Research Journal of Applied Sciences, Engineering and Technology 6(16): 3078-3085, 2013
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: January 29, 2013 Accepted: March 08, 2013 Published: September 10, 2013

Recognition System for Pakistani Paper Currency

[1]Ahmed Ali and [2]Mirfa Manzoor
[1]COMSATS Institute of Information Technology, Abbottabad,
[2]Sardar Bahadur Khan Women's University, Quetta, Pakistan

Abstract: The main purpose of this study is to propose a method that could recognize the Pakistani paper currency note. There are many real-life applications which heavily use many techniques based on Pattern Recognition such as voice recognition, character recognition, handwriting recognition and face recognition. Paper currency recognition is a new application of pattern recognition. This application uses the computing power in differentiating between different kinds of currencies with their suitable class. Selection of proper feature enhanced the performance of the overall system. We are aiming to develop an intelligent system for Pakistani paper currency that could recognize the currency note accurately. In this study, we have taken samples domain of five different Pakistani paper currency notes (Rs. 10, 20, 50, 100, 1000). We scanned total 100 currency notes, 20 from each sample of selected domain for feature extraction of these images using a software. The images will be matched with the features stored in MAT file and if the features of test images will be matched with that file, the software will return the class of that currency note. Experimental results are presented which show that this scheme can recognize currently available 8 notes of Pakistan's Currency (Rs. 10, 20, 50, 100, 500, 1000 etc.) successfully with an average accuracy of 98.57%.

Keywords: Feature extraction, Pakistan currency, recognition system

INTRODUCTION

We live in an age of information where everyone is busy and life becoming faster day-by-day. In this busy life everyone needs complete and quick and correct response so they can save their time.

Today's era is termed as the "IT age" or we can say it "Computer's Age" so it is thought inevitable to have software solutions for various problems in order to save the time, in different organizations despite of it whether the organization is small or large enough. We focus to recognize Pakistani paper currency accurately.

Paper currency recognition is one of the applications of pattern recognition. There are some similar recognition systems, such as face recognition system, fingerprint recognition system. However the theories they use are similar but the techniques and approaches are different.

The Pakistan paper currency has different denominations, with each of them looking totally different. For instance the size of the paper is different, the same as the color and pattern. The staffs who work for the money have to distinguish different type's notes and that is not an easy job. This may cause some problems (e.g., Wrong recognition), so they need an efficient and the exact system to help their work. As we mentioned before, the aim of our system is to help people who need to recognize Pakistani paper currency, and work with convenience and efficiency.

Otherwise our system is based on image processing, techniques which include.

Noise removal, preprocessing, In order to make the system more comprehensive, we need to create a small database for storing the features of the currency. The system will be programmed based on MATLAB and include a user-friendly interface. The main steps in the system are:

- Read image, reading the image we get from the scanner as well as the format of the image is JPEG
- Preprocessing, removing noise
- Feature extraction, classification
- Result

There are 7 denominations of Pakistani paper currency. Each note has different size and different color. This system is designed to reduce the human effort and to avoid the purchase of expensive hardware. This system will extract the features of the test image and will match with the features stored in training database (mat file). If the features match it will display the type of currency. There is no as such system for recognizing Pakistani Paper Currency. This system can be used in:

- ATM Machines
- Auto-seller machines
- Bank money-counters

The scope of the project is to recognize the Pakistani paper currency note correctly and accurately.

Corresponding Author: Ahmed Ali, COMSATS Institute of Information Technology, Abbottabad, Pakistan

The main objectives of this is to develop an intelligent system for Pakistani paper currency that could recognize the currency note accurately.

LITRATURE REVIEW

Takeda *et al*. (2003), they did recognition by using neural network. The neural network is widely used for pattern recognition because of its abilities of self-organization, parallel processing and generalization. The neural network can recognize patterns effectively and robustly. In this they use a new kind of banknote Thai bank note as the object of recognition. In their recognition system masking process is defined as the characteristics extraction of a bank note image. Neural network learning and recognition algorithms are implemented On DSP devices as a Neuro recognition engine; they proposed the continuous learning by the DSP unit which they have developed for banking machines.

Jahangir and Raja (2007) they had used neural network recognition method to recognize Bangladeshi currency. They had implemented this method on cheap hardware which can be used in different places. The system take the image of banknote as an input .the notes are scanned using less expensive sensors. The notes are trained for recognition using Back Propagation algorithm. If the note is flipped the correct recognition is guaranteed because the axis symmetric mask is used in the preprocessing stage. For experiment notes they used 8 notes of TAKA which were recognized successfully.

