Correlation-based Recognition System for Myanmar Currency Denomination

Thi Thi Soe[*], Zarni Sann[**]

[*] Faculty of Computer Science, Computer University, Mandalay, Myanmar

[**] Faculty of Computer System and Technology, Computer University, Mandalay, Myanmar

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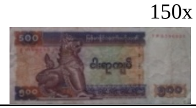
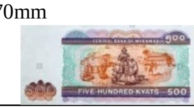
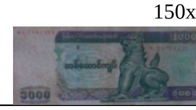
Abstract- One of the interesting and important fields of research in pattern recognition is paper currency recognition. Every person of various countries uses currencies in their daily activities. The concentrate of this paper is on automatics and reliable currency recognition. The recognition operations for Myanmar currency denominations comprise six stages: image capturing, preprocessing, target region extraction, number segmentation, currency value recognition, and output with screen displaying and voice. This paper also presents the simulation of currency counting machine to replace the manual counting process. Myanmar currency recognition system is implemented by computing the correlation coefficient to compare the similarity for each currency value template via image processing steps in Matlab environment. To demonstrate the effectiveness of the proposed system the numbers of currency images are experimented with two kinds (fresh, and medium) of each seven types of denominations. Our system achieves quite low classification error. And counting machine simulator not only accurately counts the number of each currency denomination but also displays the total amount of sum of currency contained in the money containers.

***Index Terms*-** Counting machine simulation, Currency recognition, Image processing, Template matching.

I. Introduction

Currency recognition generally defines as the classification of currency notes by denomination which means the value of currency note of various countries. Classification and counting of all currency notes by hand would be tedious, lengthy time and error prone. Therefore automatic and reliable currency recognition and counting are good options for transactions dealing with different types of task such as goods selling, public transport, gas- stations, banks etc. Until current time, there are many works developed for single-currency recognition (currency of a specific country) for example Indian currency [5-8], Chinese currency [3, 12, 13] and Bangladeshi currency [4, 11]. A number of works have also been devised on multi-currency recognition (currency of more than one country) such as [9, 10, 15]. Although the plenty of research works on currency recognition for different countries there is a little work done on paper currency recognition for Myanmar [14, 16]. For this reason the interest of this work is to design and develop a framework that can recognize seven types of Myanmar currency denominations that are currently circulation in daily life (50, 100, 200, 500, 1000, 5000, and 10000 Kyats). Table I shows seven types of Myanmar currency notes used in this work. In addition to this, the proposed solution will simulate as a money counting engine to feel free from the manual counting problems of boring, error facing, and time consuming. The organization of remaining sections is as follows: Section II is devoted to creation of template database used for correlation. The proposed approach for Myanmar currency recognition is discussed in section III. Experimental results are demonstrated in section IV. In Section V conclusion of the work is given.

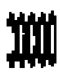
Table I: Myanmar currencies

No.	Denominations	Size	
		Obverse	Reverse
1.	K 50	145x 70mm 	
2.	K 100	145x 70mm 	
3.	K 200	150x 70mm 	
4.	K 500	150x 70mm 	
5.	K 1000	150x 70mm 	
6.	K 5000	150x 70mm 	
7.	K 10000	150x 70mm 	

II. TEMPLATES FOR CURRENCY VALUE

Before building the architecture of currency recognition system, we initially investigate the different currency denomination regions. Denomination regions for each of seven notes are shown in the first two columns of table II. These regions are specified to automatically extract the denomination information for all types of notes used in our system. The numerical value at the first position of each region is regarded as a template. Each template is shown in the third column.

Table II: Region of interest (ROI) and templates for each note

Top left region	Bottom right region	Template
50 K 	-	
100 K 	-	
200 K 	-	
500 K 	-	
-	1000 K 	
5000 K 	-	
-	10000 K 	

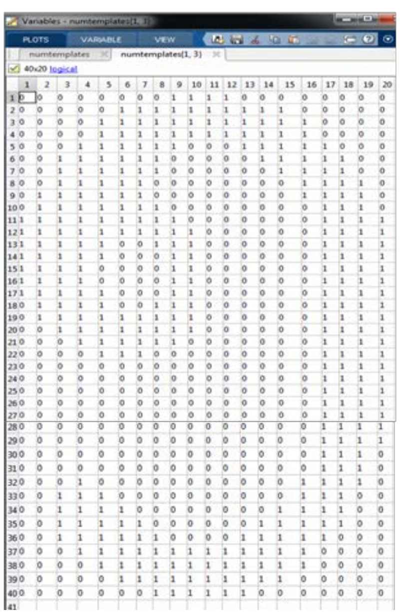


Figure 1: Template for numerical value ၅

All reference templates used in this system is bi-level format and size is 40x20 pixels. Binary images are transformed to a set of reference number array using mat2cell function. An array consists of 6 cells along a single row and each cell having 40 rows and 20 columns. Then this array is saved in the form of a template database and it is called by the currency recognition routine for correlation. Figure 1 is an example template for numerical value ၅. After collecting the necessary information from currency notes we designed the proposed system.

