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Vision Based Vehicle Speed Measurement System Using Camera

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Abstract. The advanced driver assistance systems have strong limitations for real-time execution. Vision algorithms included in these systems must balance accuracy and computational simplicity and there is an ongoing challenge to increase both goals. The vehicle detection is the first and most important step in our system. In this article we define a technique to achieve the desired result, we have recurred in the same direction symmetry approaches in the use of the Hough transformed straight to detect and limit the search space. We show an efficient performance for the detection of vehicle on the track it by matching by measuring the SAD correlation algorithm and finally, using the geometric foundations, distance and speed are calculated.

Keywords. Vehicle detection, Symmetry, Transformed, Hough algorithm, SAD measure distance and speed.

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INTRODUCTION

The increasing complexity of the road environment and the need to improve road safety explains the significant amount of work on driver assistance. The car of the future will help the driver to understand his environment to aid his decisions without the disempowering his responsibility. It must be able to perceive better the environment that cannot be done by human alone and overcome its deficiencies.

The automobile is one of the major events of the twentieth century. With this mean of transportation, men and women got access to mobility, whether professional or private. However, the vehicle remains one of the leading causes of death in our modern life, despite the efforts of the policies of prevention, of information, of repression and of those automakers in passive safety (air bag, belt...) and Active Safety (ABS, ESP ...). This state of affairs lies in the human intervention on the complex processes that govern driving a vehicle (maintaining the vehicle on the road, compliance with rules...) and which he's not always adapted to,due to physiological limits (visual acuity, assessment of distances, loss of attention, nervousness, ...), but that technological advances in recent years is trying to make it easier. With advances in automatic, computer science, telecommunications and miniaturization of instruments,

researchers are now able to develop driver assistance systems by making certain tasks automatic.
Automakers introduced new security features. On this last point, the systems must act on the controllability of the vehicle so that it responds quickly to driver's input. In addition, research laboratories aim to develop systems to predict and compensate for the failure of a Collision Warning System in front.
It is in this context, the aim of this paper, is to develop a vision-based system providing key information to traffic management to know the speed of vehicles and the distance between them.

THE ARCHITECTURE OF DRIVER ASSISTANCE SYSTEMFOR DISTANCE AND SPEED MEASURING

The automotive application of interest is to measure the distance and speed of a vehicle. This process requires gathering of information on the target vehicles, like their position (distance from target vehicles) and their size.

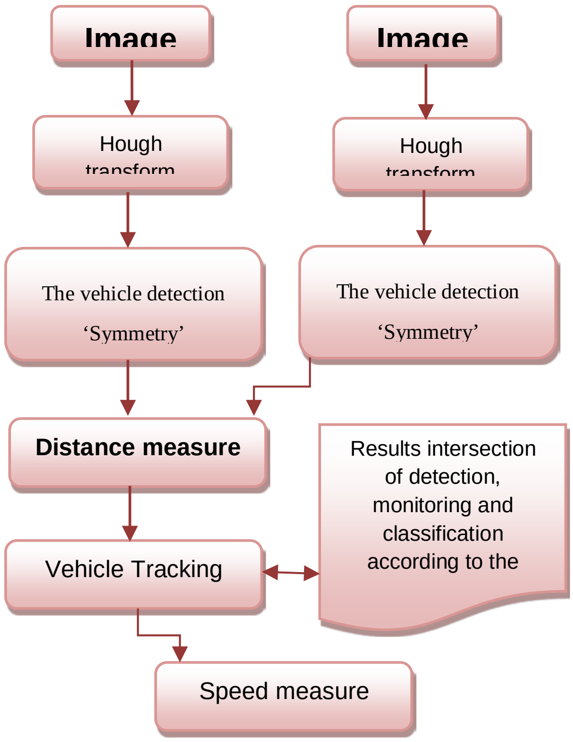


Fig.1. Diagram of the proposed device.

This intermediate processing is called "detection of obstacles." It can locate the target which is then processed by the measuring process of distance and speed.
The proposed algorithm is based on four major modules depending on the model of the road: vehicle detection, tracking vehicles and then measure the distance and speed using a DSE approach.In what follows, we show a diagram on how to proceed to calculate the speed.

Modeling the road

The modeling of the road in our image sequences is an essential step for the realization of this application. This step can also be used in other applications such as the detection of objects on the road or to avoid deviating from the road.
One can easily prove that all approaches based on the appearance of the vehicle can lead to failure and generate a lot of false assumptions about the locations of vehicles. Symmetry,

shadows ... etc., are all features that can describe objects or areas present in video sequences that are not vehicles. This is sufficient to decide to define our research area before starting the phase of hypothesizing.
On the other hand, defining the research comes to limit the area to be scanned in search of vehicles and therefore will eventually profit on the execution time is a key concept in an application that requires to operate in real time like this.
Modeling of the road consists of extracting lines that define it. This can be done automatically by the use of the Hough transform; the latter calls for mathematical basis describing the Hough transform to detect lines.

