames in video scene [11].

Different object tracking methods have been illustrated and proposed by several researchers for different issues, it consists of [12]:

B.1 Region-Based Tracking Methods

In these methods, the region of the moving objects are tracked and used for tracking the different objects (car, pedestrian, and cyclist). These regions are segmented using the subtracting process between the input frame image and prior stored background image [13]. This technique worked on sequences of traffic scenes recorded by a fixed camera for cars monocular images. It provided information about the position and speed for each object as long as it is visible.

The processing algorithms of this model represented by three levels: raw images, region level, and object level.

B.2 Contour Tracking Methods

These techniques rely on contours (the boundaries of object) which are updated dynamically in successive images of any of the three defined objects (pedestrian, cars and cyclists) in Tracking Object Process [14].

These approaches provide more efficient descriptions of objects than Region-Based Methods and have been successfully applied to practice. However, objects occlusion and automatic initialization of tracking are difficult to handle and tracking precision is limited by a lack of precision in the location of the contour.

B.3 3D Model-Based Tracking Methods

The measurement of a moving object distance succeeded through the 3D geometric shape of Objects. A new 3D model-based vehicle detection and depiction framework is based on a probabilistic boundary feature grouping, which is used for vehicle detection and tracking process [15].

B.4 Feature-Based Tracking Methods

The particular objects are detected, segmented and tracked in an image sequence by assembling, bunching and approximating the 3D world correlates of object's feature points. An iterative and distinguishable framework based on edge points as features is used in similarity process; these features represent a large region of features forming a strong depiction for object classes.

B.5 Color and Pattern-Based Tracking Methods

This approach is used to analyze image sequences colors of traffic supervision views [16]. Through the practical experiments, this method confirmed to perform great under several weather situations, and it is hardened to light variations. This model-based system is needed for real time traffic supervision for continuous visual tracking and classification of different objects for busy multi-lane highway scene [17].

In this work, we use a Background Subtraction technique for the detection and we use a temporal coherence constraint of foreground objects as a Contour Tracking Methods.

III. PROPOSED APPROACH

In our system, a smart camera has been attached on the dashboard of a car. It takes images of different road moving objects (pedestrians, cars and cyclists).

Fig2. System Overview

A. *System Flowchart*

The system architecture flowchart is shown in Fig.3.

In Fig.3, we try to validate our proposed system that controls risk level by calculating the distance to stop Ds. We note:

1. Ds= Distance to stop in meters.
2. Dr = Reaction Distance in meters.
3. Db = Braking Distance in meters.
4. Tr= Reaction Time in seconds.
5. S = Speed in km/h.
6. D: the distance between our car and the detected object, it is given by the computer's calculator.
7. Tr = 1 second for a vigilant person.
8. Θ = 1 in better weather and Θ= 1.5 in rainy weather.

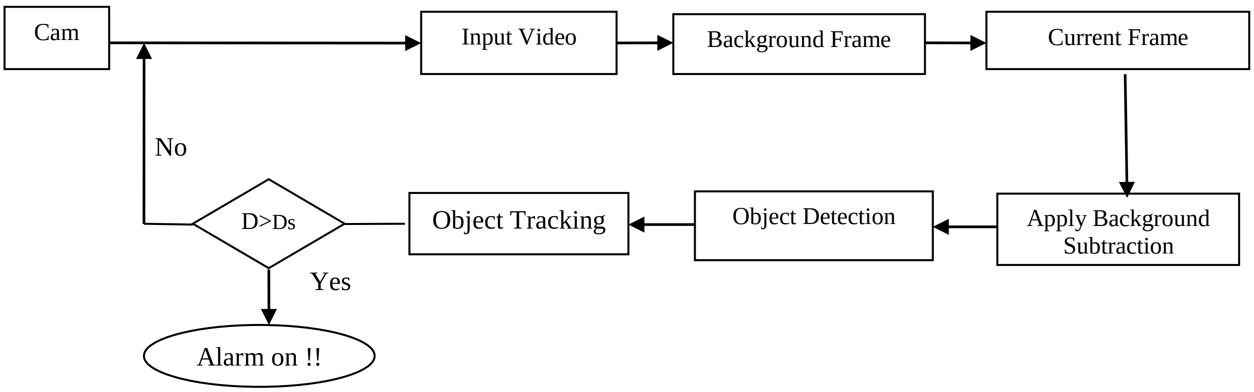


Fig.3 The flow chart of the proposed moving object detection and tracking system [18]