III. SYSTEM ARCHITECTURE

The organization of the proposed system is depicted in figure 2. The system is divided into two phases: recognition and simulating counting machine for Myanmar currency denominations. There are six main stages in the recognition phase. They are image capturing, preprocessing, target region extraction, number segmentation, currency value recognition, and output. In the second phase, the system will simulate as a counting machine for producing the total amount of currency.

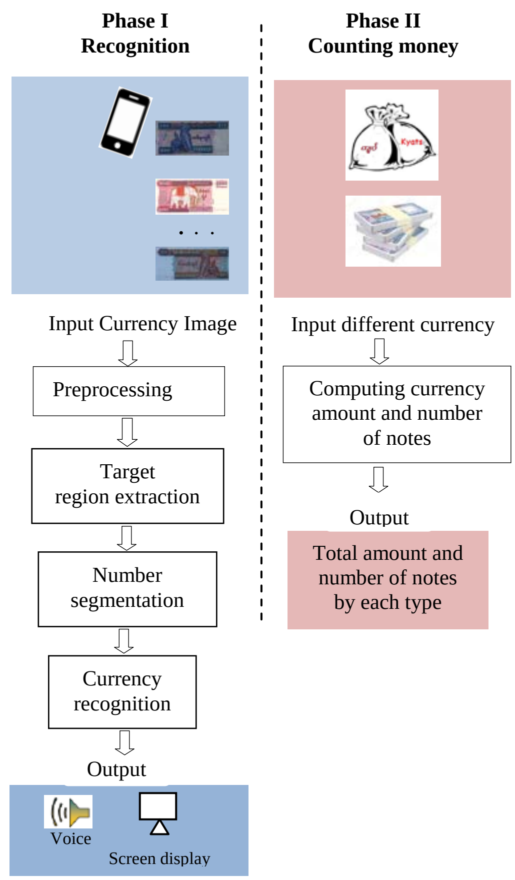


Figure.2: The architecture of proposed system

A. Image Capturing

The proposed recognition system classifies seven types of Myanmar currency denominations from obverse currency images. Therefore currency images are collected for the system.

Each of the different types of paper currency is superimposed onto a paper and taken by HUAWEI G520-0000 camera model with auto brightness level under low illumination condition. Because of the unnecessary (white) region in the captured image it is necessary to crop the desired currency image region with paint tool as shown below and saved as JPEG (Joint Photographic Experts Group) format. The captured images are fed as input to our recognition system.

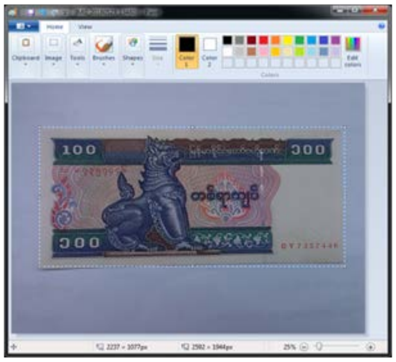


Figure 3: Cropping currency region

B. Preprocessing

Preprocessing serves as the front end for recognition system, which transforms the coarse image data into a suitable format. In the preprocessing of the images, the following process steps are needed: gray scale converting, image binarization, noise filtering, morphological operation, and black area extraction for all types of currency images.

Gray scale converting

Typically images from the camera or scanner are in the form of 24-bit true color images. Therefore, an image is first converted to grayscale and resized the image to 799x372 pixels that will be more easily and effectively processed for successive steps.

Binarization

The grayscale image is further processed into a binary image that will reduce storage space and fast process speed. For this process, Otsu's method [2] is used. Otsu's method finds the threshold level of image and then the calculated threshold that minimizes the variance within the classes, i.e. black and white. Each black pixel is assigned value to 0 and each white pixel is assigned value to 1. Original and converted binary image for denomination 50 K is shown in figure 4 (a-b).

