H-003

Comparison of Several Shape Descriptors in Order to Perform Car Recognition from a Moving Camera

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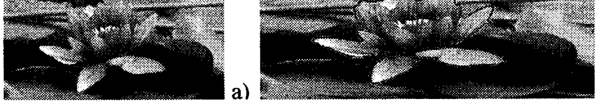
1. Introduction

The large number of crimes committed on road is an increasing police interest in intelligent systems. One of the hardest tasks for law enforcement agencies is to locate a suspect car on road network. In spite of the intense development of LPR (License Plate Reading) and GPS tracking methods for security proposes, cars are rarely equipped with these technologies and also it is relatively easy to falsify license plates. This technology requires intelligent cameras capable of dealing with real-time input for car detection and recognition. Different approaches have been described in the past for vehicle detection. Some methods focus on feature detection [3] such as SIFT [5] other focused on 3D modeling [4]. These approaches have been elaborated only for specific input of data and under certain conditions, e.g fixed camera position overlooking passing cars directly underneath.
By using the multiscale curvature-based representation to describe the car body shape for the vehicle detection, we make our algorithm effective to perform the recognition in a larger scope of scenarios. It is critical to make the recognition quickly as well as accurately. This paper addresses the challenge to present the B-spline wavelets- based shape representation method in the objective of car recognition application. In a first part we focused on the shape descriptor using B-spline wavelets. In the section 4 we describe the algorithm for corners coordinates' retrieval, necessary to reconstruct object's shape. Finally section 5 presents the car recognition algorithm.

2. Image pre-processing

Concerning contours, we search for a contour as a group of pixels whose gradient is high in the direction of the gradient. We compare each pixel with its neighbor pixels. This operation is therefore local and noisy phenomena could occur during the contour detection process affecting robustness of contours detection. To solve this problem we proceeded to a pre-processing step aiming at filtering it, to smooth irregularities without loss of information on relevant discontinuities. In our case we used a median filter because of its edge-preserving nature. Also segmentation is performed in the frame in order to remove the background because its information is irrelevant for the rest of the computation.



a) b)

Figure 1. Image segmentation a) Original image b) segmentation [1] (green contour)

We used an algorithm presented as an alternative of standard "grow cut" [1] algorithms. It is based on a biological metaphor, each pixel is considered as a cell of a certain group. Labels can be of three types: foreground, background and undefined.
A first group of sample pixels is labeled. As the algorithm proceeds, these cells "compete" to dominate the image domain. The ability of a region to grow is related to its pixel intensity and its distance. When the filtering step is complete, we detect contours by calculating a discrete gradient over the image. This calculation is performed by using the Sobel-based method for edge detection because of its sufficient results and also its fast computation.

3. Multiscale shape descriptor using B-spline wavelets

In the area of design, e.g the automotive industry, B-splines is widely used to create the main body part of the car. From this statement we decided to utilize the multiscale curvature shape representation using b-spline wavelets in order to extract car contours and then locate knots points
This section describes the existing literature on B-splines and their associated wavelets. A B-spline curve through a set of points, constitute a particular example of a convolutional basis. Because of their compact support and other attractive numerical properties, B-splines constitute a good basis choice for the forward interpolation problem which will be useful for the matching process. Because our objective is to detect car from a moving camera, the property of affine invariance of B-splines is essential. We first parametize the curve of the detected contour, using a basis of B-splines. The curve evolution can be described by:

$$f(x) = \sum_{k \in Z} c(k)\beta^m(x-k) \qquad (1)$$

β corresponds to the B-spline at order m. The m order is obtained by using a repetitive convolution of zeroth-order B-spline m times. The zeroth-order with support [- 0.5, 0.5] is given by:

$$\beta^0(x) = \begin{cases} 1, & -\frac{1}{2} < x < \frac{1}{2} \\ \frac{1}{2}, & |x| = \frac{1}{2} \\ 0, & \text{elsewhere} \end{cases} \qquad (2)$$

c(k) correspond to the weighting coefficients utilized to remove incorrect data. An approximation is performed using the

