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Coin Recognition Method based on SIFT Algorithm

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***Abstract*—Coin recognition is one of the prime important activities for modern banking and currency processing systems in which machine vision is widely used. The technique at the heart of such systems is object recognition in a digital image. Although it has high recognition speed, the traditional method of coin recognition can not recognize the coins with similar sizes. This paper presents a method based on SIFT(scale invariant feature transform) algorithm for coin recognition. SIFT algorithm can handle the issues of rotations, scaling and illumination in a digital image. Therefore it can solve the problem about distinguishing the coins which have approximate size. In experiments, we compare the performances of Chinese coin recognition with our proposed method and the traditional method(based on size). The results demonstrate the feasibility and effectiveness of our approach.**

Keywords-coin recognition; machine vision; SIFT algorithm

I. INTRODUCTION

Object recognition is the process of identifying an object being examined in a digital image for a set of known features or labels. In this research work, we have applied object recognition techniques for coin recognition. Automatic recognition of coin value has a wide range of applications. For example, slot machines for gaming, and vending machines for snacks, drinks, tickets, etc [1]. The main approach of current coin recognition systems is to measure the physical properties of the coin, such as, weight, radius, thickness, and magnetism. However, fake coins with similar physical properties are also accepted and found in these system. To increase the accuracy of the recognition rate, visual information of the coin is increasingly concerned in the coin recognition system. The image of the coin is acquired, processed, and analyzed in the recognition system.

Much work has been done for automatic recognition of coins through digital image processing techniques. Various approaches have been proposed which can be grouped into three categories, one based on coin's local features, such as color, texture, and shape [2-5], one based on BP neural network [6-10], and the last one based on image registration [11-17]. The first approach based on geometric features of coins is most widely used for coin recognition. The idea uses various machine visual method to extract the edge of coin and then estimate coin's radius and center. The BP neural network approach is trained with the parameters corresponding to various denomination of the coins, to their respective targets. After training, the performance function reaches the goal for all the samples. The image registration approach finds interesting points in the training image and the test image to provide feature descriptions of the coins. Then a similarity measurement is used to identify the matched pairs of interesting points between the training image and the test image. The coin value of the test image is finally determined based on the best match of the training image. An important characteristic for the success of the image registration approach is that the relative positions between feature points do not change from the training image to the test image. The first method based on coin's size can not recognize coins which are similar in size. The BP neural network approach takes long period in recognition for which it is not practical. Scale Invariant Feature Transform(SIFT) [18-20] algorithm is presented by David Lowe in 2004 which is a new local feature descriptor.

In this paper a method based on SIFT algorithm is proposed for coin recognition system. In order to increase the accuracy of recognition, we used median filter to preprocess the image. Then, we separate the coins which are sticking to each other in the image by Watershed Algorithm. Finally, comparison with proposed method and method based on size is made.

The remainder of this manuscript is organized as follows. In Section Ⅱ, the SIFT algorithm is introduced briefly. In Section Ⅲ, the proposed method for coin recognition is explained and the experimental results of the proposed method and traditional method are shown and discussed. The last Section is the conclusion.

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II. BRIEF INTRODUCTION OF SIFT

Image matching is a fundamental aspect of many problems in computer vision, including object or scene recognition, solving for 3D structure from multiple images, stereo correspondence, and motion tracking. In 2004, David Lowe proposed a method of extracting local feature algorithm. The algorithm is built on the basis of the image characteristic scale. First, a multi-scale space of the target image is made. The local extreme point is detected under the conditions of different scales. Then the low-contrast points and edge response points are removed, and 128-dimensional SIFT feature descriptor is simultaneously extracted. The features are invariant to image scale and rotation, and are shown to provide robust matching across a substantial range of affine distortion, change in 3D viewpoint, addition of noise, and change in illumination.

A. *Realization of the SIFT*

The SIFT algorithm process includes scale-space extreme detection, keypoint localization, orientation assignment and keypoint descriptor. Fig.1 is a flowchart of SIFT algorithm.

- Scale-space extreme detection: The first stage of computation searches over all scales and image locations. It is implemented efficiently by using a difference-of-Gaussian function to identify potential interest points that are invariant to scale and orientation.
- Keypoint localization: At each candidate location, a detailed model is fit to determine location and scale. Keypoints are selected based on measures of their stability.
- Orientation assignment: One or more orientations are assigned to each keypoint location based on local image gradient directions. All future operations are performed on image data that has been transformed relative to the assigned orientation, scale, and location for each feature, thereby providing invariance to these transformations.
- Keypoint descriptor: The local image gradients are measured at the selected scale in the region around each keypoint. These are transformed into a representation that allows for significant levels of local shape distortion and change in illumination. A feature point consists of 128-dimensional SIFT feature vectors.

