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A Speeded up Robust Scale-Invariant Feature Transform Currency Recognition Algorithm

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***Abstract*—**All currencies around the world look very different from each other. For instance, the size, color, and pattern of the paper are different. With the development of modern banking services, automatic methods for paper currency recognition become important in many applications like vending machines. One of the currency recognition architecture's phases is Feature detection and description. There are many algorithms that are used for this phase, but they still have some disadvantages. This paper proposes a feature detection algorithm, which merges the advantages given in the current SIFT and SURF algorithms, which we call, Speeded up Robust Scale-Invariant Feature Transform (SR-SIFT) algorithm. Our proposed SR-SIFT algorithm overcomes the problems of both the SIFT and SURF algorithms. The proposed algorithm aims to speed up the SIFT feature detection algorithm and keep it robust. Simulation results demonstrate that the proposed SR-SIFT algorithm decreases the average response time, especially in small and minimum number of best key points, increases the distribution of the number of best key points on the surface of the currency. Furthermore, the proposed algorithm increases the accuracy of the true best point distribution inside the currency edge than the other two algorithms.

***Keywords*—**Currency recognition, feature detection and description, SIFT algorithm, SURF algorithm, speeded up and robust features.

I. Introduction

ALL monetary standards around the globe appear to be absolutely unique. For example, the extent of the paper is extraordinary.

The point of our framework is to help individuals who need to perceive distinctive monetary standards and work with comfort and efficiency. The improvement of currency recognition system can help numerous applications like banking systems. It is exceptionally hard to include diverse category takes note of a bunch. This venture proposes a picture handling strategy for paper currency recognition [1].

The currency recognition framework is produced to perceive the cash by utilizing distinctive systems and strategies on the cash note.

The currency recognition framework ought to have the capacity to arrange the paper money to its precise class. The currency recognition framework ought to have the capacity to perceive the note quickly and appropriately. The currency recognition framework ought to be proficient to perceive cash note from any part.

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The remainder of this paper is organized as follows. In Section II, an overview on currency recognition and the feature detectors will be introduced. The architecture of the currency recognition system and its process steps will be discussed in Section III. In Section IV, the functionality and performance issues of SIFT, and SURF feature detection algorithms which will be used in a comparison with our algorithm are illustrated. Section V presents the details of the proposed algorithm. In Section VI, we show the performance results of the proposed algorithm. Finally, we draw the main conclusions in Section VII.

II. Overview

Currency recognition is an image processing technology that is used to identify currency of various countries. Due to the use of currency in day-to-day life, the importance for automatic methods for currency recognition has been increasing. An efficient currency recognition system is important for automation in many areas such as vending machine, rail way ticket counter, banking system, shopping mall, currency exchange service, etc.

There are approximately 50 currencies all over the world, and each of them looks very different. This difference can be either the size of the paper currency or the color or pattern drawn on the paper. In addition, the aim of currency recognition system is to help people to recognize different currencies and to help them work with convenience and efficiency [2], [3]. Currency recognition systems have a wide range of application in the real world environment. Because of these, there are a number of researches done for recognition of different countries' currencies. In recent years, such kind of research has been ever increasing everywhere. Some of major applications of currency recognition systems are assisting visually impaired people, distinguishing original note from counterfeit currency, enabling automatic selling-good and enhancing banking applications.

In some applications, it is not enough to extract a single type of feature from an image point to represent the image [2]. Rather, two or more features need to be extracted from each image point and represented accordingly. Feature detectors carry out the extraction of these features, and a single vector called feature vector or descriptor represents these extracted features. Finally, the feature vectors together form the feature space.

Local features and their descriptors are the building components of many computer vision algorithms such as image registration, object detection and classification, tracking, and motion estimation. The descriptors, which can be used in these algorithms, are scale, translation and rotation invariant. The most common descriptors are HOG, Scale-Invariant Feature Transform (SIFT), Fast Retina Key point (FREAK), Binary Robust Invariant Scalable Key points (BRISK) and SURF. Some researchers used local feature descriptor for currency recognition system. Paisios et al. [4] proposed a SIFT key-point classification by using a k-means clustering approach to recognize partial and even distorted images of US paper bills. Hasanuzzaman et al. [5] proposed a component-based framework for banknote recognition by using SURF, which is effective in handling background noise, image rotation, scale, and illumination changes.

