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Banknote Recognition for Visually Impaired Using Key-point and Support Vector Machine

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ABSTRACT

One among the most significant issues that Visually Impaired people face is identifying money, especially paper money. This study presents a basic money identification system that is applied to Egyptian, Saudi, and American banknotes in this work. The proposed solution relies on artificial intelligence techniques. Among the main method included in our system is the use of key-point algorithm. The test results showed that the proposed approach can distinguish different paper of money with a high accuracy of up to 97 % and in a short period of time.

Keywords: - Banknote Recognition – key-point techniques – Binary Robust Independent Elementary - Scale invariant feature transform - Voice feedback- Support vector machine.

I. INTRODUCTION

Based on the most recent studies, the World Organization of healthy estimates that there are around 285 million persons worldwide with vision impairment, of whom 246 million are visually impaired and 39 million are entirely blind [1]. The Eastern Mediterranean Region is also thought to account for 12.6% of the worldwide blindness rate [2].

The difficulty of persons with visual impairments to distinguish banknotes is a serious issue owing to the similarity of paper texture and size between denominations [3]. As a result, the job of technology is to create a solution to this dilemma in order to make the Visually Impaired and blind person feel safe and confident in financial transactions [4]. In the realm of money recognition research, there are two approaches: scanner-based and camera-based. In this paper, we assume a system based on the usage of a camera to recognize cash and then output it in the form of a voice for the Visually impaired person.

II. LITERATURE REVIEW

As an overview of the state of the art in banknote recognition, several studies are provided [5,6,7].

In [8] an embedded system was built to aid blind persons in identifying Australian banknotes. The Money Talker employs the reflection and transmission qualities of light to take use of the vastly diverse colours and patterns on each of Australia's bank notes. Light of various colours is transmitted through the inserted banknote, and the amount of light that passes through the banknote is measured using light sensors.

In [9] an application for identifying Indian National Rupee banknotes using computer vision techniques on mobile phones had presented. The system employs an iterative graph cuts technique for segmenting the banknote from the crowded backdrop, as well as a visual Bag of Words-based recognition system.

In [10] Computer vision-based method for the automated identification of American dollar bills was proposed to aid visually challenged persons. For banknote recognition, the system employs a component-based structure.

In [11] developed a portable gadget that employs a modified Viola and Jones algorithm for banknote detection in order to enable visually impaired people to identify and recognize Euro banknotes and the SURF approach for banknote recognition.

In [12] The color and texture attributes given by the RGB space and the Local Binary Patterns are used to detect Mexican banknotes. Their works is done under the premise that there are no lighting differences between the banknotes' pictures on the training and testing sets.

In [13] It was constructed a system based on simple image processing utilities. Image foreground segmentation, histogram augmentation, and area of interest (ROI) extraction are among the processes in their method. The test results show that the suggested approach can distinguish Egyptian paper money of high quality with an 89 %success rate.

In [14] A method for extracting varied and distinguishing qualities of Indian currency notes, such as the central number, RBI logo, color band, and special symbols or signs for visually impaired, has been introduced. As a result of their efforts, visually challenged persons would be able to recognize various types of Indian currencies during monetary transactions, allowing them to live freely both socially and financially. In comparison to the other approach, their suggested technique took much less time to process the input currency picture and obtain the result, the suggested method's overall accuracy is 96%, whereas the CRS system's accuracy is 89 %.

In [15] A model was presented to identify the Egyptian currency in all engineering transformation processes (measurement - rotation - mile). For the testing process, creation of a manual data set of 1200 images of Egyptian currency was created. After testing process, the result show that accuracy for all categories of the system arrive to 93%.

In this study, a system has proposed to identify the egyptian, saudi and american banknotes depends on AI techniques and its application in image processing with a high rate of recognition compared to previous studies.

III. METHODOLOGY

The proposed system offers a broad framework for recognizing paper banknotes. The system is divided into five major phases, as shown in Figure (1). The system's input is an image captured by a camera and contains the fiat currency.

