Lanes and Road Signs Recognition for Driver Assistance System

Ahmed Hechri[1,2], Abdellatif Mtibaa[1,2]

[1] **Laboratory EµE, Faculty of Sciences of Monastir, University of Monastir.**
[2] **National School of Engineering of Monastir, Av Ibn ElJazzar 5019 Monastir.**

Abstract
Driver assistance systems become one of the most important features of the modern vehicles to ensure driver safety and decrease vehicles accidents on roads. According to their type and functionality, they intervene in different levels of the control processes involved in driving. In this paper, multitasks driver assistance system has been proposed. First, the system provides the driver with real time information from lanes markers and road signs, which consist the most important and challenging tasks. Secondly, generate an acoustic warning to the driver in advance of any danger. This warning then allows the driver to take appropriate corrective actions in order to mitigate or completely avoid the event. The proposed system was tested on real road scene captured from moving vehicle. From the experimental results, the system has demonstrated a robust performance for detecting the road lanes and signs under different conditions.

Keywords: *Driver assistance systems, multitasks, vehicle, Lanes detection, road signs recognition.*

1. Introduction

The rapid growing volume of traffic has a critical affect on economic development but causes large amount of traffic accidents. According to official statics, 1.2 million people die every year on the roads worldwide and between 20 and 50 million suffer nonfatal injuries. Therefore, several security measures have been taken to reduce the number of victims of road accidents. Among these solutions, we find the development of a driver-assistance system (see Fig1) that catches the attention of the driver to avoid dangerous traffic situations. Apparently, among the complex and challenging tasks of these systems is road lanes detection and road signs recognition.

The objective of an automatic road signs recognition system is to detect and classify one or more road signs from within live colour images captured by a camera. It attempts to develop an on-board warning system to alert the driver of the warning signs. Developing a reliable road signs recognition system is considered a challenging task in this work.

Lanes detection plays an important role in driver assistance system (DAS), as it can help estimate the geometry of the road ahead, as well as the lateral position of the vehicle on the road.

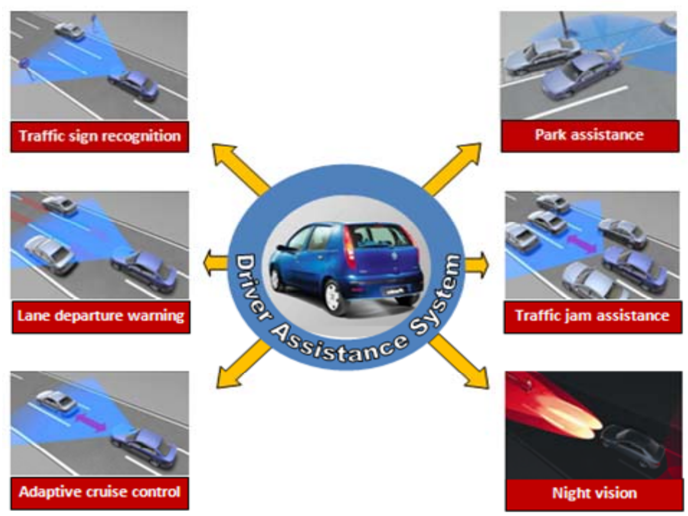

Fig. 1 Driver assistance systems functionality.

This module needs to be robust to a variety of roads conditions. By constantly monitoring the position of a car within a lane, collisions due to unintentional lane departure caused by driver distractions, fatigue, or driving under the influence of a controlled substance could be avoided.

The main objective of this paper is to develop a warning assistance system based on computer vision. First, the system provides the driver with real time information from lanes markers and road signs, which consist the most important and challenging tasks. Secondly, generate an acoustic warning to the driver in advance of any danger. This warning then allows the driver to take appropriate corrective actions in order to mitigate or completely avoid the event.

The next section presents an overview of previous works in the field of lane detection and road signs recognition. Section 3 presents the proposed warning assistance system including the approaches used to develop each modules of the system. In Section 4, a discussion on the obtained results and performance of our approach is presented. Finally, in Section 5, we conclude our work.