Guo *et al*. (2010) they use symmetrical mask for recognizing paper currency. In this method non masked pixel value of banknotes is computed and feed to the neural network for recognizing paper currency. For this two sensors are used at the front and back of paper currency but decision is made with the image of the front. In next step paper currency is divided into n equal parts along vertical vectors for these parts.

Debnath *et al*. (2010) they have represented a currency recognition system using negatively correlated ensemble neural network. They have proposed the ENN for currency recognition. For training they used the negative correlation learning. In negative correlation the entire networks are negatively correlated through the strength of penalty term. The entire ensembles interact with each other and each network has specialized for a particular portion of input vector. So when they apply a noisy pattern the network will be able to recognize as a whole. The recognition rate is better than single network. Though they have performed our experiment for Bangladeshi currency but it is equally applicable in any paper currency recognition.

Singh *et al*. (2011), the feature extraction of Indian currency notes involves the extraction of features of serial numbers of currency notes. Feature extraction means to extract the information from the raw data which is relevant to classify to minimize the class pattern variability and enhancing the between class pattern variability during feature extraction, the dimensionality of data is reduced and it is needed due to technical limits and computational memory. Heuristic analysis of characters of the serial number is done. It is a technique which actually produces a good solution. Anti-virus scanners use heuristic signatures to look for specific attributes and characteristics to detect virus. By using heuristics, time can be reduced when solving problems. As because the heuristics are fallible, it is important to understand their limitations. They are used as acids to make quick estimates and preliminary process designs.

Lee and Kims (2003), they considered the distinctive point extraction and recognition algorithm for various kinds of banknotes. By converting the scanned 256-colored image data to 4-bit gray data as pre-processing, we can get a better algorithm to find the dark areas on the special block because the dark color is robust to noise. By applying the continuous same colored area recognition algorithm to the face value of the banknote, we can extract distinctive data to classify the kind of banknotes, as the area is located in the different positions on each kind of banknotes. To recognize banknotes, we trained 5 neural networks. One is for inserting direction and the others are for the face value the distinctive data pattern according to the inserting direction shows relatively clearer tendency than that of the face value. With this method, we can get a high recognition rate except for 100 and 200 Euro bank notes. The proposed recognition algorithm does not include position correction. In banknote counting machines, the origin position of the distinctive points may be changed when banknotes are not perfectly inserted into the counting machine. This occurs frequently and thus more researches will be needed.

METHODOLOGY

We have scanned 100 Pakistani paper currency notes from different currency domain (Rs. 10, 20, 50, 100, 1000). Each note was scanned at 200 dpi using an HP scanner.

The system is based on scanner, PC, and classifiers. Here the classifier that we have used is Knn classifier that is in fact a nearest neighborhood classifier. Before applying a classifier we had used preprocessing techniques, in such a way that we had first converted the RGB image to grey scale image, in order to remove noise we had used wiener filter. The Wiener filter purpose is to reduce the amount of noise present in a signal by comparison with an estimation of the desired noiseless signal. Then the image is converted into a binary image to extract features. This

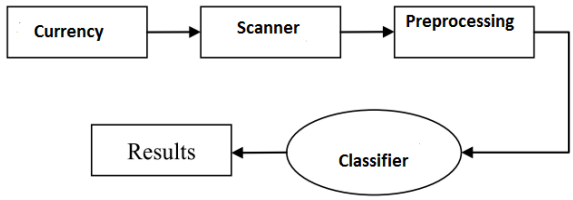

Fig. 1: System design

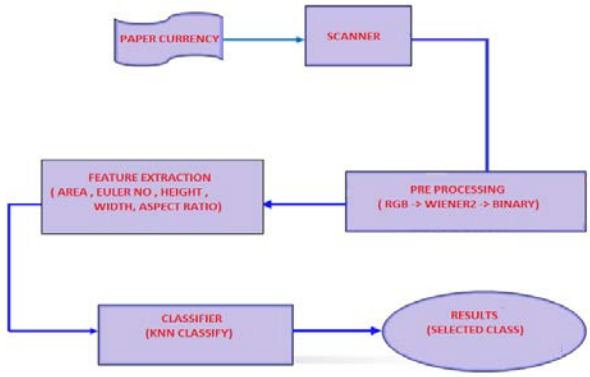

Fig. 2: Block diagram

Table 1: Number of notes scanned

Domination	Scanned notes
10	20
20	20
50	20
100	20
500	20
1000	20

system is designed under the programming tool of MATLAB.