B. *Keypoint matching*

Many features from an image will not have any correct match in the training database because they arise from background clutter or were not detected in the training images. Therefore, it would be useful to have a way to discard features that do not have any good match to the database. An effective measure is obtained by comparing the distance of the closest neighbor to that of the second-closest neighbor. When the ratio is less than the threshold value, the nearest neighbor distance corresponding to a pair of feature points are matching feature points. The distance ratio is recommended as 0.8. With a reasonable threshold, large error matching points are removed and the matching point selection is ensured.

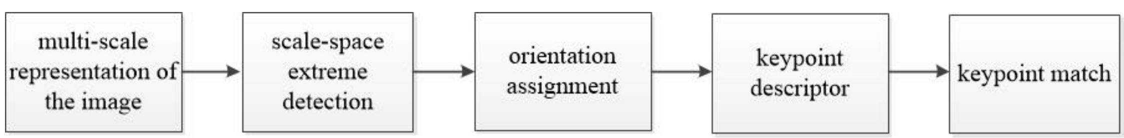


Figure 1. Flowchart of SIFT algorithm

III. PROPOSED SYSTEM

Our proposed system is based on feature extraction through Scale Invariant Features Transform (SIFT) algorithm for Chinese coins recognition. The architecture diagram of the system is shown in Fig. 2.

A. *Coin Image Acquisition*

The first step would definitely be capturing coin's image for further processing. We also need a database for training and testing purpose. Unfortunately, there is no such standard images for Chinese coins. To gain sample coin images, we have collected images of coins with 7 different currency values using a CCD camera with 72 dpi (dots per inch) resolutions; 24-bit picture scan mode with jpg image type. The sample coin images captured by the camera are shown in Fig. 3. The test images of coins are also captured by the CCD camera.

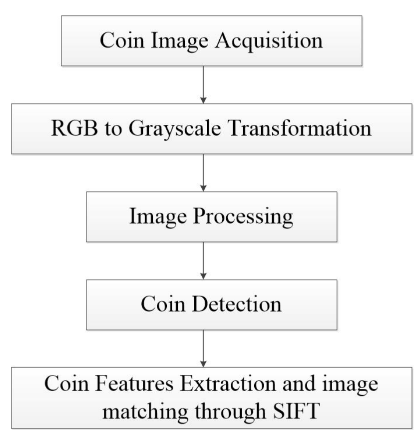


Figure 2. Architecture of coin recognition system

Figure 3. Images of Chinese coins of different worth: (1) head of RMB 1 fen coin, (2) tail of RMB 1 fen coin, (3) head of RMB 2 fen coin, (4) tail of RMB 2 fen coin, (5) head of RMB5 fen coin, (6) tail of RMB 5 fen coin, (7) head of RMB 1 jiao coin, (8) tail of RMB 1 jiao coin, (9) head of RMB 5 jiao coin, (10) tail of RMB 5 jiao coin, (11) head of RMB 1 yuan coin, (11) tail of RMB 1 yuan coin, (13) head of game coin, (14) tail of game coin.

B. *RGB to Grayscale Transformation*

As a second step of our proposed model we need to convert input 24-bit RGB images into 8-bit grayscale images. Processing images in three or four separate channels is quite complex and challenging. Therefore, we have cropped and converted input test images into 8-bit grayscale images in order to reduce the processing time. All grayscale images are resized as 250 × 250 pixel images. These grayscale images will be used as input for features extraction. The steps are shown in Fig. 4.

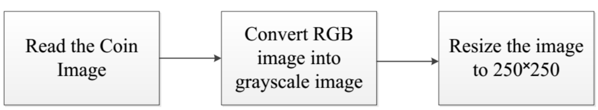


Figure 4. RGB to Grayscale Transformation

C. *Image Processing*

The database information of images captured by the CCD camera always contain some noise caused in the image acquisition and transmission process. Compared with different filter methods, median filter is the most effective way to undo the noise while maintaining the details of image. Therefore, in this paper, median filter is used in image processing, shown in Fig.5.

