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Vehicle logo recognition based on overlapping enhanced patterns of oriented edge magnitudes☆

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ABSTRACT

Vehicle logo recognition (VLR) has attracted wide attention from the community of intelligent transportation systems (ITS) due to its important role. Although many methods have been proposed for VLR, it remains a challenging problem. In this paper, we present a novel method for VLR. Our method includes (1) observation of the local anisotropy of vehicle logo images; (2) adoption of the idea of patterns of oriented edge magnitudes (POEM) and an advanced version of POEM for vehicle logo feature description called overlapping enhanced POEM (OE-POEM); (3) implementation of whitened principal component analysis (WPCA) for feature dimension reduction followed by collaborative-representation-based classification (CRC) as a classifier to perform VLR. We also construct a new vehicle logo dataset (HFUT-VL), which is larger and more comprehensive than the existing vehicle logo datasets. Finally, we conduct experiments on HFUT-VL, and the results indicate state-of-the-art VLR performance.

1. Introduction

In recent years, the application of computer-vision-based intelligent transportation systems (ITS) has attracted increasing attention from both academia and industry. Generally, ITS techniques can be used for many purposes including traffic monitoring and traffic violation recording, etc. In ITS, video-based vehicle detection and recognition is a key component of sensing technologies. That is, vehicle license plate recognition, logo recognition, color recognition, and model recognition are basic techniques for gathering vehicle information. License plate recognition is one of the most important ways to identify vehicles, and has been widely and successfully implemented. However, because of the frequent removal, staining and tampering of license plates, recognition of a vehicle's logo, color and model are becoming more important for identification. Particularly, vehicle logo, a key symbol of the car manufacturer, is difficult to counterfeit. As a result, vehicle logo recognition (VLR) has attracted more attention in recent years.

Many VLR methods have been proposed in the past decade [1–3]. Most methods have three basic steps. (1) Vehicle logo location. An excellent vehicle logo location method can directly improve the precision of a VLR method. (2) Feature extraction. Extracting a robust feature is the most important step in VLR. (3) Classification. The aim of this step is to select a good classifier, including but not limited to k-nearest neighbors (KNN), support vector machines (SVM), random forest, AdaBoost, and collaborative-representation-based classification (CRC) [4].

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In VLR, existing feature extraction methods can be divided into two groups: traditional handcrafted-feature-based methods and deep convolutional neural network (CNN)-based methods. Although CNN-based methods have achieved good recognition accuracy, they have a common weakness, that is, they require a large quantity of vehicle logo samples to train the CNN features. In real-time surveillance systems, it is difficult to obtain such a large volume of vehicle logo images for each logo. Thus, our work focuses on traditional handcrafted-feature-based methods.

In this paper, we propose a new vehicle logo descriptor named overlapping enhanced patterns of oriented edge magnitudes (OE-POEM), which is an improved version of the patterns of oriented edge magnitudes (POEM) descriptor [5]. Similar to faces, vehicle logos also contain rich texture and edge information, thus, we exploit the edge information of vehicle logo images to construct features by combining gradients in all directions. Based on the local anisotropy of vehicle logo images, the OE-POEM descriptor can enhance feature representation by overlapping blocks. In the proposed method, the CRC classifier is adopted for classification [4].

The main contributions of this work are summarized as follows:

- We construct a new vehicle logo dataset named HFUT-VL, which includes two sub-datasets, i.e., an accurate logo location dataset and a coarse logo location dataset. Both sub-datasets include 32,000 vehicle logo images from 80 vehicle types, and all samples are captured by on-road surveillance systems. To the best of our knowledge, the constructed HFUT-VL dataset has the largest number of vehicle types than other available datasets. We think HFUT-VL dataset can promote further research relevant to VLR.
- Local anisotropy of vehicle logo images is summarized, which makes the description feature of vehicle logo images different from that of face images. This property leads to the proposal of our VLR method based on the OE-POEM feature.
- We have designed a VLR method named OE-POEM. The OE-POEM feature is well-suited for describing vehicle logo images. Our OE-POEM based VLR method has been used for real-time highway surveillance systems, and has achieved satisfactory recognition results.

