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License Plate Recognition System Based on SIFT Features

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Abstract

Scale invariant feature transform (SIFT) describing local features is a robust and reliable method for many pattern recognition purposes and can be applied to a wide range of problems in which local features are critical and helpful, like recognizing characters of license car plates. This work is based on using SIFT for license plate recognition (LPR) considering the capabilities and flaws of using the method. Some cases of failure or bad recognition are improved with various kinds of image pre-processing, however some kind of failures of car plate detection are essential and need more investigation and substitute techniques. Thus, applying a method based on distribution of vertical edges is employed to detect the car plate position. Numerical rate of success employing the proposed method has been given for our database versus pure SIFT for comparison.

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*Keywords:*Scale invarient feature transform (SIFT); License plate recognition (LPR); feature extraction; edge detection

1. Introduction

Scale invariant feature transform (SIFT) is an algorithm in machine vision, finding and describing local features of the image key points in order to recognize objects in given images. In this method, proper feature description of an object plays an important role for identifying and detecting a specific object in any image. Therefore, the set of features extracted from the training images must be robust to changes in image scale, noise and illumination in order to perform reliable recognition. SIFT feature descriptor is also invariant to orientation and affine distortion [1]. So, SIFT key points of objects are extracted from a set of reference images and stored in a database. In the next stage, the method transforms an image into a large collection of feature vectors which are invariant to image translation, rotation, scaling and partially invariant to illumination changes.

An object is detected in an image by comparing a set of the features extracted from the test image to the training set of the database and finding candidates matching features based on their Euclidean distance as a common

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measure of their feature vectors. Subsets of key points that agree on the object and its location, scale and orientation in the new image are identified to extract good matches [1, 2].

The probability that "a particular set of features indicates the existence of an object" is calculated with the number of good matches against the number of probable false matches. Any object-matches passing all tests can be identified as correct with a high degree of confidence [3].

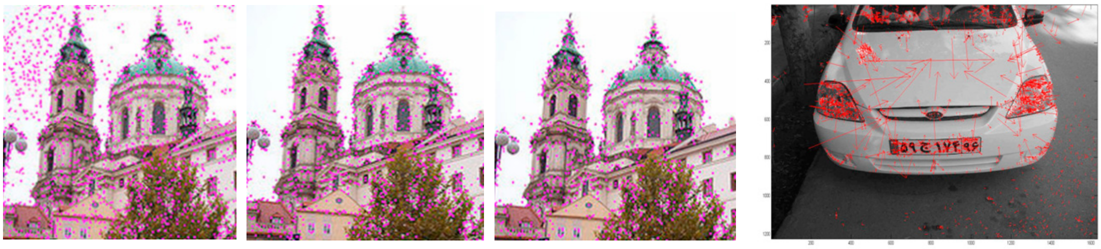

Fig. 1. Left to right: (a)-(c) SIFT feature extraction stages; (d) applying SIFT

In Fig. 1, stages of applying SIFT to an image are shown. Scale-space extreme detection produces too many key point candidates (Fig 1.a). Then, rejection of low contrast key points occurs by SIFT algorithm (remaining points are shown in Fig 1.b). At the third step, filtering out the unimportant key points which are located on the edges is done (Fig. 1.c). In Fig 1.d, one can see the resulting key points when SIFT is applied to a typical image of our database.

According to the above description, SIFT can be applied to the pattern recognition tasks in which local features are critical and vital for the algorithm's correct response. For instance, it is used for such recognition tasks as biometric identification. In these applications, SIFT features are extracted from biometric sources like the face and both irises [4] or fingerprints [5] and processed with the algorithm to recognize the authorized persons. Also, it is used for real-time image retrieval [6] and automatic content-based video retrieval of multimedia databases [7]. Furthermore, SIFT is shown to be successful in many areas like place recognition, robot localization and mapping problems [8]. Due to the main characteristics of the SIFT features like robustness against changes of illumination, scaling, rotation and affine distortion, the SIFT method is expected to work with a good rate of recognition for car plate recognition task.

However, the recognition system employing the SIFT features faces some flaws which happens due to taking the car pictures in an outdoor environment including variety of objects without any control or selection. Hence, the error analysis is done for the failure cases. In order to cope with the explored problems, a new method is proposed which is able to overcome the shortcomings.

2. Database

In order to conduct experiments by employing the SIFT features and the proposed method of this paper, a database is created with 100 different images that are taken from each of the 20 distinct cars shown in Fig. 1 (totally 2000 images). The images are taken from front-view among different forms of illumination and daylights. Assume a trapezoid is drawn on the ground so that the parallel lines have a 1m and a 2m distance from the car. The non-parallel sides have 45° angle with wider parallel line. Moving in this trapezoid, we take images of the car in different conditions and angles between the car and our camera. So, various kinds of skew in license plates, backgrounds, dirt and dust on the plate and written letters and numbers (logos and trademark) may be considered as noise versus the plate and its segments. These images are used as the input of the SIFT method.