SURF is a novel scale- and rotation-invariant detector and descriptor. It becomes better than the earlier schemes especially in the repeatability, distinctiveness, and robustness. This is carried out by depending on the existing detectors and descriptors on the image [6]. The SURF approximates the second order Gaussian derivate with box filters (mean or average filter), which can be calculated fast through integral images. The localization of interest point is determined by the determinant of Hessian matrix. Therefore, interest points are finally localized in scale space and image space by using non-maximum suppression in their 3×3×3 neighborhood. In the construction of descriptor of an interest point, a circular region around a detected interest point is first constructed. After determining the orientation of each dominant, the SURF descriptor is constructed by extracting a square spot around a point of interest [5]. The formation of SURF and SIFT descriptors is shown in Fig. 1.

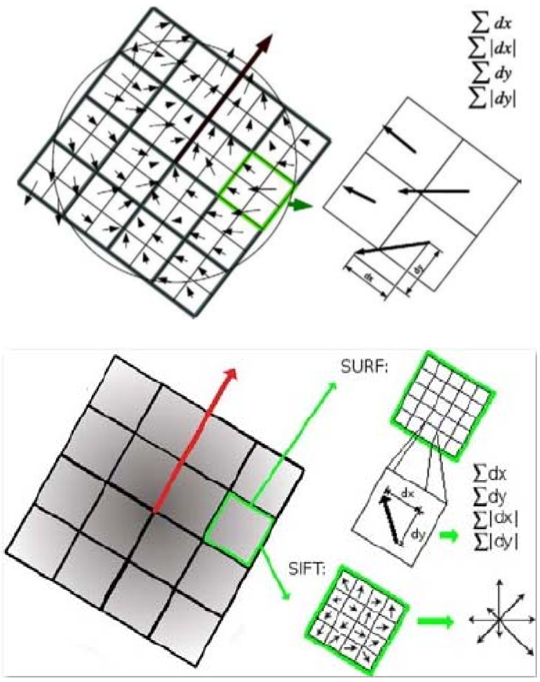


Fig. 1 Formation of SURF and SIFT Descriptors

III. Architecture of Currency Recognition

In general, any currency recognition system includes five major processes: image acquisition, pre-processing, segmentation, feature extraction and classification. Fig. 2 illustrates the architecture of currency recognition steps [7].

A. Image Acquisition

Image acquisition is an activity of acquiring the currency image in a digital form using a specific hardware designed for this purpose, usually scanner or camera [4], [7]. As the first step in currency recognition, it is a very basic process because without the currency image the other processes will not follow.

B. Pre-Processing

Pre-processing is a general name for operations done on images at the initial level where both input and output are intensity images [7]. The aim of pre-processing is an improvement of the currency image by suppressing unnecessary distortions or enhancing major image features important for further recognition processes. Among the pre-processing activities in currency recognition systems, image enhancement and image restoration are the major ones.

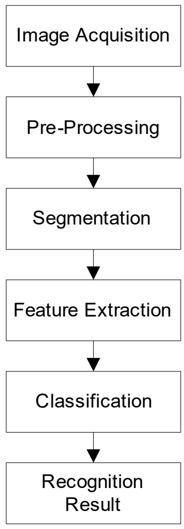


Fig. 2 Architecture of Currency Recognition

C. Segmentation

Image segmentation is the process of dividing an input image into regions according to predefined criteria set beforehand. The name of the operation comes from the result of the operation, which are segments. Segmentation is a process found between image pre-processing and image analysis [1], [7]. It is considered as an operation found at the early stage of image analysis, which is a high-level image processing task consisting of object detection and recognition. As an operation found in early stage, error or inaccuracy in segmentation causes a major error for the rest of the image analysis operations. Therefore, it is advisable to have accurate image segmentation operation as per the requirement of the specific application. In addition, ideally, it is desired that each resulting region or segment represents an object in the original image. This means that each segment is a component useful to make image content analysis and interpretation. Therefore, the set of segmented objects can be matched to a predefined model for interoperating a test image [8].