2. Related works

2.1 Lanes detection

Lane detection is one important process in the vision-based driver assistance system and can be used for vehicle navigation, lateral control, collision prevention, or lane departure warning system. Various road conditions make this problem become very challenging including different type of lanes (straight or curvilinear), occlusions caused by obstacles, shadows, lighting changes (like night time), and so on. Therefore, in the literature and recently, there have been many approaches proposed for solving the above problems in lane detection. For example, in [1], He et al. proposed a color-based vision system to detect lanes from urban traffic scenes. Cheng et al. [2] used the color feature to detect lane lines and utilized the size, shape and motion for false lane region elimination. In [3], Yim and Oh combined three features including the starting position, intensity, and direction for lane detection. In addition to the feature-based scheme, the model-based scheme is more robust in lane detection when different lane types with occlusions or shadows are handled. Kang and Jung [4] proposed a searching framework to group edges with similar directions as a road lane. However, when complicated roads were handled, their method tended to detect false candidates of lane. In [6], a deformable template model of lane structure is used to locate lane boundaries by using intensity gradient information. In [7], an approach that combines an edge distribution function and the Hough transform with linear parabolic model is developed for lane detection and lane tracking. The Hough transform is very powerful because it can detect road boundaries successfully even in an extremely snowy environment [8].

2.2. Road sign recognition

Most of the work published in the area of road sign recognition (RSR) separates the detection and classification of RS as two different problems. The detection of road signs from outdoor images is the most complex step in a RSR system. There are many ways in which the characteristics of road signs (RS) (e.g. well established shapes and colours of the signs) could be exploited. However, the necessity to analyze the images in real-time is a limiting factor as to how much information available within the image should be extracted and analyzed. Most approaches to the problem of RS detection use either colour information or shape information

Color information is usually exploited by performing color-based segmentation of the image. Such segmentation is difficult to perform in RGB space. RGB colors are very sensitive to illumination changes and traffic scenes tend to have varying illumination. Some authors [9, 10] try to overcome this by devising simple formulas relating red, green and blue components and experimenting with appropriate thresholds. Others work in HSI [11, 12] or L*a*b [13] color spaces.

Shape information can be obtained by various strategies: Hough transform, fast radial transform, corner detection, pattern matching, genetic algorithms etc. Hough transform is used to locate lines or circles corresponding to a sign [11]. Shape is sometimes determined by using corner information of candidate regions [11, 14]. Some researchers use pattern matching with simple shape templates [15]. A technique based on genetic algorithms was used for detection of circular traffic signs in [16]. Shape detection often fails in cases of insufficient edge contrast, so most researchers choose to augment it with color information.

In the classification stage a pixel-based approach is often adopted and the class of the detected sign is determined by the cross-correlation template matching [17] or neural network [18]. Feature-based approach is used for instance in [19]. Support vector machines also have been reported as a good method to achieve this main target due to their ability to provide good accuracy as well as being sparse methods. In [12], a technique based on genetic algorithms has been proposed to recognize circular road signs by using only the brightness of an input image, which is obtained in the form of a binary image with the help of a smoothing and a Laplacian filter.

3. Proposed system

The proposed system is enclosed in dotted as shown in figure 2.

Driver assistance systems, according to their type and functionality, intervene in different levels of the control processes involved in driving.

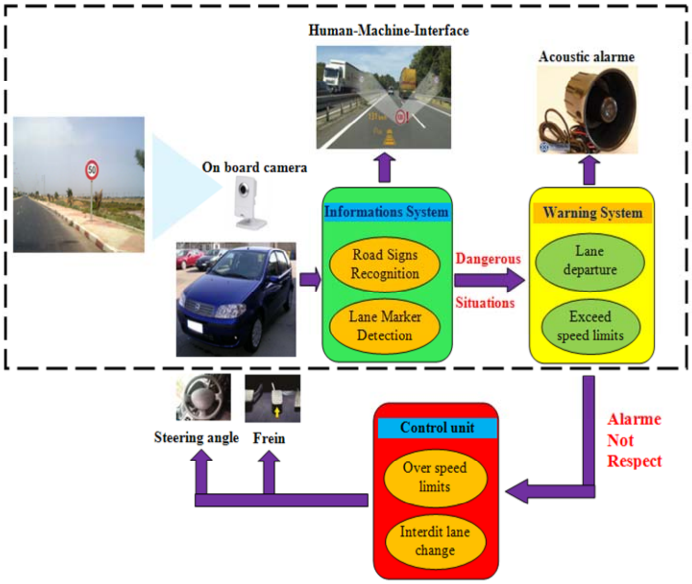

Fig. 2. Proposed system

At the most basic level, they present drivers with information which enables them to make more informed driving decisions, for example information about pedestrians not visible to the driver during night driving. At the next level, they can give the driver warnings of an imminent and possibly perilous situation to give them more time for decision making and reaction. The third level of intervention involves the system not only warning the driver but also advising or guiding them through the situation. At the highest level of intervention, driver assistance systems either take action independently or override the action of the driver.
The proposed system consists of three modules: lane detection, road signs recognition and warning system. The functionality of each module will be explained in details in the following subsections.

