Vision based Intelligent Systems for Autonomous and Assisted Downtown Driving

Miguel Ángel Sotelo[1], Ramón Flores Acedo[1], Miguel Ángel García[1]

[1] Department of Electronics, University of Alcalá (UAH), Alcalá de Henares, Madrid 28871 (Spain) email: michael@depeca.uah.es

Abstract. Autonomous and assisted driving in city urban areas is a challeging topic that needs to be addressed during the following ten to twenty years. In the current work an attempt in this direction is carried out by using vision-based systems not only for autonomous vehicle driving, but in helping the driver recognize vehicles, pedestrians and traffic signs. Some well consolidated results have been attained on a private test circuit using a commercial Citroën Berlingo as described in this paper.

1 The Global Concept

The global system undertakes either autonomous or assisted driving in urban city areas. This implies to solve the problem of intelligent unmanned mission execution using vision as the main sensor. According to this, the following remarkable challenges arise: lane tracking on non-structured roads (roads with no lane markers), sharp turn manoeuvres in intersections (very usual in urban areas), vehicle detection, pedestrian detection, and traffic sign detection and recognition. The system achieves global navigation by switching between *Lane Tracking* and *Intersection Navigation*, while detecting vehicles, pedestrians, and traffic signs in its local surrounding.

1.1 Lane Tracking

The mission of this task is to provide correct lane tracking between two consecutive intersections. A polynomial representation is used assuming that the road edges can be modelled as parabolas in the image plane [3] [4]. According to these previous considerations the incoming image is on hardware re-scaled, building a low resolution image of what we call the Area of Interest (AOI), comprising the nearest 20 m ahead of the vehicle. The AOI is segmented basing on colour properties and shape restrictions. The proposed segmentation relies on the HSI (Hue, Saturation, Intensity) colour space [2], using a modified cylindrical metric for both chromatic and intensity information. A pixel is associated to the road region if the value of chromatic and intensity metrics are respectively lower than some adaptive thresholds. To account for road shape restrictions, thresholds are affected by an exponentially decay factor yielding the new threshold values that depend on the distance between the current pixel and the previously estimated road model.

Once the segmentation is accomplished, a time-spatial filter removes non-consistent objects in the low resolution image, both in space and time (sporadic noise). After that, the maximum horizontal clearance (absence of non-road sections) is determined for each line in the AOI. The measured points are fed into a Least Squares Filter with Exponential Decay [3] that computes the road edges in the image plane as well as the central trajectory of the road using a second order (parabolic) polynomial. A complete example is depicted in figure 1.

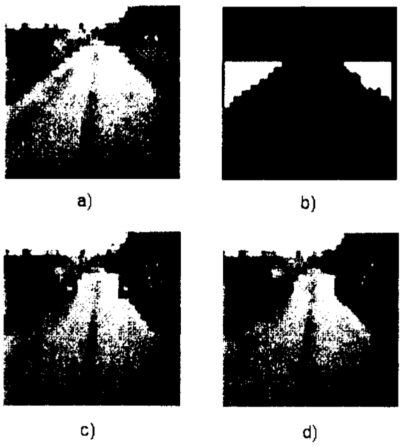

Fig. 1. A complete example: a) original image, b) road segmentation, c) edges measures, d) edges estimation.

1.2 Intersection Navigation

The vehicle can perform three possible operations at an intersection: left turn, right turn, or go ahead

- ***Left and Right turns*:** Vehicle's localisation is required along the curve trajectory so as to decide when to resume lane tracking. To provide an estimation of the vehicle's position during the turn, the arc described by the vehicle is modelled as a random variable ξ. Its probability density is maintained at any point in time in the framework of Markov localisation. The key idea of Markov Localization is to compute a belief probability distribution *Bel* over all possible locations (ξ) in the environment The belief *Bel* is updated each time the vehicle moves or the system performs a measure, accounting for the kinematic and dynamic constraints of the vehicle and considering an approximate model of the environment for modelling conditional probabilities involved in the process.
- ***Go ahead*:** In this case the incoming image is processed using the same algorithm described for lane tracking.

1.3 Vehicle Detection

Vehicle detection is accompli
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1.4 Pedestrians Detection

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1.5 Traffic Sign Detection

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2 Implementations ar

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1.3 Vehicle Detection

Vehicle detection is accomplished by using a monocular colour vision system. Using one single image leads to some limitations on the kind of obstacle that can be detected but provides a simple and fast method. Other vehicles moving in the same or opposite lane can be reliably detected using the road shape and an estimation of the road width to predict the exact area of the image where the obstacles are expected to appear. Vehicles are then characterised by symmetry and edges features, within the estimated road, as far as usual vehicles have quite a distinguishable artificial shape and size that produces remarkable vertical edges in filtered images.

1.4 Pedestrians Detection

Pedestrians detection is a challenging ongoing characteristic currently being adapted to the global navigation system. For this purpose, vertical edges and symmetries are exploited as the salient features, combined with human shape constraints. This subsystem assists the driver in detecting pedestrians along the street in common traffic situations.

1.5 Traffic Sign Detection and Recognition

In order to guarantee the fulfillment of basic traffic rules, particularly those concerning speed limits, a vision based task for traffic sign detection and recognition is also being developed at present. The set of signs considered for this application includes velocity limit signs, overtaking manoeuvres, and some triangular signs indicating the most common dangerous situations. To achieve accurate real time detection, colour and differencial information from the original and filtered image is exploited. After that, a neurally inspired classifier system is the basis for recognition and validation.

2 Implementations and results

All vision and control tasks in the system were developed in C under the Real Time Linux Operating System, running on a single PC (processing up to 15 frames/s). The system has been successfully tested in its autonomous navigation mode on an electric vehicle (Citroën Berlingo commercial prototype) illustrated in figure 2, on a private test circuit in the *Instituto de Automática Industrial* of the *Consejo Superior de Investigaciones Científicas* (CSIC). Partial results on pedestrians and traffic signs detection in operational circumstances are expected to be issued in the short term. For further results, you can anonymously retrieve some compressed (AVI type) video files from ftp://www.depeca.uah.es/pub/vision exhibiting autonomous mission execution and vehicle detection capacities.

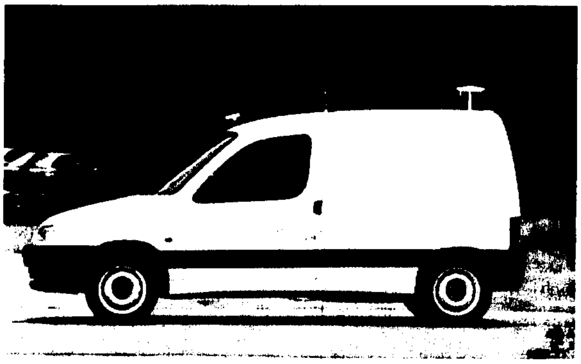

Fig. 2. Commercial prototype used for tests.

Acknowledgments

This work is supported by the University of Alcalá (project UAH2002/031) and the CICYT (project DPI2002-04064-C05-04), as well as by the generous support of the CSIC.

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