D. Feature Extraction

Feature extraction is a form of decreasing the dimensions, which produces the important parts of an image efficiently [2]. This access is useful when image sizes are heavy, and a reduced feature representation is required to complete tasks quickly such as image matching and retrieval. Before the feature extraction task is done, the features of the object need to be first detected. In addition, the feature extraction is for feature matching. Therefore, feature extraction is a task between feature detection and feature matching. In addition to currency recognition systems, feature extraction is a major part of object detection and recognition, content-based image retrieval, face detection and recognition, and texture classification problems [9].

There are mainly two types of features: structural feature, which describes geometrical and topological characteristics of pattern by representing its global and local properties and statistical feature, which describes characteristic measurements of the pattern [1]. In this paper, we are concerning with feature extraction step from the currency recognition architecture.

E. Classification

Classification includes a broad range of decision-theoretic approaches to the identification of images. All classification algorithms are based on the assumption that the image in question depicts one or more features and that each of these features belongs to one of several distinct and exclusive classes. The classes may be specified priori by an analyst (as in supervised classification) or automatically clustered (i.e. as in unsupervised classification) into sets of prototype classes, where the analyst merely specifies the number of desired categories [10], [11]. Classification algorithms are divided into two stages of processing: the training and the testing. In the training phase, the image features properties are isolated which produce one descriptor for each category. In the testing stage, the image features are classified according to their feature-space partitions. The class in a currency recognition system, which is designed to classify the currencies of different countries, is the currency names. In addition, in the case of a currency recognition system of a specific country, the class is the denomination of the currency. In both cases, the input to the classifier is a test currency image, and the output is the currency name, for the first case, and the denomination of the currency, in the second case.

IV. Feature Detection Algorithms

In this section, we focused on two types of the feature detection and description algorithms. These algorithms are SIFT and SURF algorithms. We describe the main steps for each algorithm. Then, we illustrate the advantages and disadvantages for these algorithm supported by their main features.

A. Scale Invariant Feature Transform (SIFT) algorithm

In the SIFT algorithm, the first step is to generate scale space by creating internal exemplification of the original image to ensure that the size is stable [12]. Then, it uses the operation of Laplacian of Gaussian that detects the corners and edges to find key points by looping on each pixel and all its near pixels in the current image and image above and image below. These points are approximate, as the point does not lie on pixels directly, so we must calculate the subpixel location [6].

There are many key points, and some of them are located along an edge. Those points are not useful and must be removed. After that, we apply orientation to each keypoint by making directions and sizes to each keypoint. Finally, we make mark on every point. It makes the calculation and the comparison for those keypoints easier, as explained in Fig. 3 [12].

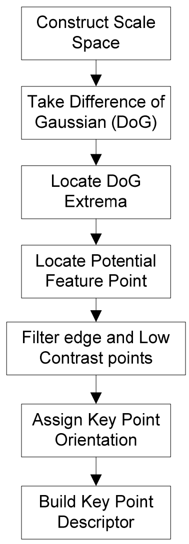


Fig. 3 SIFT Algorithm

SIFT algorithm is not affected by volume changes, rotation, lighting, and the angle of view. In addition, it is strong with noise and large areas of affine conversions with the ability to distinguish points. The disadvantages of SIFT algorithm are that it is still quite slow, costs long time, and is not effective for low powered devices.

B. Speeded up Robust Features (SURF) Algorithm

As the SIFT algorithm, the speeded up robust features (SURF) algorithm search about the orientation of the point by making directions and sizes to each keypoint [5]. Next, it calculates the descriptor that represents the nearness of the keypoint. After that, it calculates the distance on the resulting descriptors which are not on the keypoint locations, as shown in Fig. 4 [6].

SURF algorithm is a speeded-up version of SIFT algorithm. It is more robust to scale changes with the same properties of SIFT. Moreover, SURF is patent protected algorithm. The disadvantages of the SURF algorithm are: it is not stable to rotation and it is not work properly with illumination.