The software will extract the features of the test images. Once these five features will be extracted they will be matched with the features stored in MAT file. The features in MAT file are features of train images. If the features of test image will be matched with the features in MAT file the software will return the class of that currency note. If the test image features don't match with any of the features in Mat file the software will display that it is doesn't belong to any class.

In other words it will classify the paper currency to the correct class to which it belongs (e.g., 10, 20, 50, 100, 500, and 1000) (Fig. 1).

The classification is the process to classify the currency note into its correct class. For this purpose there are many algorithms like Euclidean distance classifier, Weighted Euclidean distance classifier , knn classify etc. the algorithm which we had used for classification is knn classify. Instance-based classifiers such as the knn classifier operate on the premises that classification of unknown instances can be done by relating the unknown to the known according to some distance/similarity function. Classification (generalization) using an instance-based classifier can be a simple matter of locating the nearest neighbor

Fig. 3: Rgb image

Fig. 4: Gray scale image

in instance space and labeling the unknown instance with the same class label as that of the located (known) neighbor. This approach is often referred to as a nearest neighbor classifier.

System architecture: (Fig. 2)

Acquisition of images: We had scanned 100 Pakistani paper currency notes of different dominations. Each note was scanned at 200 dpi using an HP scanner (Table 1).

Preprocessing: This procedure is done before processing by correcting imagefrom different errors. In this project the preprocessing techniques used are conversion of RGB image to Gray, removal of Noise and conversion to Binary.

- **Conversion to gray:** It represents an image as a matrix where every element has a value corresponding to how bright/dark the pixel at the corresponding position should be colored. It assigns value between 0 to 255 to represent the brightness of the pixel. 0 represents black and 255 represent white. We convert RGB color image into the gray level as color information is not useful in this recognition process furthermore it reduces the computational cost (Fig. 3 and 4)
- **Noise removing:** Many currency notes come with dust on them or something written on them. Noise removing is the process of removing such dust from these notes and makes the image clearer. MATLAB includes many noises removing filters. The filter which we used is wiener2. The Wiener filter purpose is to reduce the amount of noise present in a signal by comparison with an estimation of the desired noiseless signal (Fig. 5)
- **Conversion to Binary:** This image format also stores an image as a matrix but can only color a pixel black or white (and nothing in between). It

assigns a 0 for black and a 1 for white. After removing noise from the image the image will be converted into Binary image. The purpose of converting the image into binary image is that we are going to extract the features like Euler number and Area. These features are only extracted from binary images (Fig. 6).

Feature extraction: In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed then the input data will be transformed into a reduced representation set of features (also named feature vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. The features of the image which we had extracted are Euler Number, Area, Height, Width, Aspect ratio of that image.

- **Euler number:** Euler number is the number of objects in the image minus the total number of holes in those objects:

$$E = (O-H_0) \quad (1)$$

where,

O = The total number of objects

H_0 = Represents the number of holes in those objects

MATLAB has a built in function to find the Euler number of images.

$$E = \text{bweuler}(\ ) \quad (2)$$

- **Area:** Area is the approximate number of one bit in a binary image. MATLAB has a built in function to find the area of the particular image:

$$A = \text{bwarea}(\ ) \quad (3)$$

- **Aspect ratio:** The aspect ratio is an image projection attribute that describes the proportional relationship between the width of an image and its height:

$$As = \text{height/width} \quad (4)$$

- **Height:** Height is the measurement of vertical distance of an image
- **Width:** Width is the measurement of horizontal distance of an image

Fig. 5: Image after noise removal

Fig. 6: Binary image

MAT File: A MAT file is a Microsoft Access file. The purpose of using the MAT file here is to save the features of training images which we had extracted. The features will be used during classification. The features of test image will be matched with the features stored in MAT file. If features of the test image match with the features in MAT file the currency type will be displayed.

Classification: The classification is the process to classify the currency note into its correct class. For this purpose there are many algorithms like Euclidean distance classifier, Weighted Euclidean distance classifier, knn classify etc. the algorithm which we had used for classification is knn classify. Instance-based classifiers such as the kNN classifier operate on the premises that classification of unknown instances can be done by relating the unknown to the known according to some distance/similarity function. Classification (generalization) using an instance-based classifier can be a simple matter of locating the nearest neighbor in instance space and labeling the unknown instance with the same class label as that of the located (known) neighbor. This approach is often referred to as a nearest neighbor classifier:

$$(x,y) = \sqrt{(\sum_{i = 1..n}(a_i - b_I)^2)} \quad (5)$$

The software will extract the features of the test images. Once these five features will be extracted they will be matched with the features stored in MAT file. The features in MAT file are features of train images. If the features of test image will be matched with the features in MAT file the software will return the class of that currency note. If the test image features don't match with any of the features in Mat file the software will display that it is doesn't belong to any class.

