PATTERN ANALYSIS FOR COMPUTER-AIDED DRIVING

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Abstract: This study is based on the elaboration of a software for computer-aided driving. A video is acquired through the windscreen while driving, showing the scene observed by the driver. The purpose is to extract characteristic elements on each image of the video sequence in order to interpret them and help the driver to make a decision. In this way, the road width is estimated. As well, road signs are extracted from the video and the information they contain is interpreted. The presented works are based on a preliminary study giving a draft software and experimental results are shown on several examples.

1 INTRODUCTION

In the last few years several studies have been led concerning object detection in video showing road scenes. Some of them concern number plates in order to identify vehicles (Jia et al., 2007). Others are related with vehicle recognition in order to determine how a parking is occupied or what kind of vehicles are in a traffic jam (Taktak et al., 1995)(Kaaniche et al., 2005). And finally some of them aim to interpret a road scene as seen by a human observer, in order to help a driver to make a decision (Foedisch et al., 2006). Furthermore some studies concern the driver behavior in order to improve the road safety (Riener and Ferscha, 2007).
In this study we will firstly show how to determine the road width at each time. This information is very important as it can influence the vehicle positioning on the road. In a second time, road signs are extracted from the video in order to be interpreted.

2 IMAGE ACQUISITION

In order to acquire video sequences, a camera is set up inside the vehicle behind the windscreen and approximatively in the middle. Digitized scenes represent mainly the lane in which the vehicle is moving, but also a part of the left lane and a part of the right road side. Let us recall that vehicles move on the right side in France. On such images we can distinguish both road signs and runway markings. Fig. 1 shows an example of acquisition. Video sequences are acquired in urban context as well as in countryside.

Some complementary data are also available from the full acquisition system, such as GPS coordinates and video sequences on the rear. But in this paper no correlation between the different datasets is achieved, but it will be done in future works.

3 ROAD WIDTH ESTIMATION

3.1 Image Preprocessing

Road lane segmentation is a difficult task to achieve as context can be of various kinds: urban context, countryside, highways, etc. (Kang and Jung, 2003). Road width estimation is based on runway marking detection (Rebut et al., 2004). Fig. 2 shows examples where the lane is bounded and examples where it is not.

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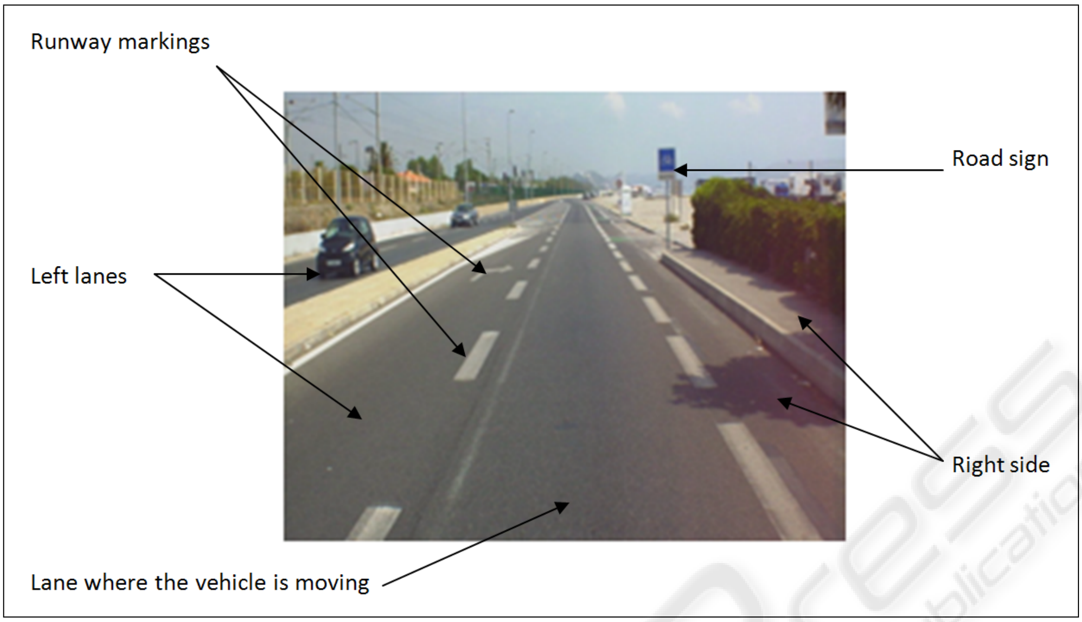


Figure 1: Example of video acquisition.