3.1. Lanes detection module

The goal of the image processing is to extract information about the position of the vehicle with respect to the road from the video image. Two major processes are implemented: the preprocessing process and then the lane detection process. The goal of pre-processing is to remove image noise and make the images sharper. The goal of lane detection is to detect the desired lane of the vehicle in order to obtain the look ahead distance and the lane angle.

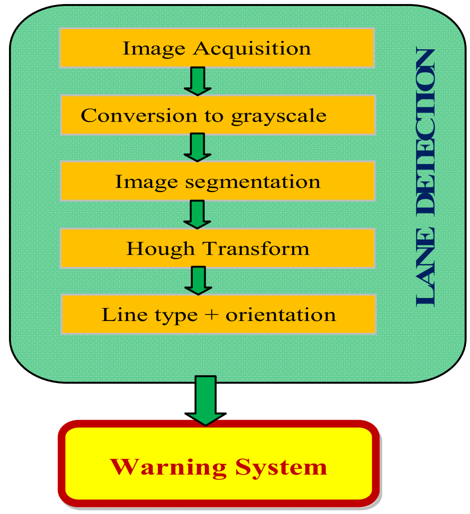

Fig. 3. Lane detection system

The first step of the lane detection algorithm is the conversion of the color image into grayscale. Then image segmentation and noise filter is carried out.

Fig. 4. (a) Original image (b) Image after segmentation

After image segmentation, we apply the standard Hough transform. The main advantage of this technique is relatively unaffected by image noise and present a reducing processing time for finding lines.

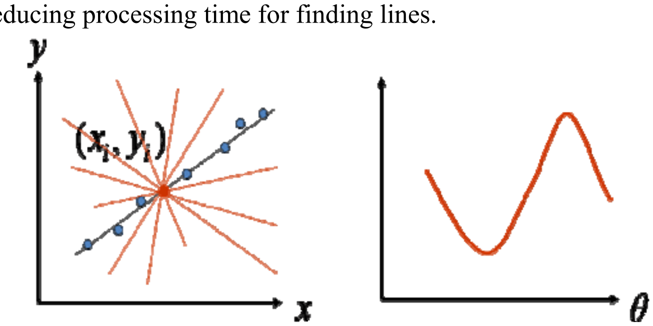

Fig. 5. (a) Image space (b) Hough space

Conversion from Cartesian coordinates [x,y] into polar coordinates [ρ,θ] is proceeded according to the following equation 1:

$$\rho = x\cos\theta + y\sin\theta \quad (1)$$

Where ρ is the line connecting the polar coordinate to the origin where the x-axis intersects the y-axis, and where θ is the angle between the x axis and ρ.

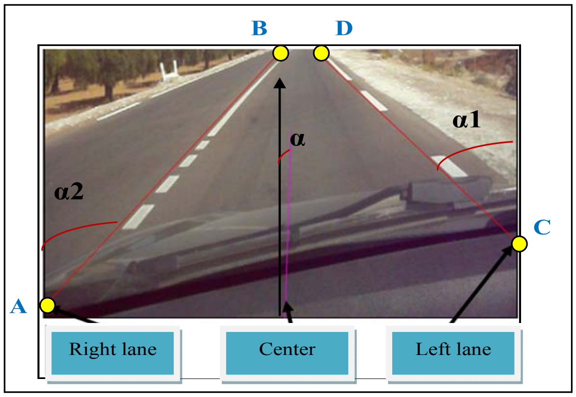

Fig. 5. Example of lane detection using Hough transforms

The steering angle α of the vehicle is giving according to the equation 1:

$$\alpha = \frac{\alpha_1 + \alpha_2}{2} \quad (2)$$

$$\text{With} \begin{cases} \alpha 1 = arctg(\frac{y_D - y_c}{x_D - x_c}) \\ \alpha 2 = arctg(\frac{y_A - y_B}{x_B - x_A}) \end{cases} \quad (3)$$

3.2. Road signs recognition module

In this section, the proposed road sign recognition system (see Fig. 6.) is described. The system consists of two modules: detection and classification. Captured images are fed into the detection module. The regions of the image containing potential road sign patterns are extracted, and then forwarded to the classification module. The classification module further process the extracted road-sign patterns and identify the type of road signs they represent.