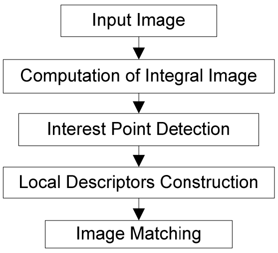


Fig. 4 SURF Algorithm

V. Speeded Up Robust SIFT (SR-SIFT): The Proposed Algorithm

In this paper, we proposed a feature detection algorithm to overcome the problems of both the SIFT and SURF algorithms. For the SIFT algorithm, we need to increase the speed. At the same time, we make our proposed algorithm robust like the SURF algorithm. We called our algorithm Speeded up Robust Scale Invariant Feature Transform (SR-SIFT) algorithm. In the SR-SIFT algorithm, there are five steps:

1. Acquisition the input image.
2. SIFT filter edge.
3. Interest point detection.
4. Detect SURF features
5. Locate the matching points

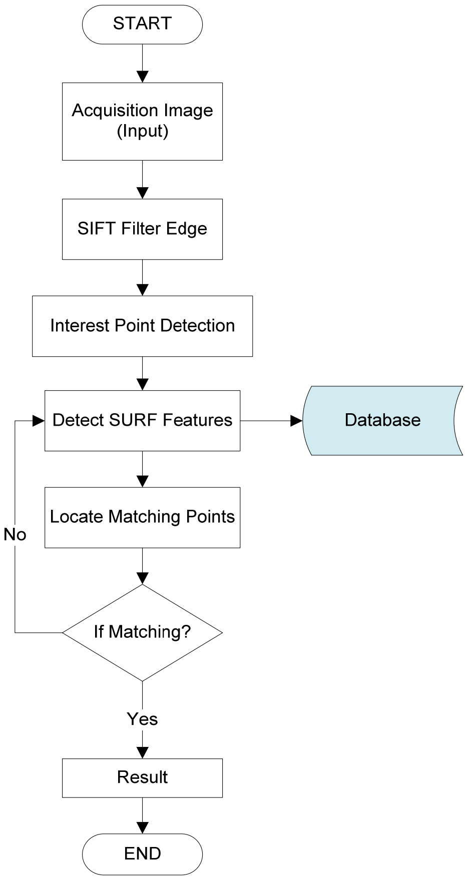


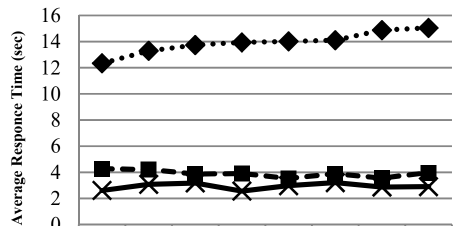
Fig. 5 Flowchart of the SR-SIFT proposed algorithm

These steps are summarized in the flowchart illustrated in Fig. 5. It is expected from the proposed SR-SIFT algorithm to become faster than the SIFT algorithm and to give stable results with rotation and different illumination.

VI. Performance Evaluation

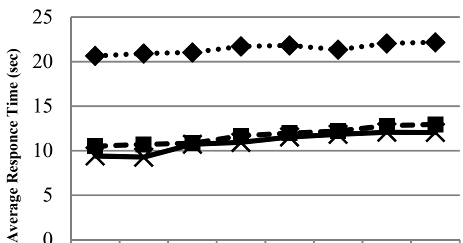
Performance is quantified through measures of the average response time, the distribution of the best key points (BKP), and the BKP accuracy. The average response time means the time taken by the algorithms in order to recognize and give the results. The distribution of the BKP means how the resulting BKP are distributed among the total surface of the currency. The BKP accuracy means the percentage of the true BKP that is detected inside the currency with the total BKP recognized by the algorithms. Simulation is performed by using MATLAB. In all our simulations, we set the same parameters in the three algorithms and use the same images.

Figs. 6-9 illustrate the average response time with the increasing of the number of tested currencies with 25, 50, 75, and 100 BKP, respectively. The results show that the proposed SR-SIFT algorithm gives the minimum average response time when the number of BKP is 25 and 50. However, with the increasing of the number of BKP, 75 and 100, the SR-SIFT gives results better than SIFT algorithm, while it gives results very close to the SURF algorithm.