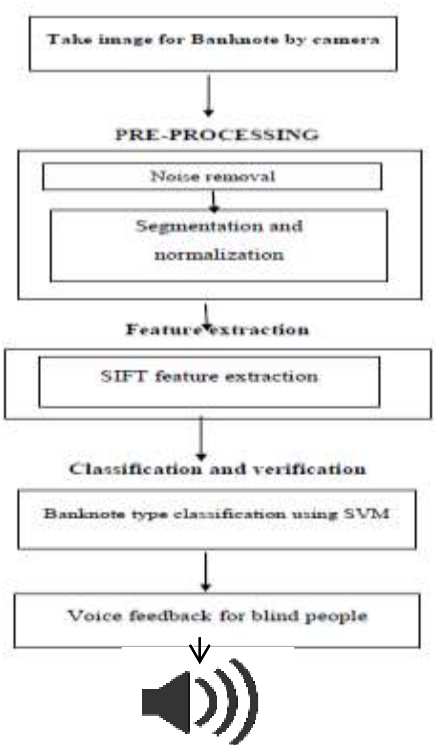

Figure 1. The Structure of Currency Recognition System

The steps of the system can be summarized as follows:

A. Capture image using camera

An image is captured by the camera where the paper currency is placed in the direction of the camera and the system also allows loading of a pre-existing image on the computer, figure (2, 3) show banknote image taken by camera.

Figure 2. Egyptian Banknote image taken by camera

Figure 3. Saudi Banknote

B. Image Preprocessing

In this step, image processing methods are applied to prepare the currency image for feature extraction process, figure (4) shows banknote image after Preprocessing.

Figure 4. Egyptian Banknote after pre-processing

C. Feature Extraction

At this step, the attributes are extracted using k-point algorithm as shown in the following steps. figure (5) shows the matching between two images using key-point.

Key- point such as: SURF, BRISK, BRIEF, ORB, SIFT and FAST are feature description used to identify and describe image key-points.

SURF Feature: Short for Acceleration Feature, a feature that detects the image, such as: image rotation, image orientation, and fixed-band properties.

- **BRISK Feature**: strong scalable binary core points Image Scale Detection.
- **BRIEF property**: It is an abbreviation for strong independent binary elementary properties, effects, static calculation, image in pixels.
- **ORB**: It is an abbreviation for short, fast and directed Location Determine the points of the external image (the points that define the image).
- **SIFT property**: fixed-scale feature transformation Location Determine the actual location of the image.
- **FAST feature:** It is an abbreviation for the accelerated section test Angle positioning for the image.

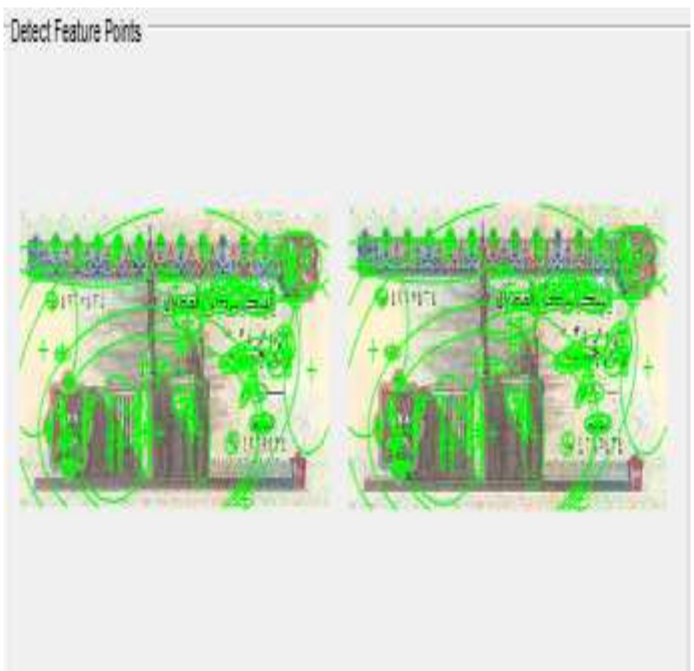

Figure 5. Matching between two images using key-point

D. Classification using support vector machine

Support Vector Machine training is a procedure in which the Support Vector Machine learns the pattern of the banknote's paper characteristics [16].

Training procedure:

learns the patterns of the training banknotes, and the result is a Support vector classifier. The task of training data is critical in the recognition process.

Classification procedure:

After collecting banknote feature vectors, it is important to recognize the pattern of the banknotes based on these extracted features, which should be taught by a successful classifier for banknote identification system. Figure (6) shows putatively matching point between two currency using SVM.