Looking through the common form of a car plate in Iran (Fig. 2), three distinct regions are evident; A blue region with the flag and the "I.R.IRAN" phrase, the main region which consists of 2 digits followed by a letter and continued by another 3-digit number, and at the most right region which consists of the word Iran (in Persian) and a 2-digit number that indicates the city that the plate is authorized. Some sample images from the cars including a plate and presenting the variety of the database images are shown in Fig. 2.

Fig. 2. Car plates in Iran and sample images showing the variety in the database images

3. System Description

As it is explained before, by comparing a set of the features extracted from the test image with the key points indicated in the training set of the database, an object can be detected in the test image. One can see a successful try in matching key points in Fig. 3.a. Also considering occlusion and dirt on a car plate, finding the key points in a car plate with filled regions (Fig 3.b) and using a small part of a car plate (Fig. 3.c) show a good result as it is expected. It means not only the SIFT features are capable of recognizing the dirty car plates, but it can also work with less process using a small part of a car plate.

Fig. 3. Left to right: Successful recognition of a plate: (a) whole plate, (b) filled region and (c) only 2-digit number of area part

In contrary to the above results shown in Fig. 3, due to the car pictures being taken in an outdoor environment, poor condition of illumination, blurring, high skew and also occurrence of many vertical and horizontal lines as observed in the road surface area, many failures and mismatching happens (Fig. 4).

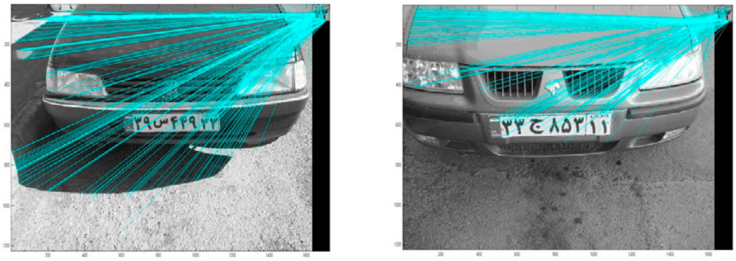

Fig. 4. Mismatching of the key points due to the occurrence of many edges in the image

Actually, SIFT detects edges but not the right edges of desired objects which are called desired key points. Although some pre-processing techniques are applied to the images that are improper through SIFT feature method (Fig. 5), unfortunately the result is not improved very much.

Fig. 5. Different kinds of pre-processing methods employed on an image

It seems that in order to avoid mismatching cases which occur in the other areas of an image like road surfaces and also other parts of a car, a first cropping stage is unavoidable to employ before extracting SIFT features. Therefore, some preliminary experiments are done on the manually cropped car plates and it is concluded that cropping the car plates from the whole images can change the failure cases into a correct recognition. Consequently, an automatic method is proposed to crop the car plates automatically. In the proposed algorithm [9], the car plate area is detected by using the density of the vertical edges where it is higher in the plate area in comparison to the rest of the image. In Fig. 6, the proposed algorithm is presented step by step being applied on an image sample.

Fig. 6. Proposed algorithm steps for car plate detection

4. Experimental Results

Due to the robustness of the SIFT features, it is expected employing pure SIFT features without any modification can result in an acceptable recognition rate. However, many failures have occurred resulting in a recognition rate of %84. Error analysis shows the failure cases happens in the images that were taken in poor condition of illumination, blurring, high skew, existence of many vertical and horizontal lines in the image or existence of another car in the picture. In order to defeat the problem which is occurred due to the shortcomings of the SIFT features in this application, a pre-processing is used which increases the recognition rate up to %89.

As it is explained in the previous section, the experiments show that most of the failures are happened due to the matching of the key points into the area which includes some objects in the background like the road surface that contains many edges. So, the experiments are carried out on the images of the database cropping the plate and eliminating the areas yielding the mistakes and failures. A good recognition rate of %98 which is achieved by doing the experiments on cropped car plates leads us to employ an automatic way for cropping the car plates. Consequently, by cropping the car plate area in the images of the database automatically, the acquired rate of recognition is raised to %99 which is a very good result for this application.

5. Conclusion

Using SIFT for car plate recognition is inspired by the success of using SIFT features in the recognition applications which are strongly dependent on local features of the images. Since, the car images are taken in an outdoor environment, using this kind of features for car plate recognition faces some problems due to the different backgrounds or the occurrence of some other objects in the pictures. Hence, based on the experimental results and analysis done on the errors, a new method is proposed in order to cope with the shortcomings of using SIFT features in the application of car plate recognition. Obtaining an error rate less than 1% shows that the SIFT features can be used for this application along using the proposed methods.

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