RESULTS

Snap shots:

- **10 Rupee note:** First 10 rupee note test image will be given for recognition to the software. The

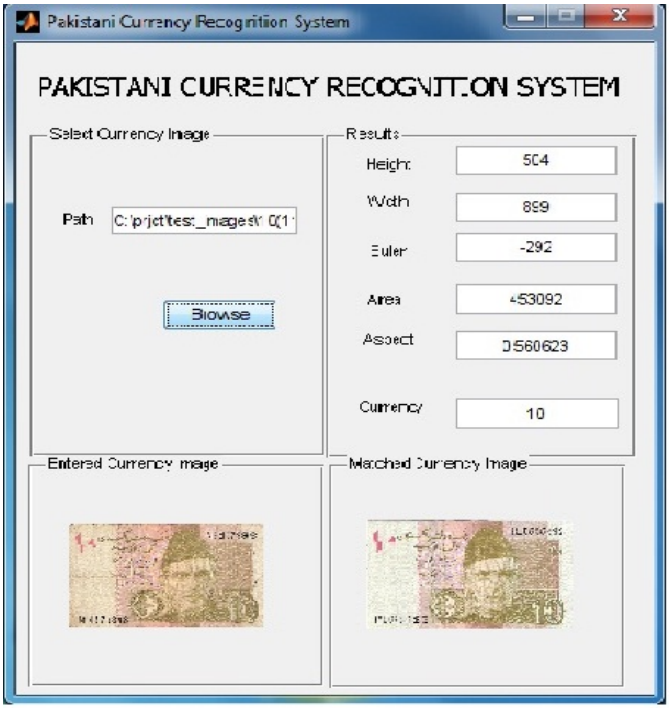

Fig. 7: Recognition of 10 rupee note

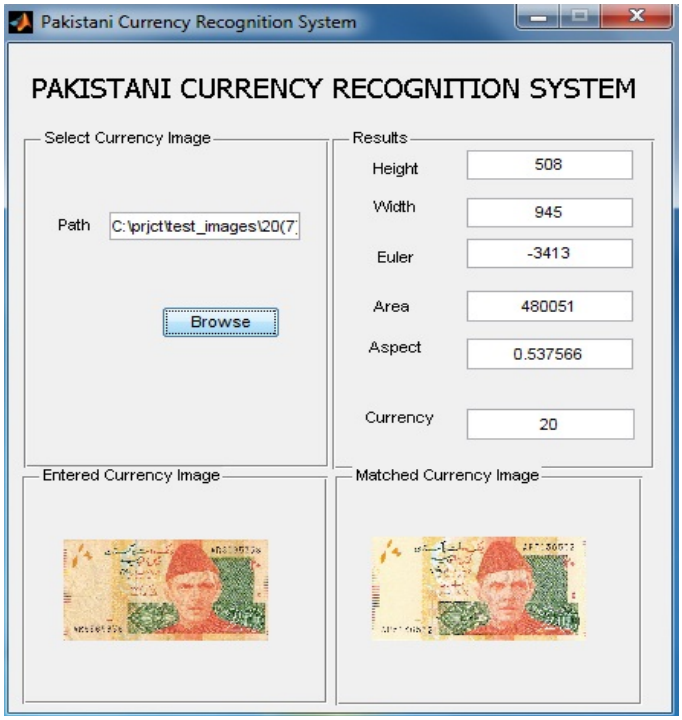

Fig. 8: Recognition of 20 rupee note

features of that image will be extracted and will be matched with the features in mat file. If the features matched the software will recognize that it is the 10 rupee note and will display the type and the image.10 different images of 10 rupee notes were given to this software for recognition and all of them were recognized successfully (Fig. 7)

- **20 Rupee note:** First 20 rupee note test image will be given for recognition to the software. The features of that image will be extracted and will be