	5	10	15	20	25	30	35	40
SIFT	12,34	13,29	13,74	13,94	14,02	14,11	14,88	15,05
SURF	4,27	4,21	3,87	3,9	3,54	3,89	3,56	3,97
SR-SIFT (Proposed)	2,61	3,08	3,18	2,56	2,97	3,21	2,87	2,9

Fig. 6 Average Response time vs. No. of tested currencies (BKP=25)



	5	10	15	20	25	30	35	40
SIFT	20,64	20,91	21,04	21,71	21,82	21,34	22,05	22,17
SURF	10,51	10,72	10,84	11,67	11,98	12,21	12,81	12,95
SR-SIFT (Proposed)	9,41	9,28	10,73	10,94	11,54	11,84	12,08	12,05

Fig. 7 Average Response time vs. No. of tested currencies (BKP=50)

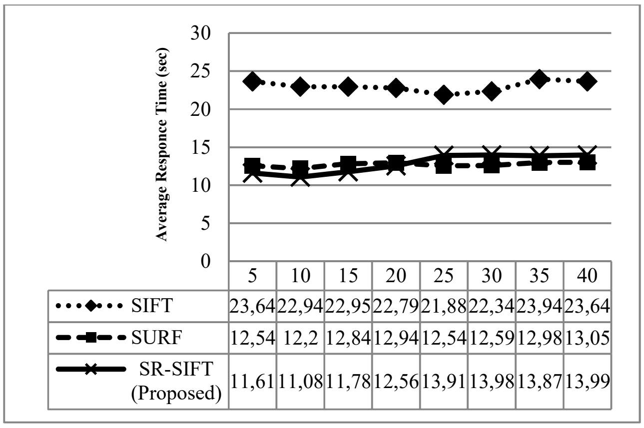


Fig. 8 Average Response time vs. No. of tested currencies (BKP=75)

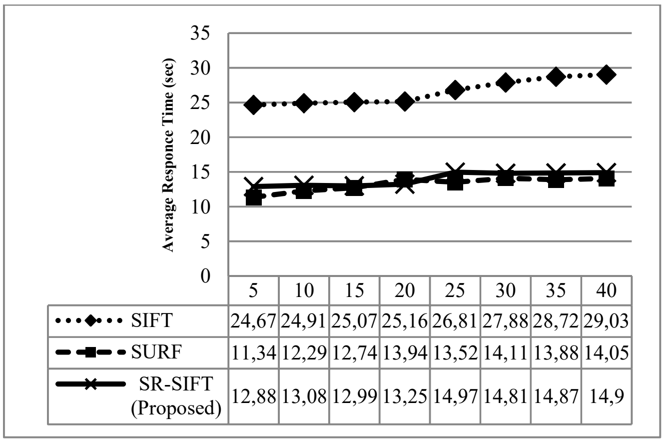


Fig. 9 Average Response time vs. No. of tested currencies (BKP=100)

Fig. 10 represents the average response time with the increasing of the number of BKP.

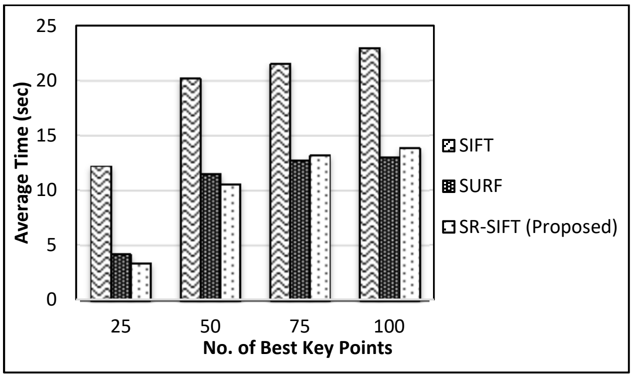


Fig. 10 Average Response time vs. No. of best key points

The distribution of the BKP in the surface of the currencies with the increasing of the number of BKP is shown in Fig. 11. The figure illustrates that the proposed SR-SIFT algorithm gives better results than the SIFT and SURF algorithms. Furthermore, the distribution of the number of BKP on the surface of the currency is better than the other algorithms.

