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Vehicle and Pedestrian Detection Applications

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Abstract

This paper describes a target detection system on road environments based on Support Vec-tor Machine (SVM) and monocular vision. The fi-nal goal is to provide pedestrian-to-car and car-to-car time gap. The challenge is to use a single camera as input, in order to achieve a low cost final system that meets the requirements needed to undertake serial production in automotive industry. The basic fea-ture of the detected objects are first located in the image using vision and then combined with a SVM- based classifier. An intelligent learning approach is proposed in order to better deal with objects vari-ability, illumination conditions, partial occlusions and rotations. A large database containing thousands of object examples has been created for learning pur-poses. The classifier is trained using SVM in order to be able to classify pedestrians, cars and trucks. In the paper, we present and discuss the results achieved up to date in real traffic conditions.

Keywords: Vision, pedestrian detection, vehicle detection, SVM (Support Vector Machine) and tracking..

1. Introduction

This paper describes a vision-based candidate extraction method for pedestrian and vehicle detection in Intelligent Transportation Systems (ITS). These methods are a challenging problem in real traffic scenarios since they must perform robustly under variable illumination conditions, variable rotated positions and pose, and even if some of the object parts are partially occluded. An additional difficulty is given by the fact that the camera is installed on a fast-moving vehicle. As a consequence of this, the background is no longer static, and candidates significantly vary in scale. This makes the ITS problem quite different from that of detecting and tracking objects in the context of surveillance applications, where the cameras are fixed and the background is stationary. To ease the recognition task in vision-based systems, a candidate selection mechanism is usually applied. The selection of candidates can be implemented by performing an object segmentation in either a 3-D scene or a 2-D image plane.

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Not many authors have tackled the problem of monocular pedestrian [1],[2] and vehicle recognition [10]. Concerning the various approaches proposed in the literature,most of them are based on shape analysis. On the one hand, about pedestrian detection, some authors use feature-based techniques, such as recognition by vertical linear features, symmetry, and human templates [2], Haar wavelet representation [5], hierarchical shape templates on Chamfer distance [3], correlation with probabilistic human templates [6], sparse Gabor filters and support vector machines (SVMs) [7], and principal component analysis [8].

On the other hand, some previous developments use available sensing methods for vehicle detection, such as radar[14], stereo vision or a combination of stereo-vision and laser [12]. In [9] the authors propose the fusion of stereovision and radar for creating a hybrid velocity adaptive control system called HACC. Only a few works deal with the problem of monocular vehicle detection using symmetry and colour features [10] or pattern recognition techniques [13]. In [10] the authors propose the use of horizontal edges and vertical symmetry together with a shapedependent process for removing objects that are too small or too big in the image plane. In [11] the authors propose the use of a geometrical model for vehicle characterization using evolutionary algorithms, assigning different geometrical models depending on the vehicle lane.

The remaining of the paper is organized as follows: Section 2 provides a description of the pedestrian candidate selection mechanism. Section 3 describes the vehicle detection method. The implementation and results achieved up to date are presented and discussed in Section 4. And finally, Section 5 summarizes the conclusions..

3. Pedestrian Detection

To detect the different pedestrians on the image, two methods are used, depending on their kind of movement and their distance from the camera: motion analysis and texture analysis. Motion is the main extraction method to select candidates who are moving, because it detects each movement in the image; but there are complex situations which need further exhaustive analysis. The idea is to select the candidates by following the next rule: in- ward movement with motion analysis, standing candidates with texture analysis and outward movement by a decision between both methods depending on the situation. After selecting the candidates, a classification and tracking step is done, in order to decrease the number of false positive detections and keep the valid candidates under detection.

3.1 Inward Motion

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This algorithm is an adaptation of the crowd detection system of [1], which uses the temporal consistency of the gray levels in the image to detect the regions with high probability of being moving. The gray level information of selected regions of the image in consecutive frames is used to estimate the motion on that region. The motion system architecture loops through the following modules: xt image, turning detection, inward motion detection and candidate generation.

3.2 Texture Analysis

The main target of this system will be the pedestrians moving laterally and towards the path of the vehicle. The ego-motion of the vehicle and the cluttered environments make the motion maps very noisy at the sides when moving forward or at the front when turning. In these situations it is not easy to separate the movements of the candidates from the movement of the background due to the ego-motion. In fact, when the vehicle is moving the velocities of a longitudinally walking pedestrian and of a wall, street lamp, door, etc, behind them are very similar.

A different detection technique is thus needed for these scenarios: texture analysis.The texture analysis consists of two basic steps: Image preprocessing, where image textures are extracted, protecting vertical edges, an important pedestrian characteristic; and Spatial localization, to find the different candidates of the image based on the high entropy areas.

3.3 Pedestrian Recognition and Tracking

Pedestrian recognition is carried out by using a learningbased approach in which discriminative features are extracted from each candidate and then, they are passed through the learning machine or classifier (SVM classifier). The tracking process relies on Kalman filter theory to provide spatial estimates of detected pedestrians. Thus, steadier 2D spatial positions of pedestrian in the image plane are obtained. In addition, Kalman filter provides the prediction of the 2D position of each candidate in the next frame, which will be very useful when solving the data association problem, that is, the association of the candidates state vectors at frame i and the measurements available at frame i + 1. The overall structure of this part of the algorithm is depicted in Figure 9.