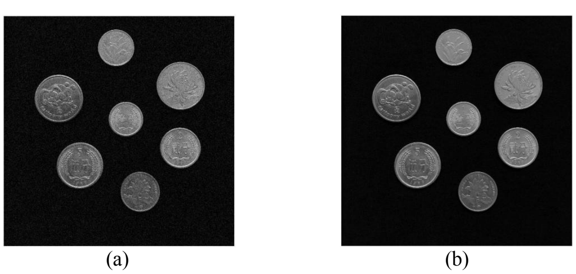


Figure 5. Result after median filter: (a) original coin gray image. (b) coin image after median filter

D. *Coin Detection*

In order to extract the features of images of coins, we need to detect the coin in the image. The first step is coin separating. There exists some situations where coins are sticking to each other in the image. In this case, we must separate such coins or they will be recognized as one unit. In this paper, we used Watershed Algorithm to separate coins into single one. Fig.6 is the result of the algorithm.

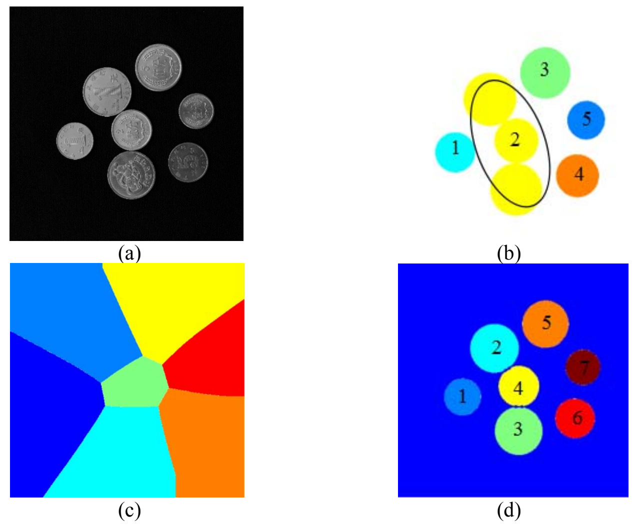


Figure 6. Result of Watershed Algorithm: (a) original coin gray image. (b) image with labels of connecting region. (c) image with edges of watershed (d) result of watershed algorithm

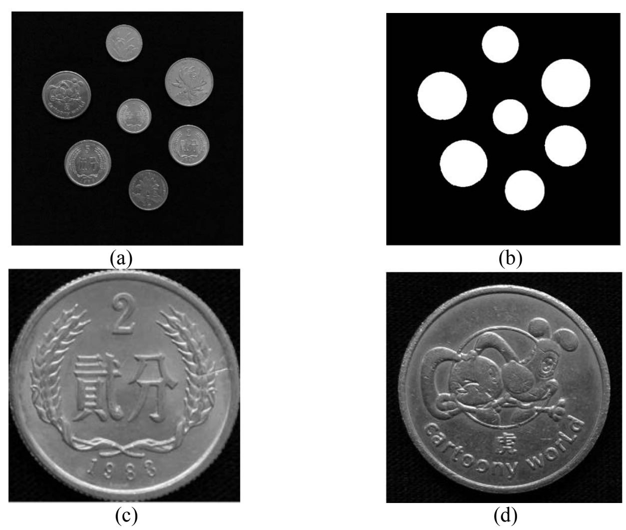


Figure 7. Processing of extracting single coin images: (a) original coin gray image. (b) binary coin image. (c) single 2-fen coin image (d) single game coin image

The second step is image segmentation. In order to sort coins, it is necessary to extract each coin from the image and then match the single coin image to the sample coin images. Threshold segmentation method is used to get a binary image and we can gain a image with full circles after some proper morphology algorithms. Each circle is a region which has a minimum enveloping scope. With the scope, each coin can be cut from the whole image, shown as Fig.7.

E. Coin Features Extraction and image matching through SIFT

For the human vision this is so simple to understand and describe a complex story from a single image. On the other hand, a computer program can also discover semantic concepts from digital images but it is quite difficult task for the computer system. The first prime activity for an intelligent system in technical understanding is to extract efficient and effective visual features from a digital image.

In our case, it is important to consider here that coins are round in shape. Therefore, we cannot make sure a fix degree of coins during the image acquisition process. Due to the rotation invariant, extracted features should not be the same for a same coin at different degree of rotation. It crates challenges for the classifier algorithm to detect and classify the object in right direction. In this regard, the SIFT algorithm have a good discrimination power to extract rotation invariant features.

First, we use SIFT algorithm to extract features often called SIFT key points from the test image and the sample images. Some sample images with extracted features are presented in Fig. 8.

Figure 8. Feature points detection using SIFT

After features extraction, we require a similarity measurement to identify the matched pairs of features extracted from the sample images and the test image. An effective measure is by comparing the distance of the closest neighbor to that of the second-closest neighbor. When the ratio is less than the threshold value, the nearest neighbor distance corresponding to a pair of feature points are matching feature points. Fig.9 is the game coin matching chart.