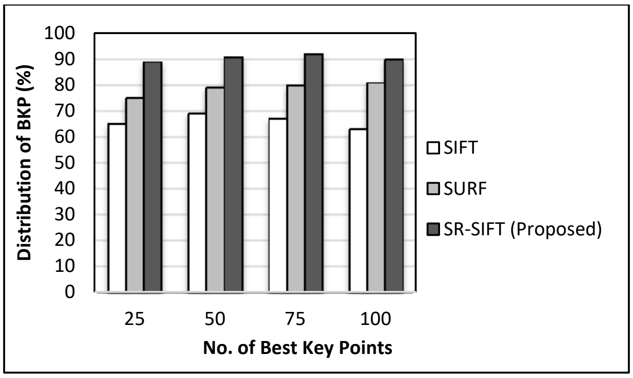


Fig. 11 Distribution of BKP vs No. of BKP

As demonstrated in Fig. 12, the accuracy of the true number of BKP with the total number of the true and false BKP is shown. The figure proves that our proposed SR-SIFT algorithm gives maximum percentage of the true BKP that the other two algorithms.

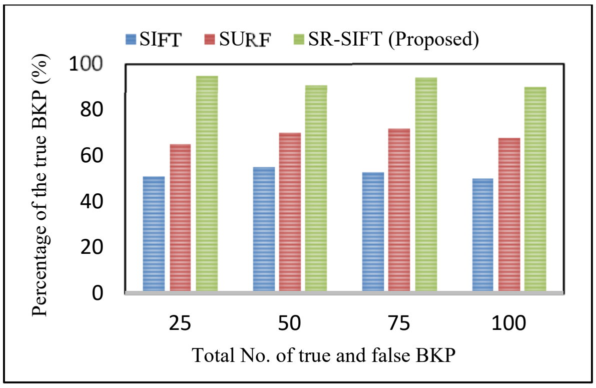
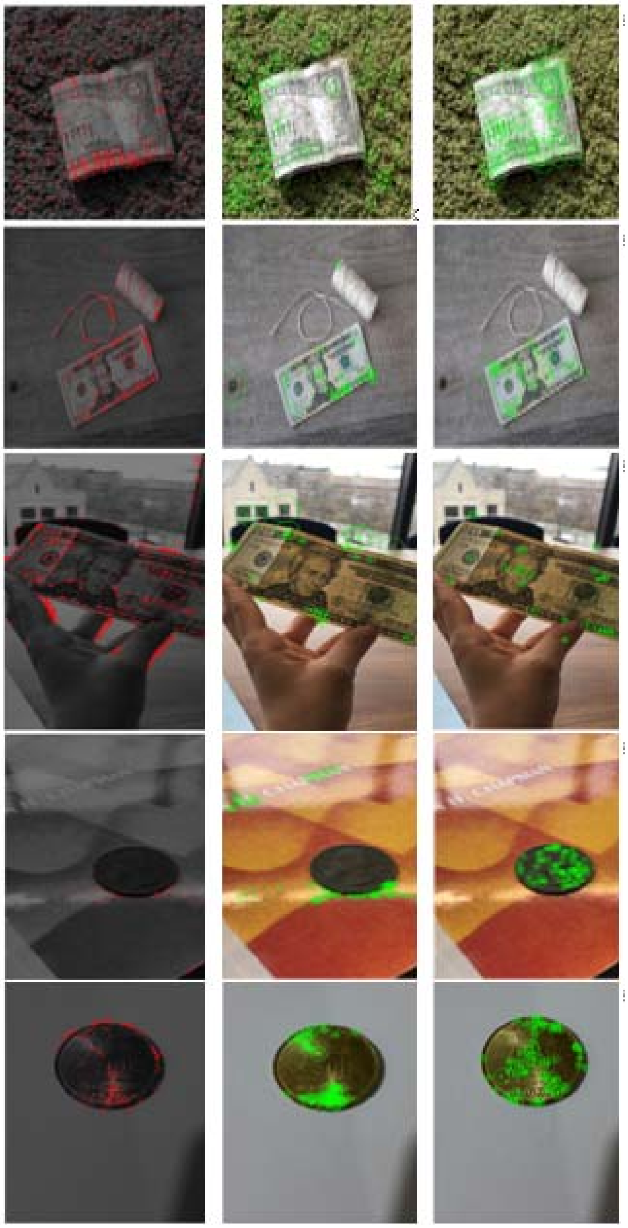


Fig. 12 BKP Accuracy: Percentage of the true BKP vs. total No. of BKP

Fig. 13 shows samples of the BKP for different currencies resulting from the SIFT, SURF, and the proposed SR-SIFT algorithms. The images illustrate that the distribution of the BKP on the surface of the currencies is covering most of the surface space when applying the proposed SR-SIFT algorithm. Otherwise, the other two algorithms give results with less distribution of the BKP on the surface space. Furthermore, the figure demonstrates that the number of true BKP, which is detected inside the border of the image, is improved by applying our proposed SR-SIFT algorithm.