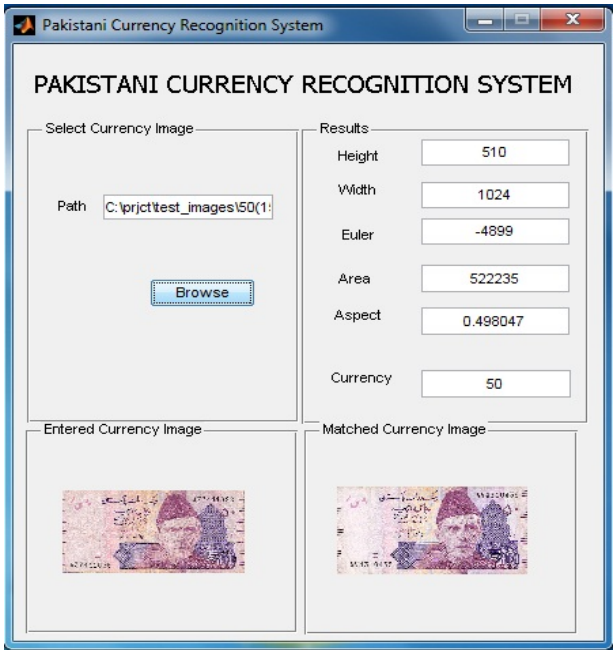

Fig. 9: Recognition of 50 rupee note

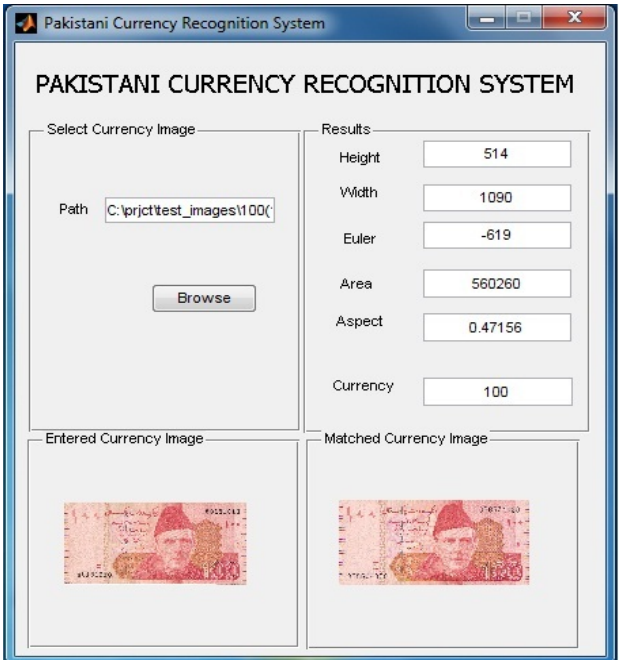

Fig. 10: Recognition of 100 rupee note

matched with the features in mat file. If the features matched the software will recognize that it is the 20 rupee note and will display the type and the image.10 different images of 20 rupee note were given to this software for recognition and all of them were recognized successfully (Fig. 8)

- **50 Rupee note:** First 50 rupee note test image will be given for recognition to the software. The features of that image will be extracted and will be matched with the features in mat file. If the features matched the software will recognize that it is the 50 rupee note and will display the type and the image.10 different images of 50 rupee note were given to this software for recognition and all of them were recognized successfully (Fig. 9)
- **100 Rupee note:** First 100 rupee note test image will be given for recognition to the software. The features of that image will be extracted and will be