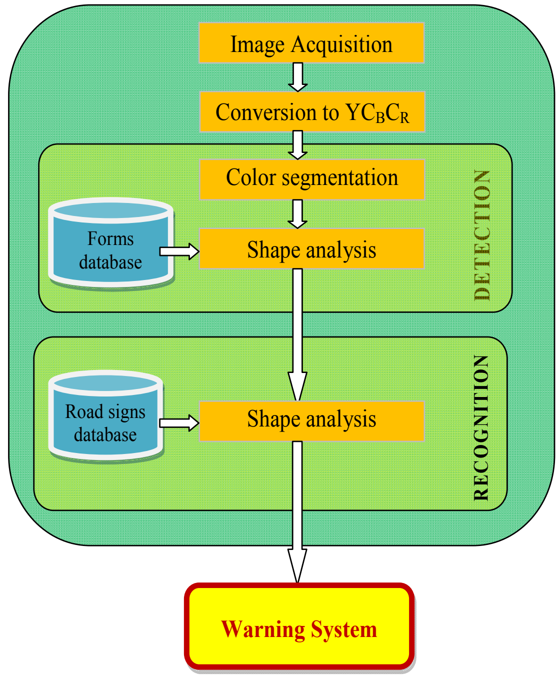

Fig. 6. Road signs recognition system

The illumination variation degrades considerably the performance of the detection module. Thus, in order to reduce the influence of luminance, acquired images were converted from RGB color model to the YCbCr color model according to the following equation:

$$\begin{bmatrix} Y \\ C_b \\ C_r \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.5 \\ 0.5 & -0.419 & -0.081 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (4)$$

First part of proposed algorithm is sign detection. The main task of the detection module is to segment the input image and extract out the areas that contain road sign patterns, and then forward them to the classification module for identification. After color segmentation, some morphological operations have been applied such as dilation, erosion and whole filling. Then we have applied template-matching algorithm to filter out the extracted non road sign objects. Template matching involves comparing a given template with windows of the same size in an image and identifying the window that is most similar to the template. In this work, the mean square error (MSE) shown in (5) is used for evaluating the similarity index.

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}\left[T(x,y) - I(x,y)\right]^2 \quad (5)$$

Where T(x,y) is the intensity value of the pattern image at the position (x,y), and I(x,y) is the intensity of the input image at position(x,y). M and N are the width and height of the image respectively.

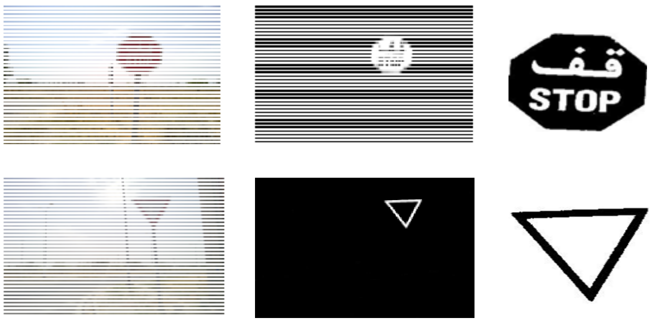

Fig. 7. Detection results

Once one or more candidates to be a road sign are found by the detection algorithm described in the previous section, a recognition stage must validate and possibly classify each candidate according to its similarity to one of the signs of a suitable database. The output of the detection algorithm is an image of road sign with nearly constant orientation, but the unknown factors, such as camera viewing direction and their relative position, will complicate the input image. Therefore, we need to use as many rotated, translated, or scaled templates as possible for identification (see figure 8).

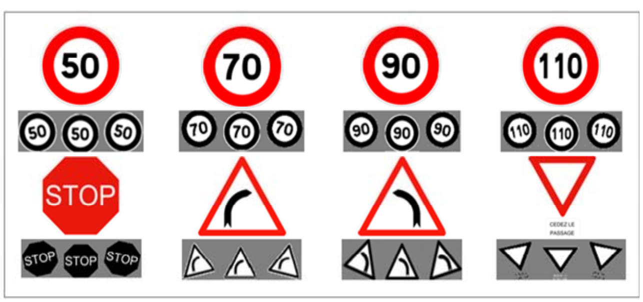

Fig. 8. :Road signs database for recognition system

In this work, a recognition scheme based on a normalized cross correlation between the window of the unknown road sign and the objects of the database work has been adopted. The cross-correlation coefficient S(I,J) between two image I and J is definied as :

$$S(I,J) = \frac{\sum_i (I^i - \overline{I})(J^i - \overline{J})}{\sqrt{\sum_i (I^i - \overline{I})^2 \sum_i (J^i - \overline{J})^2}} \quad \textbf{(6)}$$

Where $\overline{I}$ and $\overline{J}$ denote the corresponding mean of the image intensities.