(a) SIFT (b) SURF (c) SR-SIFT

Fig. 13 Samples of BKP for different currencies by (a) SIFT (b) SURF and (c) SR-SIFT (proposed) algorithms

VII. Conclusions

In this paper, the feature detection and description algorithms of the currency recognition architecture are very important and there are many researches which are focused on it. However, these algorithms still have some disadvantages as in the SIFT and SURF algorithms. In this paper, we proposed a new feature detection algorithm that solves some of these disadvantages. The proposed algorithm merged between the SITF and SURF algorithm in order to have the advantages from both and decrease the disadvantages. We called our proposed algorithm Speeded up Robust Scale-Invariant Feature Transform (SR-SIFT) algorithm. It increased the speed of the SIFT algorithm and kept it robust. Our simulation results concluded that the proposed SR-SIFT algorithm gives better performance than the SIFT and SURF algorithms. It reduced the average response time especially with a small and minimum number of BKP, increased the distribution of the number of BKP on the surface area of the currency. Moreover, it increases the accuracy of the true BKP distribution inside the currency edge, which is better than the other two algorithms.

References

[1] A. Ahmadi and M. Manzoor, "Recognition System for Pakistani Paper Currency", Research Journal of Applied Sciences, Engineering and Technology, Vol. 6, No. 16, 3078-3085, Sep. 2013.

[2] R. Choras, "Image Feature Extraction Techniques and Their Applications for CBIR and Biometrics Systems", International Journal of Biology and Biomedical Engineering, Vol. 1, No. 1, 2007.

[3] V. Jain, and R. Vijay, "Indian Currency Denomination Identification Using Image Processing Technique", International Journal of Computer Science and Information Technologies, Vol. 4, No.1, pp. 126 -128, 2013.

[4] N. Paisios, A. Rubinsteyn, and L. Subramanian, V. Vyas, "Recognizing Currency Bills Using a Mobile Phone: An Assistive Aid for the Visually Impaired", User Interface Software and Technology, CA, USA, Oct. 2011.

[5] F. Hasanuzzaman, X. Yang, Y. Tian, "Robust and Effective Component-based Banknote Recognition by SURF Features", Wireless and Optical Communications Conference 20th Annual, Newark, NJ,1-6, April 2011.

[6] H. Bay, A. Ess , T. Tuytelaars, and L. Gool, "Speeded-Up Robust Features (SURF)", Computer Vision and Image Understanding: Similarity Matching in Computer Vision and Multimedia, Vol. 110, No. 3, pp. 346–359, June 2008.

[7] H. Aggarwal, and P. Kumar, "Indian Currency Note Denomination Recognition in Colour Images", International Journal on Advanced Computer Engineering and Communication Technology, Vol.1, No.1, ISSN 2278-5140, 2012.

[8] W. Kavinda, and S. Dhammika, "Bank notes recognition device for Sri Lankan vision impaired community", 8th International Conference Computer Science & Education (ICCSE), Colombo, 609-612, April 2013.

[9] N. Arora, N. Dhillon and K. Sharma, "Bank Automation System for Indian Currency a Graphical Approach", International Journal of Computer Science and Communication Engineering Special Issue on Recent Advances in Engineering & Technology NCRAET, ISSN 2319-7080, 2013.

[10] X. Zhu, and M. Ren, "A Recognition Method of RMB Numbers Based on Character Features", 2nd International conference on Information, Electronics and Computer, May 2014.

[11] D. Liliana, and I. Neforawati, "Automatic Recognition of Rupiah Currency using Naïve Bayes Classifier", Seminar on Electrical, Informatics and it Education, 2013.

[12] L. Abu Doush and Sahar AL-Btoush "Currency recognition using a smartphone: Comparison between color SIFT and gray scale SIFT algorithms", Journal of King Saud University – Computer and Information Sciences, June 2016.