Noise filtering

Various noises can appear in digital images during capturing and transmission due to environmental condition and the quality of sensors. Noise may affect segmentation and pattern matching. Hence we want to eliminate salt and pepper noise and we work with non-linear filter known as median filter. They are also called order-statistics filter, because their response is based on the ordering or ranking of the pixels contained within the mask. It preserves edges while removing unwanted noise [1]. In our system 5x5 size of mask is used. Filtering operation produces the output as given in figure 4 (c).

Morphological operation

In order to clean the region of denomination, we choose two morphological operations clean and majority provided by image processing toolbox. Clean operation removes isolated pixels (individual 1s that are surrounded by 0s), and majority operation sets a pixel to 1 if five or more pixels in its 3x3 neighborhood are 1s; otherwise, it sets the pixel to 0. Both operations are applied repeatedly until the image no longer changes. Figure 4 (d) shows the resultant currency image after applying the two morphological operations. Enhanced denomination region is depicted by zooming.

Black region extraction

After getting the enhanced image, the next preprocessing step includes clipping some useless segments. There are white areas at the border of the enhanced image, which are not relevant to the identification of denomination. This is the reason for clipping. Doing so requires clipping left and right border of the images by 10 pixels and top and bottom border of the images by 2 pixels. Black regions of entire image are extracted with the find function of image processing techniques. Figure 4 (e) shows the extracted black area image.

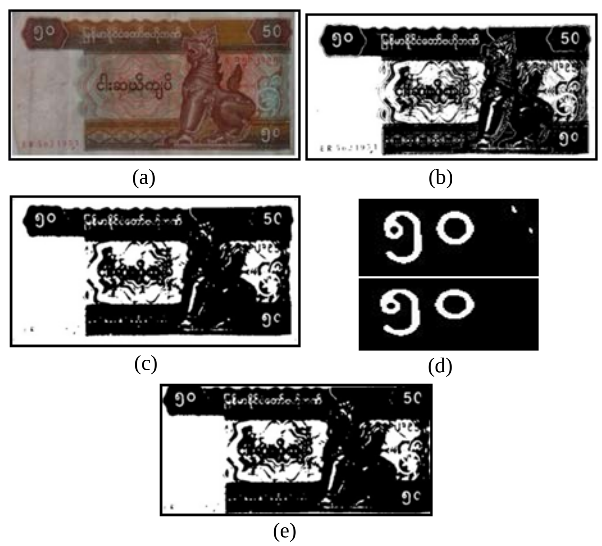


Figure 4: (a) Original image, (b-e) Preprocessing results of (a)

C. Target Region Extraction

The denomination information for Myanmar currency is usually located at the top left corner of all notes except 1000 K as described in table 1. In order to classify the value of currency, we use only these denomination regions instead of using the characteristics of the whole image. Top left region and bottom right region are identified for 50, 100, 200, 500, 5000 Kyats and for 1000, 10000 Kyats respectively. To obtain these target regions, coordinates y and x values are specified on the resultant image of preprocessing steps. For 50, 100, 200, 500, and 5000 Kyats, start and end values of y and x are (16:65, 24:145). This gives a 122 x 50 pixels size of target region. Coordinate values for 1000 kyats are (266:310,630:746) and size is 117 x 45 pixels. Coordinate values for 10000 Kyats are (278:342,632:774) and size is 143x 65 pixels. Sample extracted top left region for 50 Kyats is shown in figure 5 (a).

D. Numerical Segmentation

In order to differentiate each numerical value present in the ROI, we have used the connected component labeling algorithm [1]. The individual numbers are cropped into different sub images. Sub images are treated to be of certain fixed size 40x20 pixels as template size for pattern matching. The numbers of connected components are recorded that are useful for currency classification routine. For 50 K, sub image of initial value is shown in figure 5 (b) and number of connected components is 2.