We calculate this distance Dr by formulas:

$$Dr = Tr * \frac{S*1000}{3600} \quad (1)$$

$$Db = \frac{S*3}{10} * \theta \quad (2)$$

$$Ds = [\ (Tr * \frac{S*1000}{3600}) + (\frac{S*3}{10} * \theta)\ ] \quad (3)$$

In this work, we define three rules in order to monitor the risk state:

- R1: If (D> Ds), Risk state=0.

⇨ There is no risk.

- R2: If ((D< Ds) and (D> Dr)), Risk state=1.

⇨ There is a small risk, but the driver has time for a reaction i.e. he has chance to avoid the accident.

- R3: Else, Risk state = 2.

⇨ There is a remarkable risk; driver must brake immediately.

B. Background Frame

Once the background frame is initialized it will referred as the reference frame. There are many ways to obtain the initial background image. For example, take the first frame as the background directly, or the average pixel brightness of the first few frames as the background or using a background image sequences without the prospect of moving objects to estimate the background model parameters.

C. Background Subtraction

The difference between the current image and background image is used for the detection of moving objects by using simple algorithm. It gives the most complete object information when the background is known. However, it has a poor anti-interference ability, and it has been sensitive to the changes which occur in the external environment [19].

The operation of subtraction will be done pixel by pixel (x, y) of the two frames: the background one and the current one. There are three stages in the process:

C.1. Background initialization:

The first stage of the background model until the background pixels are stable is simple temporal frame differencing [20]. The temporal frame difference FDt(x, y) at time t is given in equation

$$FDt(x, y) = |\ It(x, y) - It-1(x, y)\ | \quad (4)$$

Where It(x, y) is the intensity of pixel (x, y) in the frame at time t.

The foreground binary mask is achieved by comparing FDt(x, y) to a threshold T1 which is empirically decided on [21]. A pixel is considered as having significant motion if the difference is greater than threshold and termed as foreground.

$$FGt(x, y) = \begin{cases} 1 & \text{if } FDt(x,y) > T1 \\ 0 & \text{otherwise.} \end{cases} \quad (5)$$

A pixel is regarded as “stable” or a background pixel if there is no huge movement identified i.e. FDt(x,y)<T1 for a specific number of frames, which is denoted by Tfr. Consider a frame count Cfr that is increased by 1, every time FDt(x, y)<T1, at the point where Cfr > Tfr is analytically determined. We can utilize this pixel as a part of the current frame to develop a model for the background.

When the background data is available for a pixel i.e. BMt (x, y) is developed using equation (6) and the foreground mask is calculated adopting background differencing.

$$BM_t(x, y) = \begin{cases} I_t(x,y) \text{ if } Cf_r > Tf_r, \\ 0 \quad \text{otherwise.} \end{cases} \qquad (6)$$

C.2. Background maintenance:

We define the background difference frame as:

$$Dt(x, y) = |It(x, y) – BMt\text{-}1(x, y)| \qquad (7)$$

To compute the adaptive threshold, an iterative process is proposed. The difference image Dt(x, y) is sectored in two sections. The first threshold is considered to be the center value of the magnitude of intensities, and then the image is threshold with this intermediate value. The intensities of sample means are associated with the foreground and background pixels determined for each iteration. The average of the two sample means determines the new threshold value. The iteration process concludes when the threshold stops changing [22].

This threshold is defined as ThAd,t, and will be used in equation (8).

$$FGt(x, y) = \begin{cases} 1 \quad \text{if } D_t(x,y) \geq Th_{Ad}, t. \\ 0 \quad \text{otherwise.} \end{cases} \qquad (8)$$

C.3. Foreground/background pixel classification:

The next step in the process is to classify the pixels as foreground/background using the current frame and background model. The zones of significant motion are showed by a foreground mask by the threshold, ThAd, t. This threshold is achieved using the technique mentioned above, and using the present difference image Dt(x, y), it is resolved for each frame adaptively.