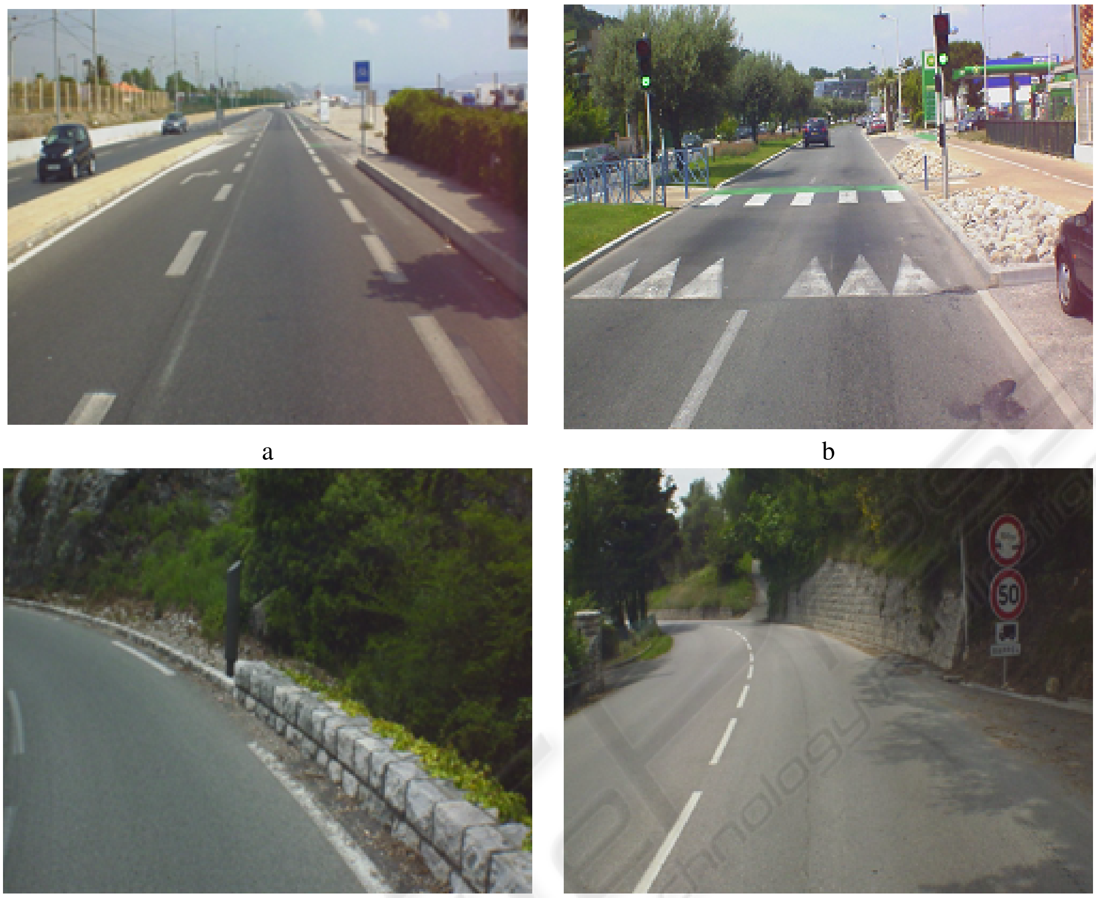
In this paper let us assume that the lane where the vehicle moves is bounded on both sides by runway markings or at least by a sidewalk of light color. Then the main step of the preprocessing process consists of the localization of those markings. This marking detection is achieved by a marginal thresholding on the three color planes of an image. The threshold value is high: if v_{max} is the maximal value of the considered plane, the threshold value is equal to $0.9 \times v_{max}$. In this way we keep only high values on the three planes. Then if a high value is detected at the same position in both red, green and blue planes, this is representative of white or quasi-white points. The final thresholded image contains only white or quasi-white points. As runway markings are painted in white, they are detected on the resulting thresholded image. Fig. 3 shows thresholding results on images of Fig. 2.