(a) (b)

Figure 5: For 50 K (a) Top left region, (b) sub image at first position

E. Currency Recognition

Sub image in Figure 5 (b) is compared with six template cells. For this matching process corr2 function is used as below:

sim=corr2(numtemplates{1,n},imagn)

corr2 computes the correlation coefficient between two 2-D arrays P and Q using the following equation:

$$c = \frac{\sum_m \sum_n (P_{mn} - \bar{P})(Q_{mn} - \bar{Q})}{\sqrt{(\sum_m \sum_n (P_{mn} - \bar{P})^2)(\sum_m \sum_n (Q_{mn} - \bar{Q})^2)}} \qquad (1)$$

where, $\bar{P}$ and $\bar{Q}$ are mean of P and Q respectively

After computing the correlation coefficients, the operation detects the maximum value of it by find function. In this way, recognition routine produce the recognized denomination result using the following segment of code for input currency image, where Ne means the number of connected components. Table III shows the similarity values (maximum similarity highlight in red) and recognized currency value, 50 Kyats.

```
.........
elseif id==3 && Ne==2
   Evalue='50';
   Eword='Fifty';
   Mvalue='ig;q,f';    %%     Myanmar winInnwa font
```

Table III: correlation coefficient values and recognition result

Sub image	Templates						Recognized value
	1	2	3	4	5	6	
							
	-0.1057	0.1238	0.8293	0.3912	0.4751	0.0515	50 Kyats

IV. EXPERIMENTAL RESULTS

In order to check the validity of the proposed currency recognition system, 52 images for 50 K, 64 images for 100 K, 26 images for 200 K, 32 images for 500 K, 33 images for 1000 K, 37 images for 500 K and 11 images for 10000 K are used as testing input. Figure 6 shows the interface of the currency recognition system and recognized denomination along with step by step processing results for input image 1000 K. For this testing input image, the number of component is 3 and largest similarity value is 0.701.

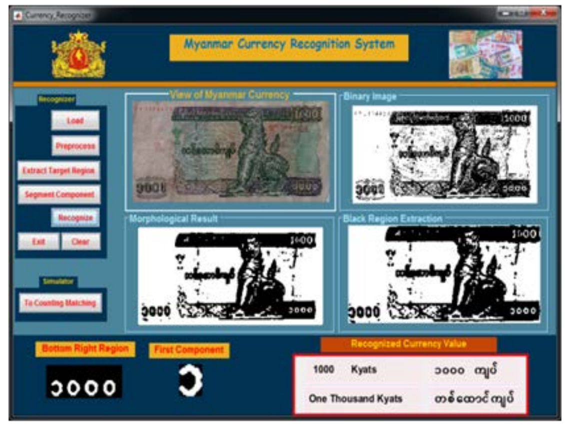


Figure 6: System interface with recognized value 1000 K

The next testing sample image is currency 5000 K in which ROI is successfully extracted as in figure 7. Although the largest similarity value 0.5422 is correctly matched for the first component, the number of connected components, Ne, is 3 instead of 4 due to blurring the input image. Image blurring is caused by instability of the camera at the time of image capturing. In this testing the system produced the incorrect result 500 K for input currency value 5000 K.

Figure 7: Incorrect recognized value 500 K for input 5000 K

When the user has not been properly cropped the currency image area the system cannot be extracted the precise denomination region. Also the system cannot be completely worked if the border of currency note is physically damaged by stains, scratches, writing, etc as in figure 8. These facts lead to decrease the performance of the currency recognition system.

Figure 8: Damage image

Computed similarity values for some of recognized currency notes are presented in table IV.

Table IV: Similarity value (maximum value in red)

Recognized value	Similarity value					
	1	2	3	4	5	6
50 K	-0.0591	0.0667	0.8770	0.3581	0.4366	0.0534
	-0.1090	0.0465	0.7596	0.3601	0.4329	0.0259
100 K	0.9198	-0.2746	-0.1018	0.0680	-0.1965	0.0314
200 K	-0.3070	0.8553	0.1477	0.0128	0.5693	0.0057
500 K	-0.0020	-0.0460	0.3122	0.7675	0.2031	0.1468
1000 K	-0.0340	0.3571	0.4120	0.3235	0.7380	-0.0789
	-0.0376	0.4001	0.3054	0.2236	0.7010	-0.1790
5000 K	0.1222	-0.0731	0.3617	0.6695	0.2182	-0.0092
10000 K	-0.1006	-0.0969	0.0017	0.0141	-0.0993	0.4246
	-0.0376	-0.1565	-0.0440	0.0309	-0.1562	0.3416

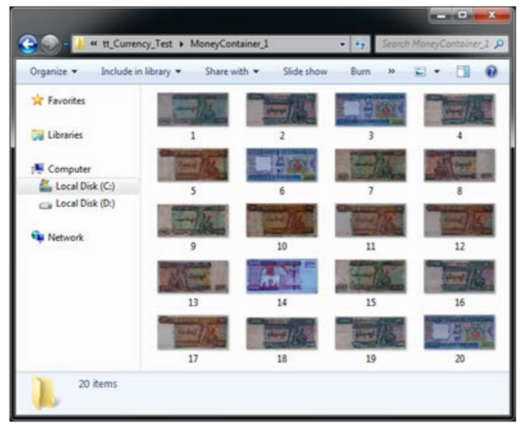
Evaluation rate of the recognition system is calculated using the Equation 2. The recognition accuracies are described in Table V.