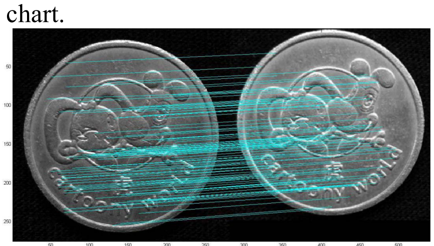


Figure 9. Game coin matching chart

IV. EXPERIMENTS AND RESULTS COMPARISION

A. Experimental condition

In order to verify the accuracy and feasibility of the proposed method, a system is built in the laboratory to carry out experimental studies. The system includes light source, Chinese coins, a camera, a computer. In the computer, the setup is Intel(R) Core(TM) i5-4210U CPU @ 1.70GHz-2.40GHz, 6.0GB memory.

In this paper, circular light source is used to make the brightness uniform in the coin images, which is helpful to extract the features of coins in the later processes. The model of camera is RS-A2300-GM/GC50 from Microview in Beijing, 1200 $mm \times 1200$ mm image size and 4.5 $\mu m \times$ 4.5 μm pixel size. In the computer, MATLAB is the software development platform to operate the algorithm. The background of the image in this paper is black in order to fuse the shadow of the coin into the black background, which can reduce the recognition error rate, shown in Fig.10.

(a) (b)

Figure 10. Comparison of two backgrounds: (a) coins in white background. (b) coins in black background

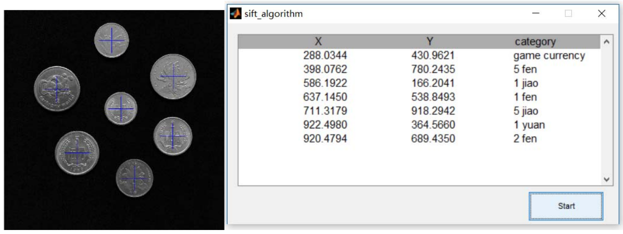
The main processes of the system is instructed below: the industrial camera collected the images of coins and input the images to computer. Then the image processing software in the computer(MATLAB) analyzes the information contained in the images. Finally, we can obtain the category and position of each coin.

B. Experimental results and comparisions

During the experiment, 100 coin images of different values are captured as test images. These 100 coin images include sever types of coins-six types of coins in current and a type of game coin. The test is performed in a PC equipped with Intel(R) Core(TM) i5-4210U CPU and 6.0GB RAM, and runs Microsoft Windows 10 64-bit operating system. .Fig.11 is one of the recognition result based on SIFT algorithm.

The results of the proposed method and method based on coin's size are listed in Table I for comparisons. Table I shows that the proposed approach has a higher recognition accuracy than the other one and the overall result is quite encouraging as almost 99% of the coins are classified correctly. To compare the recognition speed of these two methods, the recognition time of each coin is examined. As we can see from the Table I, the proposed method uses

0.5985 seconds to recognize a coin while the method based on size takes less time, about 0.4356 seconds.



(a) (b)

Figure 11. Recognition result: (a) original coin gray image. (b) recognition result in MATLAB

TABLE I. THE RECOGNITION PERFORMANCE FOR THE PROPOSED METHOD AND THE METHOD BASED ON SIZE

Methods	***No.of Coins tested***	***No.of coins recognized***	***Accuracy (%)***	***Recognition time(sec/coin)***
SIFT	700	690	98.6	0.5985
SIZE	700	460	65.7	0.4356

V. CONCLUSION

Automatic recognition of coin is a practical and widely needed technique in our daily life. In the current practices, coins are automatically recognized almost based on the radius of the coin. However, fake coins with similar radius usually pass these checks. In this research work we have proposed a method for coins recognition based on SIFT algorithm. SIFT feature matching algorithm has good invariance of scale, rotation, illumination. Therefore it can solve the problem about distinguishing the coins which are close in size. Chinese coins are considered as objects of recognition, there are sever types of coins (1fen, 2fen, 5fen, 1jiao, 5jiao, 1yuan and a game coin). In this system coins are captured with a digital camera and set of SIFT features are extracted based on variances. Medium filter is applied to preprocess images to undo noise in the image. As for case in which coins are sticking together, we used watershed algorithm to separate the coins. For evaluating the performance of the recognition system, experiment has been done on 100 coins images. The proposed method improves the recognition accuracy for about 30% compared to the method based on size. Our future work will focus on the improvement of the SIFT algorithm to reduce the recognition time for real-time using in the future.

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