3.2 Width Estimation

In order to measure the road width, an extraction of runway markings is achieved from the thresholded image. Then these markings need to be continued so that the lane is fully bounded on each side. This continuation process is done by considering the vertical median line as the starting point set. This median line is scanned from bottom to top until half the image height. Then the first white point on the right and the first white point on the left, if they exist, are detected for each ordinate value. This gives two different point sets: the one for points on the left and the other one for points on the right. These sets are arranged in order according to ordinate values. When points are missing for some ordinates, a linear interpolation is achieved to prolongate the markings (Fig. 3a, b and c).

When the two lane sides are fully bounded (Fig. 3a and b), an estimation of the lane width can be done. As shown in Fig. 4, the median line in orange is scanned again in order to measure the horizontal distance between a point of the left set and one of the right set. These two points can belong either both to the marking set (in yellow), or both to prolongated lines (in cyan) or one to the marking set and the other to the prolongated lines (in green). It makes no sense to explore the image beyond the downer part because the image is too distorted because of perspective deformation and measures will be too erroneous.

Depending on the ordinate value a scale ratio is applied to each horizontal distance estimated in pixels in order to obtain a distance in meters. This scale ratio obviously depends on the ordinate value as this value is itself strongly correlated with the distance to the vehicle. A calibration is achieved before the video acquisition. From this calibration step, distances can be estimated in meters from measures in pixels in the transversal direction (horizontal on the image) and in the longitudinal direction (vertical on the image) on the bottom half of the image. In other words, distances can be estimated until a real distance of 20 meters ahead from the vehicle.



a b c d

Figure 2: Examples of road views: a) road lane bounded by markings, b) road lane bounded by markings and light sidewalk border, c) hairpin bend and d) road lane bounded by markings only on the left-hand side.

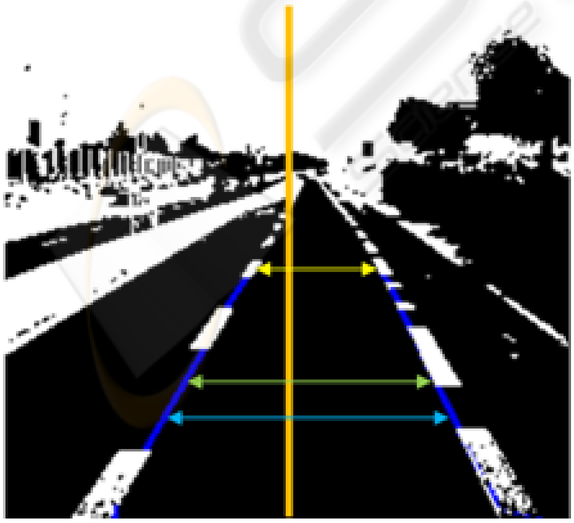


Figure 4: Horizontal distances between left and right points.

4 ROAD SIGN ANALYSIS

4.1 Road Sign Detection

Road sign interpretation is also a very important point to deal with, as it implies modification of the driver behavior. Several studies have been led to determine how the driver detects and interprets road signs (Won et al., 2007). In order to detect road signs the image is roughly partitioned in several regions. Interesting road signs are located on the right side of the road. Furthermore it is of no interest to try to identify signs that are too close or too far from the vehicle, because the information contained in the sign can be highly biased due to the road curvature (if too far) or to a partial image of the sign (if too close). That is why the study is restricted to a sixth of the whole image (Fig. 5): part number 3.