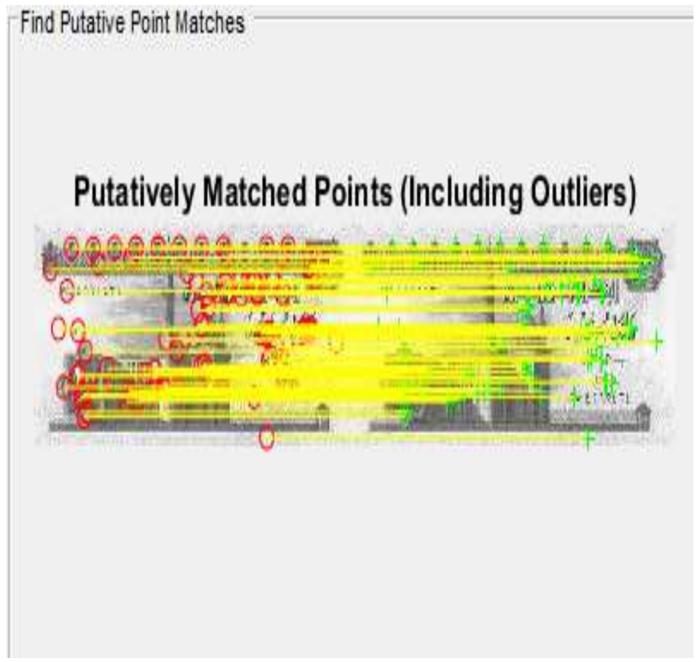

Figure 6. putatively matching point between two currencies using SVM

After the feature extraction operation has been completed, the kind of banknote must be decided [17]. The vector machine classifier was used to solve this assignment. SVM is a new machine learning algorithm that is already being used to identify public domains. Figure (7) shows k-point classification process for Egyptian currency matching. The Separating hyperplane conclusively debunks the supervised learning model SVM [17].

SVM is a supervised learning approach that constructs a decision-making mechanism to better understand data using a pre-defined training data set. Using a hyperplane, which is commonly used in pattern recognition and classification, the technique, seeks to reveal decision boundaries that split data points from numerous groups [16].

The equation of the hyperplane is defined by [18]:

$$\boldsymbol{r^T d + h} \qquad (1)$$

- ❖ d : is the input vector.
- ❖ r : signifies the weight vector that may be adjusted (the maximum possible separation among the true and false instances). signifies the weight vector that may be adjusted

(the maximum possible separation among the true and false instances).

- h refer to the bias

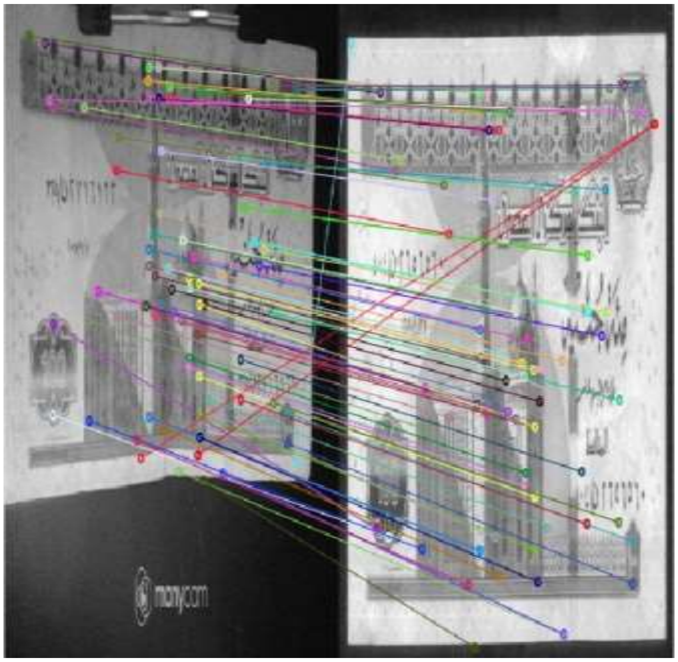

Figure 7. key-point classification for Egyptian currency

E. Sound feedback

The relationship between the images database and the sound database is created as a consequence of the classification process. Each image in the database is accompanied by an audio recording. Based on the categorization result, this audio file is shown.

The audio is captured using a microphone, and each sample is stored as a Microsoft wave form file with a sampling ratio of 44100 Hz and quantization of 16 bits. Figure (8) shows sound signal of ten pounds.