If the difference between the two pixels is greater than the threshold, the movement of the pixel is considered significant. A foreground binary mask is generated according to the below equation and the position of the moving pixels is implied by the foreground mask [23].

In this proposed system, by using a Gaussian Smooth operator in order to reduce image noise and details, we can dynamically change the threshold value according to the lighting changes of the two images obtained. This method can effectively reduce the impact of light changes. Here, we regard first frame as the background frame directly and then that frame is subtracted from current frame to detect moving object.

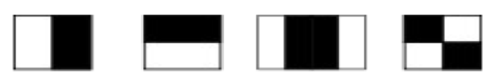
$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \qquad (9)$$

D. Object detection

As it is known, a video is a gathering of fundamental structural units, for example, scene, shot and edge. Objects (cars, pedestrians, etc.) are distinguished by the technique for Viola-Jones. This strategy permits the location of items for which learning was performed [24, 25]. It was composed particularly with the end goal of face location and might be utilized for different sorts of articles. As an administered learning system, the strategy for Viola-Jones obliges hundreds to a great many samples of the located item to prepare a classifier. The classifier is then utilized as a part of a comprehensive quest for the item in all conceivable positions and sizes of the image to be prepared [26].

This system has the playing point of being compelling and fast. The system for Viola-Jones utilizes manufactured representations of pixel values: the pseudo-Haar characteristics. These attributes are controlled by the distinction of pixels' wholes of two or more contiguous rectangular areas (Fig.3), for all positions in all scales and in a detection window. The number of features may be high. The best peculiarities are then chosen by a technique for boosting, it gives a "solid" or "weak" classifier.

The Viola-Jones method used by the Adaboost algorithm.



(a) (b) (c) (d)

Fig.3 Examples of neighborhoods used.

The exhaustive search for an item is inside an image which can be measured in computing time. Every classifier decides the vicinity or nonappearance of the item in the image. The least difficult and quickest classifiers are put in the first place, which rapidly disposes of numerous negative.

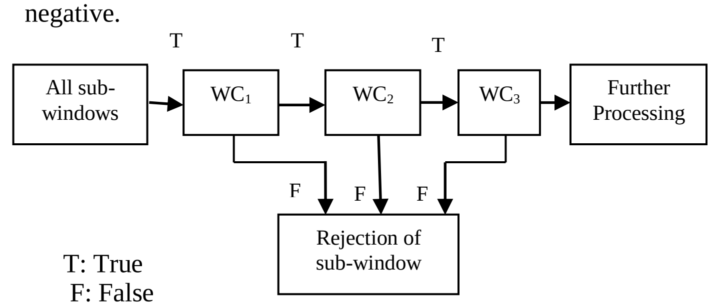


Fig.4 Cascade of classifiers [27].

In general, the technique for Viola-Jones gives great results in the Face Detection or different articles, with few false positives for a low figuring time, permitting the operation here progressively [28].

The recognition of different road moving objects is essential to reduce the impact of having an accident.

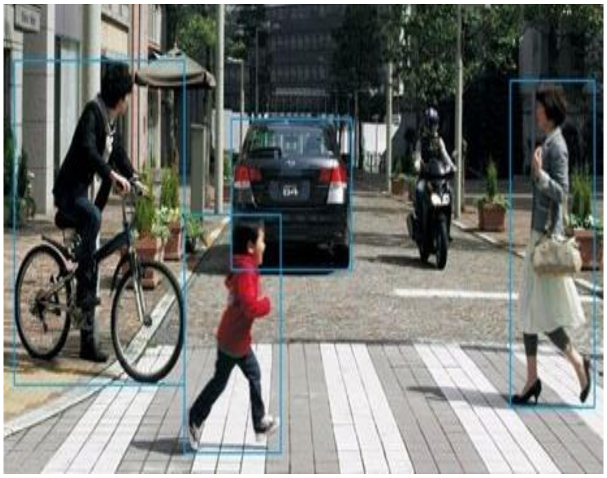


Fig.5 Example of road moving objects: cyclists, pedestrians and cars.

E. Object Tracking

Object tracking is initiated when an object enters a scene, and moving object detection will be terminated. When the position and dimensions of an object in a video sequence are needed, object tracking is adapted and are showed with one or many points by rectangles or ellipses and contours for indefinite objects.