The image is then thresholded in order to extract

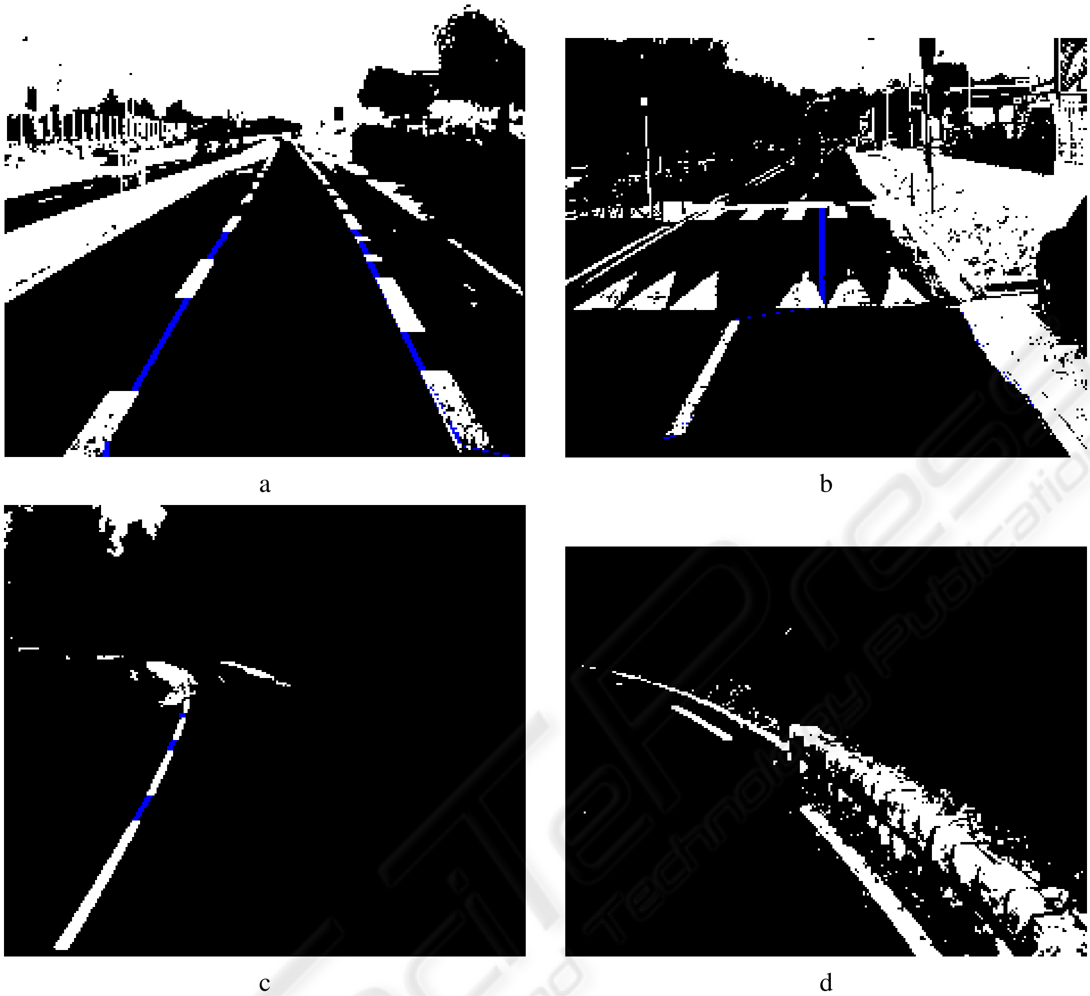


Figure 3: Thresholded images corresponding to original images of Fig. 2. In blue, runway marking prolongations.

Figure 5: Image partition for road sign detection.

the sign itself. Based on the assumption that signs are made of vivid colors, the thresholding stage is achieved as well as in the first part for runway marking detection. But in this case, all light color values are interesting as road signs are mainly bordered in white, yellow, blue or red. The thresholding step is then achieved in a marginal way, before merging thresholded images. Fig. 6 shows a sign detection by thresholding.

4.2 Information Extraction

Two different kinds of information are extracted to identify a road sign: its content and its shape (Gao et al., 2006). Actually, the meaning of a road sign depends on its shape: for example triangular signs indicate a hazard. This discriminates main families of road signs as we are going to distinguish several el-

Figure 6: Image of a road sign (a) and detection by thresholding (b).