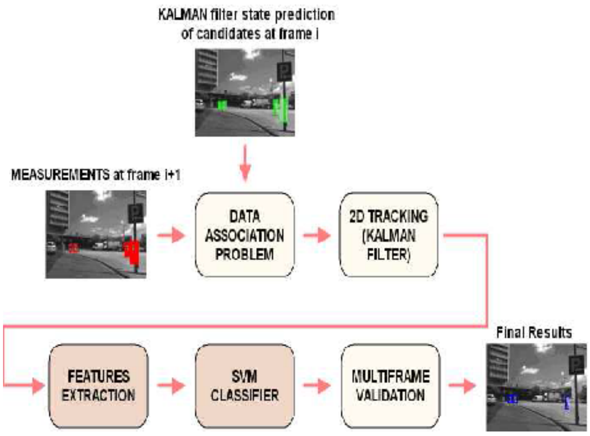

Figure 9: Overall scheme of tracking and recognition steps.

4 Vehicle Detection

4.1 Candidate Selection

The main idea of the vehicle candidate selection is to make a sequential scanner for each road lane, from the bottom to the horizon line of the image looking for collections of horizontal edges that might represent a potential vehicle. The scanned lines are associated in groups of three. For each group, a horizontality coefficient is computed as the ratio of connected horizontal edge points normalized by the size of the area being analysed. The resulting coefficient is used together with a symmetry analysis in order to trigger the attention mechanism

An adaptive thresholding process is implemented in order to obtain robust edges from the road images. This adaptive process is based on an iterative algorithm that gradually increases the contrast of the image, and compares the number of edges obtained in the contrast increased image with the number of edges obtained in the actual image. If the number of edges in the actual image is higher than in the contrast increased image the algorithm stops.

Otherwise, the contrast is gradually increased and the process resumed. After thresholding, horizontal edges in the scanned regions given by a Lane Departure Warning System (LDWS), developed by the authors in previous works [15], are examined to detect the rear part of potential vehicles. In order to decide if the collection of horizontal lines represents a possible vehicle candidate, its width is compared to that of an ideal car. The ideal car width is obtained for each vertical coordinate using the camera pinhole model explained in section 2.2. Once the car width is computed at the current frame it is compared to the collection of horizontal lines found after the thresholding analysis. If they are similar to some extent defined by an empirical value, a square area above the collection of horizontal lines, denoted as candidate ROI, is considered for further analysis. The aim is to compute the entropy of the candidate ROI and its vertical symmetry. Only those regions containing enough entropy and symmetry are identified as potential vehicles. Figure 10 shows a detailed block diagram of the detection procedure and figure 11(a) depicts an example of the detection step.

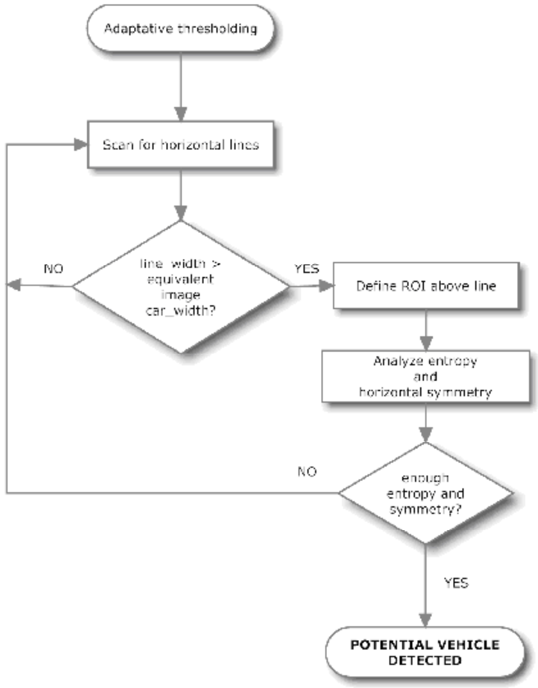

Figure 10: Block diagram of the vehicle detection mechanism.

Similarly to pedestrian detection, detected candidates are classified as vehicles or non-vehicles depending on features obtained from the vehicle ROI using Support Vector Machines (SVM), and after that they are tracked using Kalman filter techniques. Figure 11(b) shows the result of the classification step. The purpose of the Kalman filtering is to obtain a more stable position of the detected vehicles. Besides, oscillations in vehicles position due to the unevenness of the road makes y coordinate of the detected vehicles change several pixels up or down. This effect makes the distance detection unstable, so a Kalman filter is necessary for minimizing these kinds of oscillations.

5 Conclusions

We have developed and implemented a pedestrian & vehicle detection system based on Support Vector Machine (SVM) and monocular vision with the objective of providing pedestrian-to-car and car-to-car time gap measurement for applications in the framework of Intelligent Transportation Systems (ITS). Candidates are raised using
an attention mechanism based on inward motion, textures, horizontal edges, vertical symmetry and entropy. The detected objects are passed on to a SVMbased classifier. After classification, detected objects are tracked using Kalman filtering. A large database containing thousands of examples extracted from real images has been created for learning purposes. After assessment of the practical results achieved in our experiments, the following general conclusions can be summarized:

• Car dynamics (yaw rate and velocity) have to be taken into account in order to improve data association and tracking stages. Moreover, at present, the region of interest is statically fixed. By using yaw rate and car velocity variables we can define a more precise region of interest and evaluate the risk for each candidate.

• The performance of the vehicle detection module is significantly increased by building on the output provided by the LDWS function. • The presence of large shadows on the asphalt due to vehicles circulating along the road produces negative effects on the candidate selection mechanism, yielding to inaccuracy in measuring the distance to the vehicles.

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