Literature survey on Image Segmentation and Shape Analysis for Road-Sign Recognition

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ABSTRACT

Road sign detection has been an important issue for research recently. The goal of this work is to find and classify road signs. In developing a new algorithm for road-sign detection and recognition, we think that any road-sign recognition algorithm should be as general as possible to work with large groups of road signs. This paper proposes an automatic road-sign recognition method based on image segmentation and joint transform correlation (JTC) with the integration of shape analysis. The presented system is universal, which is able to detect traffic signs of any countries with any color and any of the existing shapes (e.g., circular, rectangular, triangular, pentagonal, and octagonal) and is invariant to transformation (e.g., translation, rotation, scale, and occlusion). The main contributions of this paper are: 1) the formulation of two new criteria for analyzing different shapes using two basic geometric properties, 2) the recategorization of the rectangular signs into diamond or nondiamond shapes based on the inclination of the four sides with the ground and 3) the employment of the distortion-invariant fringe-adjusted JTC (FJTC) technique for recognition.

Keywords: Clustering, distortion invariant, feature extraction, fringe-adjusted filter (FAF), joint transform correlation (JTC), segmentation.

1. INTRODUCTION

Improving traffic quality and safety cannot be achieved without correctly applying and maintaining road traffic signs, traffic signals and road markings. Road sign detection is a technology by which a vehicle is able to recognize the different signs put on the road e.g. "speed limit" or "stop sign" or "children" or "turn ahead" etc. Traffic signs are used to regulate the traffic. Traffic signs are used for guiding the driver. Automatic detection and recognition of road traffic signs is an essential task of regulating the traffic and guiding and warning drivers and pedestrians [1]. The goal of this work is to find and classify road signs. In developing a new algorithm for road-sign detection and recognition, we think that any road-sign recognition algorithm should be as general as possible to work with large groups of road signs.

Previous work

In recent years, one of the most accepted and widely used approaches in object detection has been image feature clustering [1], detected signs using a set of color-sensitive Haar wavelet features obtained from AdaBoost training and temporal information propagation. Classification was performed using Bayesian generative modeling with temporal hypothesis fusion. To avoid the limitations of the original boosted classifiers in terms of the dimensionality of the feature space, Baró proposed a binary classifier through an evolutionary version of AdaBoost [2]. Some approaches, such as [3,4] reduce the memory and processing requirements by using tracking. The recognition process was based on shape analysis. Only road guidance signs were detected using the color segmentation method in the RGB color space. Then, the obtained regions were grouped using the eight-neighbor method, and nonrectangular regions were filtered out by using shape properties.

As the sensitivity to lighting variation was one of the main problems, they worked with relations between the RGB color components or subgroups within this color space. As the standard color space cannot always guarantee perfect color segmentation, several more complex color classifications have been proposed. Thus, a hierarchical region-growing technique was shown in, a database for the color pixel classification was presented [5], and the use of textures was proposed. Although these methods are more complex and complete than those using thresholding with fixed values, they are computationally extensive, and they do not take into account the occlusion problem.

Our goal is to formulate a general framework that can detect road signs of any countries and any languages with any color and any of the five shapes (circle, triangle, rectangle, pentagon, or octagon), provided that the road signs are included in the reference database. The main contributions of this paper are: 1) the formulation of two new criteria for analyzing different shapes using two basic geometric properties, 2) the recategorization of the rectangular signs into diamond or nondiamond shapes based on the inclination of the four sides with the ground and 3) The employment of the distortion-invariant fringe-adjusted JTC (FJTC) technique for recognition.
2. PROPOSED WORK

Our proposed road-sign recognition algorithm uses the combination of color feature clustering and shape analysis for detection and a distortion-invariant fringe-adjusted joint transform correlation (FJTC) technique for classification. A 2-D feature space is used to keep the algorithm computationally light without compromising the segmentation quality. Afterward, the image is segmented using features to find the ROIs, a novel shape analysis and a reassortment technique for the rectangular shapes are proposed to considerably reduce the search area from the whole reference database to a small subset consisting of the reference signs with the same shapes and to eliminate the false candidates that do not fall into any of the permitted shape groups. The list of candidate regions is then classified by exploiting the distortion-invariant FJTC technique. For classification, a normalized composite filter is created using a set of distorted reference images for each road sign in the database. It is then applied to the unknown image for classification, and some similarity measure is computed. Of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper [5].

The design of an automatic road-sign recognition system includes a detection phase and a classification phase. In the detection phase, the system searches for road signs within an image. In the literature, image segmentation has been widely used to detect the road signs. There are three main approaches for road-sign segmentation: 1) border detection in a gray-level image and their analysis; 2) histogram thresholding with a given color space; and 3) feature extraction and clustering. In the classification phase, the system evaluates the regions found by the detection phase and identifies the signs. Our proposed road-sign recognition algorithm uses the combination of color feature clustering and shape analysis for detection and a distortion-invariant fringe-adjusted joint transform correlation (FJTC) technique for classification. A 2-D feature space is used to keep the algorithm computationally light without compromising the segmentation quality.