Hough transform
The simplest case of the Hough transform is converted to the linear extraction of lines. We regard the image as a space, a line can be described by $y = mx + b$.
The Hough transform considers the characteristics of the right rather than as a set of points in the image, but in terms of its parameters, namely the slope parameter m and the parameter b intersection. Starting from the fact that a line can be represented by a point (b, m) in the parameter space, one problem encountered is that the vertical lines gives rise to infinite values for the parameters m and b. The solution is to switch to a pair of second parameter, denoted r and θ,for characterizing the lines. These parameters are polar coordinates. The parameter r is the distance between the origin and the right, while the angle is θ the vector from the origin to the closest point. By using the polar coordinates, a line can be described as:
$y = (-\frac{\cos\theta}{\sin\theta}) + (\frac{r}{\sin\theta})$ (1)
Pouvant être décrite aussi par :
$r = x\cos\theta + y\sin\theta$ (2)

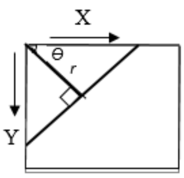


Fig.2. Polar considered a right.

Figure 3 shows the result of the modeling of the road, you can ignore all the information found on the outside of the two lines.

Fig.3. Interval Research obtained after edge detection by the operator **"Canny".**

The vehicle detection
For vehicle detection we used the method of symmetry after background subtraction using Hough transform that we will detect two lines of the road.

The symmetry
As one of the main signatures of manmade objects, symmetry was often used for object detection and identification in computer vision (Bertozzi et al., 2000). Images of vehicles are

observed from rear or frontal; the views are generally symmetrical in the horizontal and vertical directions. This observation has been used as a selection for vehicle detection in several studies (Zielke et al., 1993; Von Seelen et al., 2000). An important question arises when the symmetry calculation of intensity is the presence of homogeneous sectors. In these areas, symmetry evaluations are sensitive to noise. Information about the edges was included in the assessment of symmetry to filter out homogeneous sectors (Bertozzi et al., 2000). In a different, Seelen and al symmetry detection formulated as optimization problem was solved using neural networks (NNs) study (Bertozzi et al., 2000).

Symmetry Calculation Algorithm

Among the main methods of vehicle detection, the method of symmetry the latter is based on the features.In our project we studied the axial symmetry, which is indicative of a geometric transformation of the plane that models a fold or a mirror.

An object in a picture has a symmetrical shape so it can be divided into two equal halves, and each side is a reflection of the other side with respect to a vertical axis.

$$Symmetry = -\frac{\sum_{h=1}^{H}\sum_{w=1}^{W/2} G\left(\frac{W}{2}-w,h\right)-G\left(\frac{W}{2}+w,h\right)}{H*W} \quad (3)$$

Where G (x, y) is the gray level of the point (x, y), H and W respectively denote the width and height of the window (Chambon 2005).

We model the symmetry in a digital image by a one-dimensional signal, which gives us the value corresponding to the position of the vertical axis of symmetry of objects in the image as shown in figure 4.

Fig.4. Symmetry of signal.

The variation of the window size

The route takes the form of a trapezoid, which widens the closer you are to the camera. We see the same effect on vehicles, the further away, and the vehicle width in pixels decreases. However, the actual size of the vehicles and the road width "L" remain constant or fixed.

The difficulty is the variability of the size of the vehicles; the proposed solution to this problem is to fix the size of the rectangle to progressively move along the image. This amounts to calculate the width of the road, to know the width of the vehicle.

Vehicle Tracking

The detected vehicles are tracked throughout the video sequence. To do this, the technique used is the search for a match between the vehicles, of each pair of successive images through the mapping more known Matching.

The mapping is to find through the primitive counterparts in successive images, in other words, the primitives which are the projection of the same entity.

The matching algorithm

The matching algorithm is based on the principle of matching points between successive images. Traditional approaches to evaluating one by one the points of the image It that may correspond to those of the image I t +1, and retain the best match. The quality of the match is expressed by a correlation criterion.

The correlation function quantifies the similarity in appearance between two points. As the only measure of correlation between pixels is not discriminating enough, it is usually calculated over a window of pixels surrounding that point. There are several methods to measure the similarity between two windows of pixels (Chambon 2005; Garcia and OLP 2002). Among these we chose the SAD.

SAD: Sum of Absolute Differences or sum of the absolute differences between corresponding terms of the two windows.

$SAD = \sum_{(i,j)\in F} |I1(i,j) - I2(i+x, j+y)|$ (4)

In what follows, we will present the steps of matching and result.

Matching Step:

- Select points of interest;
- From the point selected, take a window f of width L f and height H f;
- Delineating research zone ZR around the searched point;
- Sweep the search area by the window f in ZR applying the SAD, line by line, column by column;
- In the ideal case, the equivalent point has a value of zero for the SAD, but in practice, the minimum value will be taken.