4. Experimental results

To evaluate the lanes and traffic signs recognition system, experiments were performed on the real data collected from Tunisian roads. Sample video sequences were acquired from an Axis IP video camera mounted in our vehicle were used for the input to our system. Each video sequence was down-sampled to a frame rate of 5Hz before being submitted to the system.

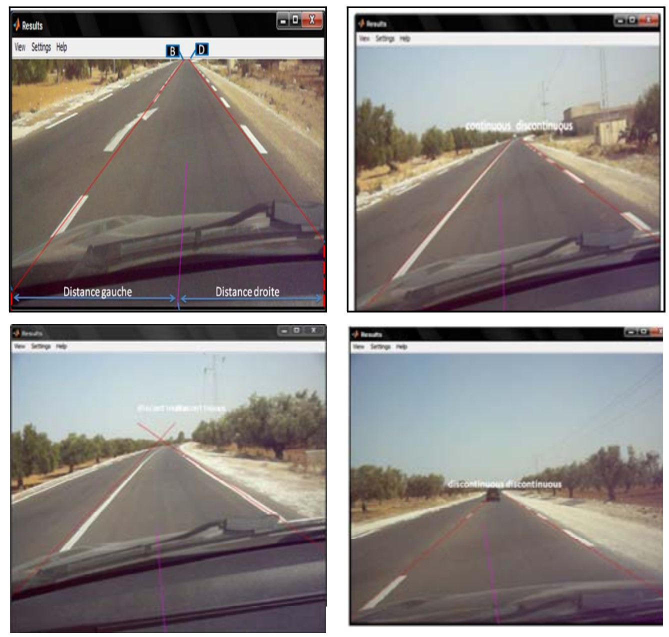

Fig. 9. Some results of the lane detection module

Some sample lane detection results are also provided in Fig8. It can be seen that the performance of the detection algorithm is quite robust in detecting lanes on urban streets with varying conditions. The proposed approach achieves good results for detecting all the visible lane boundaries especially in clear conditions. However we get some false positives due to stop lines at cross streets, at cross walks, near passing cars.

Captured video for the road sign recognition module content depicts the total of 204 signs and includes urban, countryside, and motorway scenes in natural daytime lightning, with numerous signs appearing in shade and in cluttered background. Table 1 illustrates road sign recognition results

Experimental results for the road sign recognition module demonstrate the superiority of the proposed approach which has achieved an average accuracy of 90% on completely novel test images. Our tests have demonstrated the effectiveness of our approach handling

TABLE I

DETECTION AND CLASSIFICATIONS RESULTS

Sign shape	Detection rate	Classification rate	Global
Octagon	100%	100%	100%
Circle	89%	82%	85,5%
Triangle	83%	86%	84,5%

occlusion in real traffic images including high noisy, bad illumination conditions and occlusions.

Fig. 10. Some results of the road sign recognition module

In a few false alarms across all test sequences were reported. The majority of detection failures were caused by the insufficient contrast between a sign's boundary and the background, especially for the signs appearing in shade or seen against sunlight.

5. Conclusion

In this paper, warning assistance system has been presented. Two driving tasks are considered: lane detection and road sign recognition. Firstly, a robust lane detection method has been developed which is based on Hough transform. This approach for safe lane systems has developed a safety system for avoiding lane departures for a large and complex set of traffic scenarios. Then, efficient approach for road sign recognition system was developed and evaluated extensively through various test sets. The results prove the efficiency of the presented algorithms and show that our approach could have good prospects for application on board of intelligent vehicles.

Future work will include the full development of a HW/SW demonstrator to be mounted in a commercial car to verify the effectiveness of the concepts and the quality of the implemented strategies.

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Ahmed Hechri received the degree in Electrical Engineering from Sfax University, Tunisia in 2006. In 2008 he received his M.S degree in Electrical engineering National School of Engineering of Monastir. He is currently preparing his PhD degree in the Electronics and Microelectronics Laboratory (EμE) at the Faculty of Sciences of Monastir.
His current research interests include modeling and control of mobile robots, image and video processing.

Abdellatif Mtibaa received his PhD degree in Electrical Engineering at the National School of Engineering of Tunis. Since 1990 he has been an assistant professor in Micro-Electronics and Hardware Design with Electrical Department at the National School of Engineering of Monastir. His research interests include high level synthesis, rapid prototyping and reconfigurable architecture for real-time multimedia applications, processing, embedded systems and pattern recognition.