Compared with existing VLR methods, the novelties of the proposed method are as follows: (1) It is the first time that the local anisotropy of vehicle logos has been analyzed. (2) It is the first adoption of POEM-based descriptors for VLR; using an overlapping blocks strategy, an improved version named OE-POEM is described, and is demonstrated to be more suitable for the VLR problem. (3) In the field of VLR, we are the first to exploit the CRC classifier for VLR recognition.

The rest of this paper is organized as follows. Section 2 is a brief review of the related work on VLR. In Section 3 we describe our HFUT-VL dataset. In Section 4 the details of the proposed OE-POEM feature descriptor and its application in logo recognition are described. Section 5 contains the experimental results, and Section 6 concludes the paper.

2. Related work

As mentioned above, existing VLR methods can be roughly divided into two categories: (1) Those representing vehicle logos with traditional handcrafted features, such as scale-invariant feature transform (SIFT), the KAZE feature, and local difference binary (LDB). (2) Those representing vehicle logos with learned features, which have recently achieved excellent performance.

Among all kinds of handcrafted-feature-based methods, SIFT has been widely used to represent vehicle logos for VLR because SIFT features have many excellent properties, such as rotation invariance, scale invariance, illumination invariance and robust representativeness. Dlagnekov et al. [2] proposed the use of SIFT to identify vehicle logos and model on rear-view vehicle images, but performance fails to satisfy real-time requirements. Yu et al. [6] developed a system for VLR based on the bag-of-words model, which uses a dense SIFT algorithm to extract stable features, quantizes the extracted features by soft assignment, and computes a histogram with spatial information to improve the recognition accuracy. In Yu's method, vehicle logos are represented as histograms of visual words and are then classified by an SVM. However, according to the reported results, although Yu's method achieves good performance in terms of recognition accuracy but is time consuming. Gu et al. [7] proposed a recognition-before-location framework, which exploits a directional SIFT flow parsing method to extract dense SIFT features, to handle multiscale vehicle logos.

In addition to SIFT features, other features based on edge, grayscale, and shape have been adopted to describe vehicle logos. Combined with certain classification methods, these features can be used for logo recognition. Liu et al. [8] proposed a kernel-based L_2-norm regularized least squares (RLS) method. In RLS, a kernel function is used to enlarge the dimensional space of the sample dictionary, then, the objective function is optimized via the RLS algorithm to solve the L_2-norm problem. Hu et al. [9] considered the problem of vehicle logo location as an object classification problem. They first extracted the discriminative binary features for a given collection of vehicle logos using a deformable parts model and then used classifiers, such as KNN, SVM, and random forests, to determine the location of the vehicle logo. Xiao et al. [3] proposed a novel VLR method to recognize vehicle logos in real-time by constructing a weighted multi-class SVM (W-SVM) ensemble model to classify vehicle logos based on the extracted sharpness histogram features, in which a vehicle logo was represented by edge information. Dai et al. [10] adopted Chebyshev moment invariants to extract six eigenvectors of a vehicle logo and applied an SVM classifier for binary VLR. This method achieved good performance in terms of both recognition accuracy and computational cost on publicly available datasets. Llorca et al. [11] presented a novel VLR system using HOG features and an SVM classifier to work with images supplied by traffic cameras, where the logos appear with low resolution. The results showed an overall recognition rate of 92.59% on the publicly available dataset, which supports the use of the system for real applications. Sam et al. [12] proposed a solution for the VLR problem using modest AdaBoost combined with radial Chebyshev moments, which was tested on images captured from traffic cameras in outdoor conditions. However, this solution is limited to uncrowded scenes because it is time consuming. To improve the efficiency of VLR, Peng et al. [13] proposed a new method to treat low-resolution and poor-quality images captured from urban crossings in an ITS. The proposed approach is based on