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convolution of an inverse B-spline of a suitable order l with the original coordinate's vector.

$$c_0(k) = (b^l)^{-1} * V(k)_{(3)}$$

These two expressions enable to obtain a multi-resolution description by convolving the curvature function with a scaled B-spline.

$$\beta_s^n(u) = (1/s)\beta^n(u/s)_{(4)}$$

Because noisy issues are accentuated by using first and second derivatives of coordinates, this description allows us to avoid noise sensitivity by computing wavelets transforms for the estimation of the curve at different scales. Wavelets enable to improve the ratio between noise and accuracy by dealing only with first order difference to estimate derivative values. This is a critical aspect of our research since our objective is to perform car recognition under different conditions.

$$\kappa(u,s) = \frac{W_1x(u,s)W_2y(u,s) - W_1y(u,s)W_2x(u,s)}{(W_1x(u,s)^2 + W_1y(u,s)^2)^{3/2}} \quad (5)$$

4. Algorithm for corner points retrieval

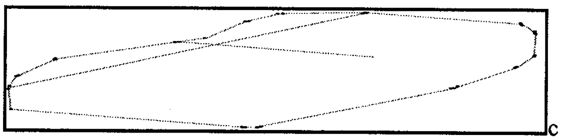
The last step consists of detecting relevant corner candidates by using an algorithm for curve data compression. After locating extrema points, we verify if theses points do not match another corner candidate from their neighborhood at a higher scale. An algebraic inequality is proposed as a condition of corner matching, where epsilon is the threshold parameter.

$$d(p_k^{i+1}, p_l^i) \le \varepsilon_{(6)}$$

At finer scale we observe the detection of a large number of corners (figure c, shape of a dodge viper). To solve this problem we introduce a condition to keep only relevant corner, points where the angle variation is important. Therefore for each group of three consecutive corner points we use this formula comparing distance between these three points. Thus we remove phantom corners

$$\overline{P_{k-1}^iP_k^i} + \overline{P_k^iP_{k+1}^i} \ge \lambda\overline{P_{k-1}^iP_{k+1}^i}_{(7)}$$

Remaining points correspond to the relevant control points (figure d) for the contour reconstruction in order to perform a matching process with our generic car contour model.


c

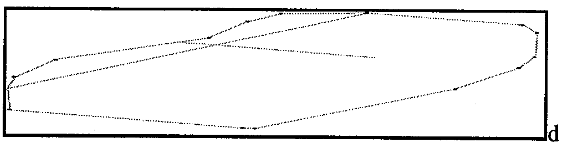

d

Figure 2 c) corner detections at finer scale d) result of corner retrieval algorithm

5. Car recognition algorithm

Car recognition issue is an important and challenging issue among computer vision topics; we theoretically propose a method for handling car silhouette based recognition. As mentioned previously in this paper, spline - wavelet analytical framework extracts the contour inflexions while eliminating the noise factor. Then, nearest-neighbors (NN) method is chosen, it classifies objects based on closest training examples in the feature space. Its practical simplicity and its fast computation make NN a powerful tool for pattern recognition. The classifier in this research is constructed within the curvature feature space that is consistent with the feature extraction process. The manually labeling result for pre-defined sample car silhouette images from MPEG-7 image database are input the NN for the training stage. The feature centroid for trained classifier is computed accordingly. At the practical computation step, query images are then recognized with the trained classifier by calculating the Euclidean distance for the same feature against the feature centroid. Car shape object is then detected if the distance is below a pre-defined threshold

6. Conclusion:

This paper a method of applying the shape descriptor based on B-splines to perform car recognition from a moving camera's video sequence. We focused on obtaining a fast computing algorithm to extract contours of object. This method can be used to describe from simple to more evolved car body shapes because of its multi-resolution approach and its strong robustness to noisy measures. In this method the descriptor has the advantage to be represented and stored compactly.

References

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