After the refinement step, some false positive foreground pixels still exist, especially in complicated scenes with noisy objects like road panels. In order to further improve the performance of our method, we resort to tracking to use the temporal coherence constraint of foreground objects.

IV. EXPERIMENTAL RESULTS

In this section, we are going to describe different experimental results developed throughout this work.

A. Database

To evaluate the performance of our proposed solution, we have implemented our approach on the KITTI dataset [29] which includes a street scene dataset for moving object detection (3 categories: car, pedestrian and cyclist). It contains 7481 images of street scene, 28521 car objects [30].

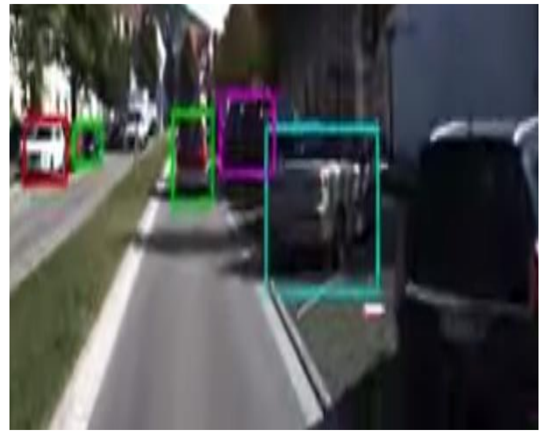


Fig.6 Moving car detection and tracking in KITTI dataset.

B. Results

We have implemented experiments on 18 test sequences from KITTI database.

The estimation of this algorithm is made by the calculation of the rate of good detections moving object (GDR) using the following formula.

BDR : Bad Detection Ratio.

$$GDR = \frac{\text{Number of detected moving object}}{\text{Total moving object}} \quad (10)$$

$$BDR = 100 - GDR \quad (11)$$

TABLE.I. QUANTITATIVE ANALYSIS OF OUR PROPOSED SYSTEM [18]

Video Stream	Moving Object	Object Detected	GDR(%)	BDR(%)
1	15	13	86.67	13.33
2	3	3	100	0
3	15	14	93.34	16.46
4	98	95	96.94	3.06
5	20	19	95	5
6	9	8	88.89	11.11
7	41	39	95.12	4.89
8	4	4	100	0
9	15	14	93.33	6.67
10	9	8	88.89	11.11
11	50	48	96	4
12	28	26	92.86	7.14
13	27	26	96.30	3.70
14	60	57	95	5
15	4	4	100	0
16	56	55	98.21	1.79
17	68	65	95.59	4.41
18	66	65	98.48	1.56

As a result of the analysis phase of TABLE I, we have obtained a favourable rate of recognition to the moving object detection. Our new approach improves the detection's measurements of the system in the presence of the occlusion's problem. It betters the results between 86% up to 100% of detection ratio (GDR).

The evaluation of our proposed system is given by the calculation of Detection Ratio (DR) and False Alarm Ratio (FAR). In Eq.(10) and Eq.(11) TP is the true positive of moving objects, FP is the false positive of moving objects and FN is the false negative of moving objects.

$$DR = \frac{TP}{(TP+FN)} \quad (12)$$

$$FAR = \frac{FP}{(FP+TP)} \quad (13)$$

TABLE.II. QUANTITATIVE ANALYSIS OF OUR PROPOSED DETECTION AND TRACKING SYSTEM.

Dataset	DR	FAR
KITTI(cars)	93.24 %	0.32 %
KITTI (pedestrian, cyclist, cars)	89.13 %	0.47 %

TABLE II illustrates the performance of our system. The experimental results show that our system can achieve good performance in detection rate.

V. CONCLUSION AND FUTURE WORKS

This paper describes the basic study on the proposed techniques which have used in ADAS. It focuses particularly on a Real Time Road Moving Object Detection and Tracking System.

In this study, we present a new system for Advanced Driver Assistance System as well as a new system for controlling the outside car risks by detecting and tracking of different road moving objects. This developed system is based on computer vision techniques.

We tend to propose a safety car assistance system that controls both: the inside car risks by monitoring the driver vigilant states [31], and the outside car risks (pedestrian, moving object, road lanes, and panel roads).

VI. ACKNOWLEDGEMENT

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