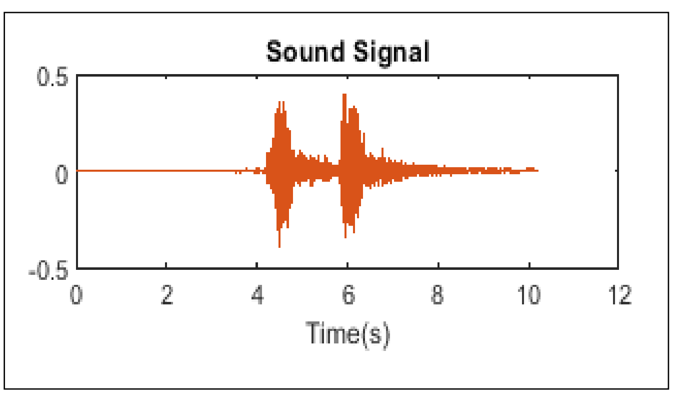

Figure 8. Sound signal of ten pounds.

IV. IMPLEMENTATION

Matlab is used to the execution of our system. All photos in our collection are taken by camera, Table (1) shows the intrinsic and extrinsic parameters of web camera used.

Table 1: The intrinsic and extrinsic parameters of web camera

Intrinsic parameter	Web camera
Focal length (pixel)	[872.425,873.481]
Principal point (pixel)	[317.448,244.397]
Skew	0
Extrinsic parameters	Translation(mm)= $\begin{bmatrix} -69.5292 & -1.0367 & 3.4411 \end{bmatrix}$

All images have pre-processed by segmentation and normalization then support vector machine has used to classification process. Figure(9) shows Gui for putatively matching point between two Egyptian currencies.

Figure 9. Gui for putatively matching point between two Egyptian currencies.

V. EXPERIMENTAL RESULTS

Our proposed method was developed and tested using a database of 300 images. 225 images were used in the training process and 75 images in the testing process.As a result of the proposed approach, we arrive that the images change based on quality and features of the camera used. Based on the proposed method and our result, table (2) shows Number of key-points and Processing time (s) for banknote gray approach.

Although the dataset has many features that are duplicated by several currencies, they may not harm the accuracy of the system or increase the time it takes to get a result. Figure (10,11) show Sample of System database and their key-points.

Figure 10. Sample of the testing banknote and key-points

TABLE 2. banknote grey SIFT technique, the number of key-points and processing time (s)

Banknote Name	Number of key-points	Processing time (s)
Ten Egyptian pounds	510	1.335337
Five Egyptian pounds	403	1.459745
Twenty Egyptian pounds	512	1.333186
One hundred Egyptian pounds	580	1.665082
Five Saudi riyals	522	1.471801
Ten Saudi riyals	592	1.331734
Ten Saudi riyals	405	1.087652
One hundred Saudi riyals	546	1.435297
One hundred Saudi riyals	488	1.368860
One hundred Saudi riyals	413	1.125639
One hundred American Dollar	410	1.015633
Twenty American Dollar	588	1.444211

Figure 11. Samples of System database

Equation (2) is used to assess the proposed system's accuracy. Banknote classification result are shown in table (3).

$$\text{Recognition rate} = \frac{\text{the number of success identification}}{\text{Total number of identification trials}} \quad (2)$$

As:

success identification: is number of correct results.

Trial identification: is the number of uncorrect results.

TABLE 3. Banknote classification result

	Egyptian banknote	Saudi Banknote	American Banknote
Quantity	100	100	100
Accuracy (%)	96%	97%	96%

After testing process using images that have been captured using web cameras with different resolutions, viz. VGA, 1.3 megapixels (MP), 2 MP and 5 MP, the average accuracy arrives to 97%. Compared to previous studies such [15, 16], Our system has a high rate of recognition compared to previous studies.

VI. CONCLUSION AND FUTURE WORK

Paper Currency Recognition is a significant Pattern Recognition application. Many investigations have been conducted in order to recognize banknotes. Another way of identifying currencies has been proposed in this research, which is based on Using K-point And Support Vector Machine. The suggested approach is completely autonomous and does not require any human involvement. The author is also considering using the proposed feature technique to another classification model. It may increase the process's accuracy and efficiency. This study is now under development as a follow-up to the issue of considering several currencies with a single system. In the future we will apply mobile application to this system.

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