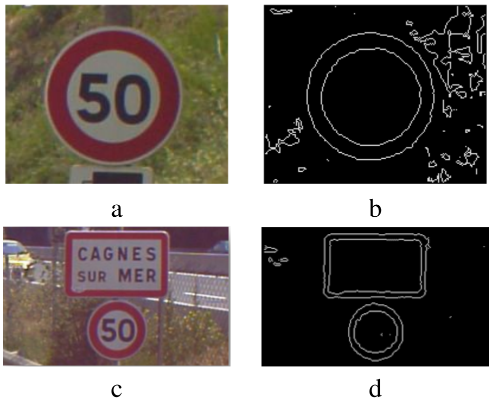


Figure 7: Image of a road sign (a,c) and contour detection (b,d).

ementary shapes: disks, rectangles, squares and triangles. Furthermore, inside a given family, the information contained by the road sign enables to fully identify the sign meaning.
So the contour of the road sign is extracted from the thresholded image. Afterwards this set of points is vectorized (Hilaire and Tombre, 2006) in order to keep only a few points: three for triangles, four for rectangles or squares and six at least for disks. Fig. 7 shows different contour extractions and Fig. 8 contour vectorizations. The processing is achieved only on the outer contour.

Depending on the point number resulting from the vectorization step, a first classification is established and the sign under study is associated with one of the main families.

Finally information is extracted from the sign by processing the image only inside the previously determined contour. In this way a basic thresholding gives the result, as shown on Fig. 9.

4.3 Estimation of the Sign Height

Another information that can be helpful for computer-aided driving is the road sign height or its post length. In order to compute this height, we start from the

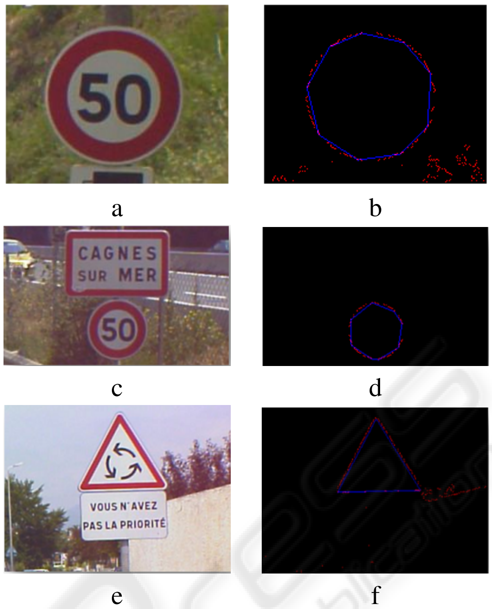


Figure 8: Image of a road sign (a, c, e) and contour vectorization in blue (b, d, f).

a b

Figure 9: Image of a road sign (a) and extracted information (b).

point in the middle of the sign bottom and we try to go down through the post with respect to some criteria. This progression stops as soon as homogeneity criteria in terms of colors are no more respected. These homogeneity criteria are computed by determining a color distance between the next bottom point and points already identified as part of the sign post. The post height is then estimated by pixel counting, when using a coefficient given by the calibration step of the whole system, so that the height is converted in meters. Fig. 10 shows an example of post detection. The red cross marks the last point identified as belonging to the post. Unfortunately the homogeneity criteria need to be improved as we did not reach the post foot.

Figure 10: Image of a road sign and detection of its post foot.

5 CONCLUSIONS AND FUTURE WORKS

Up to now, the developed software is a prototype version showing that it is possible to extract useful informations from the video sequences. But in future works we will have to solve several problems involved by scene shading or weather. The scene lightning is also preponderant and it depends on many factors such as hour of the day or season.
Nevertheless, the presented works show that algorithms have been successfully set up. Experimental results are encouraging and computation time are low enough not to prevent from real-time processing.
Furthermore we will have to deal with more complex scenes including for example more than a single sign. Concerning the road width, we also have to improve our algorithm so that it will be able to process images even if the road lane is not fully bounded. That requires the detection of non-homogeneous road borders in terms of color, especially in countryside scenes.

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