3. PROPOSED ALGORITHM

The outline of the road-sign recognition algorithm is presented in the figure1. The road signs are detected by using color clues and carrying out geometric property analysis. The system is initiated by clustering the color features for segmentation of the image to search objects with similar colors. The segmented regions are analogized with some possible attributes of a road sign, such as size or aspect ratio, to discard unreasonable objects and retain the candidate ROIs. Next, shape classification is performed to categorize the ROIs into different shape groups and also to eliminate the false candidates that do not fall into any of the permitted shape groups. Finally, for recognition, we use the distortion-invariant FJTC technique. In this system, the query image is compared with the composite filters corresponding to reference images in the database, and the reference sign that is most similar to the query sign is returned to the user. The FJTC-based similarity measure used to compare two images is efficient enough to match similar signs and to discriminate dissimilar signs.

![Fig1: Flow diagram of the proposed algorithm][1]
4. SHAPE CLASSIFICATION

The blobs that are obtained from the segmentation stage are verified in this stage according to their shape using two basic properties of a polygon, e.g., the ratio between the square of the perimeter and the area, and the number of sides [6]. Any traffic-sign shape should fall into any of the following shape categories such as circular, rectangular, triangular, pentagonal, and octagonal. Any particular shape has a unique value of the parameter Perimeter/Area, which is a constant for that shape [1]. This parameter is named Peri2Area. Additionally, the number of sides is a standard attribute to distinguish among different polygonal shapes, and it is named NumSides. Both these features have the inherent characteristic of being independent of translation, scaling, and 2-D rotation of an image and would not only help identify the correct shape but also help reject the false objects (for example, cars and buildings) that are still present in the segmented image as candidate ROIs. Table I shows all the shapes used for the purpose of road traffic control. In this table, the shapes are labelled with their dimensions. The values of Peri2Area and NumSides for the shapes are also given in Table I.

<table>
<thead>
<tr>
<th>Shapes</th>
<th>Circular</th>
<th>Triangular</th>
<th>Rectangular</th>
<th>Pentagon</th>
<th>Octagonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perimeter/Area</td>
<td>(2πr)^2 / πr^2</td>
<td>(2√3s^2) / 2√3s</td>
<td>(4s^2) / 4</td>
<td>(5s^2) / 2</td>
<td>(8s^2) / 8</td>
</tr>
<tr>
<td>NumSides</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 1 SYNTHETICALLY GENERATED DIFFERENT SHAPES USED AS TRAFFIC SIGNS[7]

To find the NumSides[2] of a shape, we need to plot the distances of the boundary points from the centroid of that shape. As shown in Table I, x is the variable distance of a boundary point from the centroid. The value of x is maximum when the boundary point is at the vertex of the polygon and continues to decrease as the boundary point moves toward the point at which x is normal to the polygon side, where the value of x is minimum, and then again proceeds to increase until the boundary point reaches the other vertex of that side of the polygon. Thus, the plot for x is a parabola for each polygon side. In the experiment, to compute the Peri2Area of a candidate ROI, the total number of pixels in a blob is accounted as the area of that blob, and the sum of the distances between adjacent pixels in the boundary of the blob is accounted as the perimeter. The decision boundaries for shape classification based on the values of Peri2Area are determined by employing linear interpolation on the precise values of Peri2Area for different shapes, as determined in Table I.

4.1 Fringe Adjusted Joint Transform Co-relation

JTC is one of the major techniques of pattern recognition. In JTC, the unknown input scene s(x, y) and the known reference image r(x, y) are displayed side-by-side in the input plane known as the input joint image, which is Fourier transformed. The Fourier-transformed patterns constructively interfere with each other to create an interference pattern called joint power spectrum (JPS). The JPS is inverse Fourier transformed to yield the correlation output. For a match, two correlation peaks or bright spots are produced, and for a mismatch, negligible numbers of or no correlation peaks are produced. In FJTC, the JPS is multiplied by a filter called fringe-adjusted filter before applying the inverse Fourier transform. A desired target in an input scene may be distorted or corrupted in many different ways (in-plane or out-of-plane rotation, scale variation, or translation). Many methods for invariant recognition have been proposed by using transform coefficient features, algebraic features, visual features, moment-based methods, and synthetic discriminant function (SDF)-based methods. To accommodate distortion invariance in FJTC, the SDF concept is adopted in [9]. The SDF can be synthesized by the linear combination of the target image and its many distorted images. Then, this SDF is used as the reference image in FJT.

5 CONCLUSION

We have proposed a real-time system for the automatic detection and recognition of traffic symbols. The most important advantage of the proposed system is the presented system is universal, a precise real-time road-sign detection scheme with a low rate of false positives is very important to offer increased improvement to the safety and efficiency of driving. In this paper, an algorithm for the detection of road traffic signs has been proposed. The segmentation-based detection algorithm is found to be robust for its ability to mark a road sign as an ROI. Then, the shape classification algorithm
improves the computation time in the next stage of recognition and rejects the nontraffic-sign objects of similar colors as traffic signs (for example, cars and buildings) with a high probability. Followed by the preliminary detection, a classification/recognition segment deals only with the ROIs that are denoted as potential candidate regions. The distortion-invariant FJTC-based matching algorithm has excellent discrimination ability between target and nontarget objects. The FJTC technique yields sharper and stronger correlation peaks for the desired target than for the other nontarget objects, decides unerringly about an ROI to be a road sign or clutter, and then correctly classifies it from the known reference signs. This proposed work would detect the road sign when the sign is partially occluded, rotated or tilted. The proposed algorithm improves the efficiency, by detection of small scaled road signs.

References