$$\text{recognition accuracy} = \frac{\textit{number of correctly classified denomination}}{\textit{total number of testing images}} \times 100 \qquad (2)$$

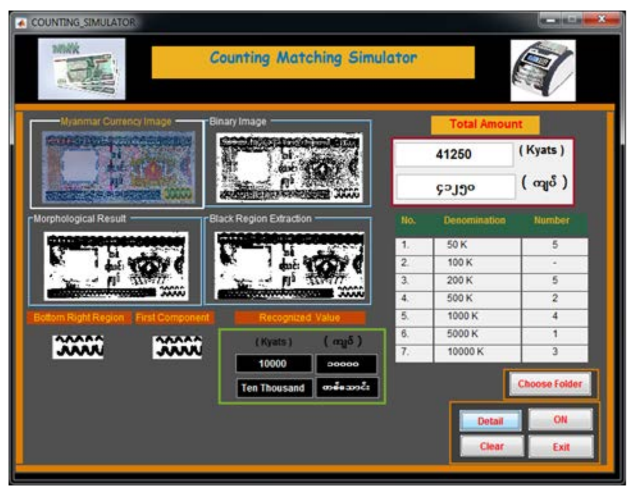
Table V: Accuracy rate of Myanmar currency recognition

Denominations (Kyat)		Number of samples	Number of correct classification	Accuracy rate
50	medium	4	4	100%
	fresh	48	48	
100	medium	6	6	100%
	fresh	58	58	
200	medium	2	2	100%
	fresh	24	24	
500	medium	19	17	94%
	fresh	15	15	
1000	medium	19	18	96%
	fresh	14	14	
5000	fresh	37	35	94%
10000	fresh	11	10	90%
Total		257	251	97%

According to the experimental results the proposed system can be able to use the real life transactional areas: bank, gas-station, and shops, etc. In these areas user computes manually the total sale amount at the end of the daily transaction. Presence counting machine can be able to count only on homogeneous currency type. For counting the different notes need to rearrange them. To compensate for this difficulty we simulate the counting machine at the second phase of this work. The proposed counting simulator not only computes the total sum of different notes but also automatically inform the number of each type of notes to user. Figure 9 (a) describes 20 different currency notes present in MoneyContainer_1. Figure 9 (b) shows UI window of counting machine simulator. Total amount of sum is 41250 Kyats and the number of each type of notes is automatically extracted as shown in this window.



(a)



(b)

Figure 9: (a) 20 different notes in money box (b) Result of total amount and number of notes by each type

V. CONCLUSION

In this paper, an automatic tool is developed for Myanmar currency recognition on front view of seven types of currency images. The design could be simply deployed a correlation based method to reduce human power required for currency classification routine with very less amount of time. This work also successfully created a currency counting machine simulator to replace the manual counting process. The simulator could be able to count the number of currency notes and compute the total sum of notes in money containers. According to the experimental results the proposed system ready to use as a real time application in several market areas. The reliable of currency recognition system depends not only on precise extraction of denomination region but also on connected component labeling results. Sometime the system could not be able to extract the target regions if we have carelessly cropped the currency image region with paint tool before feeding to the system. In some cases the number of connected component is not correct. This is due to the instability of hand, various distance, and environmental condition at the time of image acquisition with camera. The better recognition performance can be achieved by carefully cropping the entire currency image region and by using scanner instead of camera. Any orientations of input images are not acceptable by our system. This will be further step of the coming time.

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AUTHORS

First Author – Thi Thi Soe, Ph.D(IT), Faculty of Computer Science, University of Computer Studies (Mandalay), Mandalay, Myanmar.
E-mail: hlaing.nn@gmail.com

Second Author – Zarni Sann, Ph.D(IT), Faculty of Computer System and Technology, University of Computer Studies (Mandalay), Mandalay, Myanmar.
E-mail: zarnisann@gmail.com

Correspondence Author – Thi Thi Soe, Professor in Faculty of Computer Science, University of Computer Studies (Mandalay), Mandalay, Myanmar.

E-mail: hlaing.nn@gmail.com.
Tele: + 95-9798958083, 256170332.