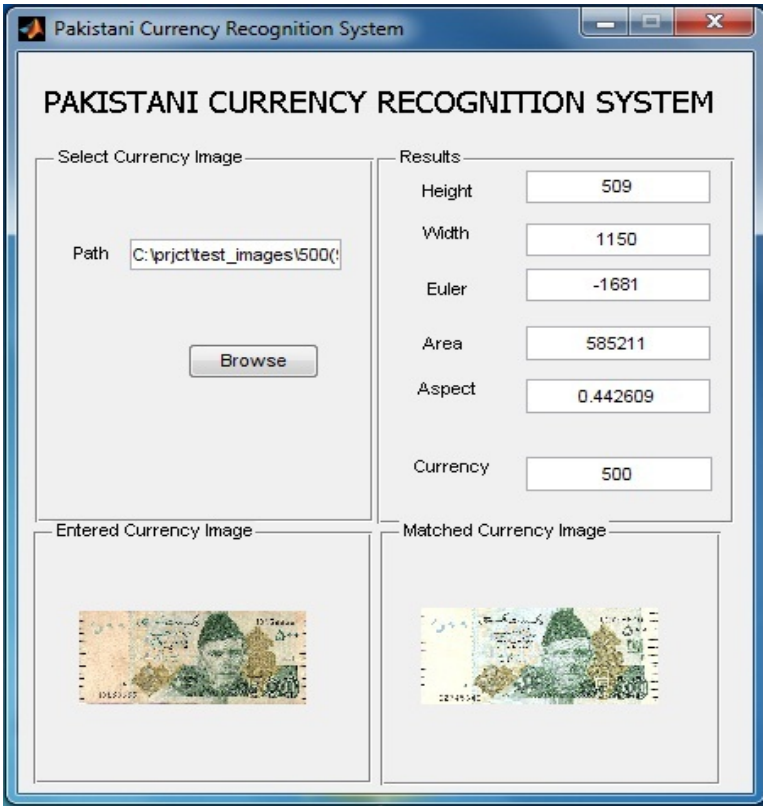

Fig. 11: Recognition of 500 rupee note

Table 2: Number of trained and tested images

Type	Training	Testing
10	15	10
20	15	10
50	15	10
100	15	10
500	15	10
1000	15	10

Table 3: Recognition ability

Banknote type	No. of note tested	No. of note recognized	Recognition ability (%)
10	10	10	100
20	10	10	100
50	10	10	100
100	10	10	100
500	10	10	100
1000	10	10	100

matched with the features in mat file. If the features matched the software will recognize that it is the 100 rupee note and will display the type and the image.10 different images of 100 rupee note were given to this software for recognition and all of them were recognized successfully (Fig. 10)

- **500 Rupee note:** First 500 rupee note test image will be given for recognition to the software. The features of that image will be extracted and will be matched with the features in mat file. If the features matched the software will recognize that it is the 500 rupee note and will display the type and the image.10 different images of 500 rupee note were given to this software for recognition and all of them were recognized successfully (Fig. 11)
- **1000 Rupee note:** First 1000 rupee note test image will be given for recognition to the software. The features of that image will be extracted and will be matched with the features in mat file. If the features matched the software will recognize that it is the 1000 rupee note and will display the type and the image (Table 2). 10 different images of 1000 rupee note were given to this software for recognition and all of them were recognized successfully (Table 3).

CONCLUSION

This thesis shows the method for currency recognition using image processing. The proposed system uses the different features of the currency for recognition. Our experiment shows that this is the low cost machine to recognize the Pakistani paper currency notes. We had checked different notes on this system and the result is 100% which means that the system is working efficiently (Fig. 12).

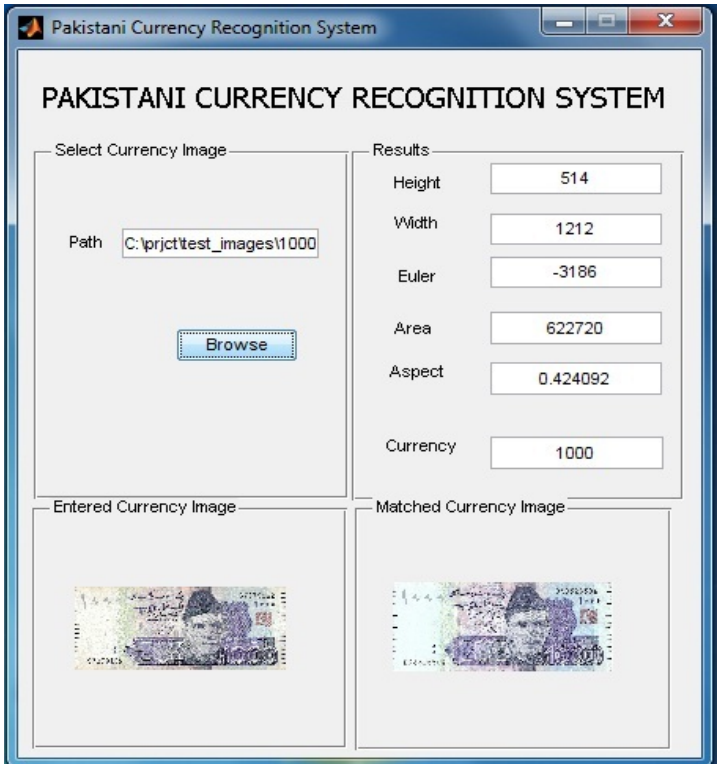

Fig.12: Recognition of 1000 rupee note

ACKNOWLEDGMENT

The future study will be done by applying different filters. In this thesis the images were scanned horizontally in the future the images will be scanned with different angles. Different currencies could be used for recognition like Indian Rupee, US dollar, EURO etc. Similarly different features can be used for recognition.

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