The matching application by correlation measure for object tracking

The same process as above is usedfor the vehicles detected by the symmetry. The search window is the object of interest (vehicle) and therefore the size of the window is equal to the size of the object. Figure 5 shows the result of vehicle tracking with matching by measuring the SAD correlation algorithm.

Fig.5. vehicle detection at instant (i) and the tracking in instant (i-1).

Distance measure from the width of the road

Figure 6 illustrate how to calculate the distance from the width of the road. The two yellow lines represent the lower boundary of the object at the time t1and t2. We calculate the two crossover points formed by intersection of the boundary lines and the lower boundary of the object. The width of the road in this instant is equal to the vertical component of the two points.

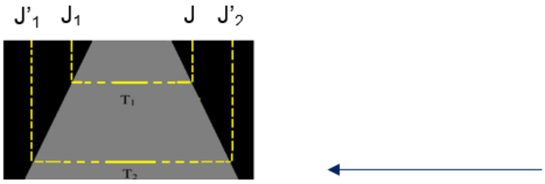


Fig.6. Distance measure from the width of the road.

The following equations give the width of the road to two moments' t_1 and t_2.

$T1 = |J1 - J2|$ (5)

$T2 = |J'1 - J'2|$ (6)

$D_1 = f\frac{Tr}{T1}$ (7)

The distance from the object at the two moments and data by the following equations:

D_1 : represent the distance initiale of the object

$D_2 = f\frac{Tr}{T2}$ (8)

D_2: represent the distance of the object at the current time.

Tr: represent the width of the road and it is fixed.

Speed measure

We calculate the difference between frames in the video "inter frame." The speed is used as follow:

1. Calculated the distance between frame (I) and frame (i+1) to obtain the distance Δd ;
2. Calculated the difference between frame (i) and frame (i+1) to obtain the time Δt.

The correspondent formula then is:

$$vitesse = \frac{|D_{frame}(i) - D_{frame}(i+1)|}{|frame(i) - frame(i+1)|} \quad (9)$$

System of evaluation

In this section, we focus on the results obtained from the different experiments to bring out the reliability of our proposed system. We are going to expose the obtained results in each step of the processing to evaluate the performance of the proposed algorithm.

We propose to validate the results using the sequences recorded in Oran. The sequences were taken during a day using a camera of CMOS sensor (Fig.7), this camera was chosen because of its low cost and good recoding quality and its reliability in energy consummation.

RESULTS AND DISCUSSION

Vehicles that appear in the field of vision of the camera are constantly changing their speed. The obtained figures are of size 640x480.

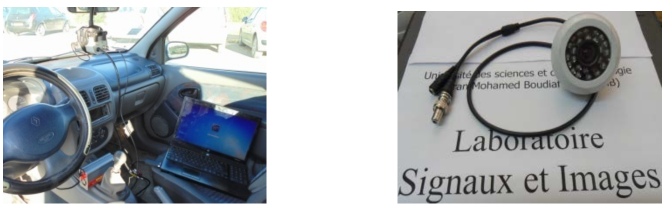


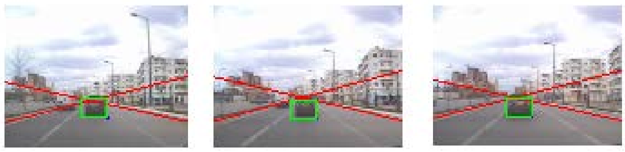
Fig.7. our system install inside the Vehicle.

The next figure illustrates our embedded system, this last is composed of camera, a transformer 12V to 220V (1000W) to supply the system. Cables to connect the components and a laptop.

Frame N°=10845 Frame N°=10857 Frame N°=10938

Fig.8. Road modeling using Hough.

In this section (Fig.8), we have obtained good results.



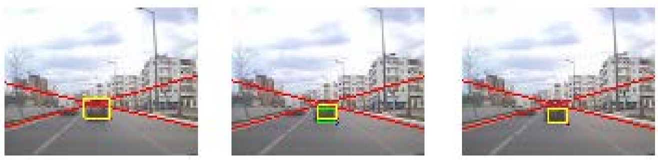
Frame N°=10846 Frame N°=10870 Frame N°=10944

Fig.9. Vehicle detection using symmetry.

Table 1. Results obtained after a treatment on 1500 images.

Frames		**True Detection**	**False Detection**
Frame1	500	500	9
Frame2	500	499	13
Frame3	500	496	16

The yellow frame represent the result of tracking the object detected in the previous image which is represented by the green frame.



Frame N°=10847 Frame N°=10848 Frame N°=10849

Fig.9. the result of vehicle tracking of the image It_{-1}.

CONCLUSION

In this paper, we present as vision system, to enhance the security of driving a vehicle, this system allow to the conductor to keep a safety distance from the preceding vehicle. Then, a segmentation scheme is applied to detect the moving vehicles. In this step an in depth study was conducted. The system starts by detecting the road delimiters. After that object tracking was done using the symmetry. To monitor the vehicles a fusion step of the data collected from the detection and the tracking is included. Finely using geometrics Foundation, the distance and the Speed are calculated.

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