SRI LANKAN CURRENCY NOTE RECOGNIZER FOR VISUALLY IMPAIRED PEOPLE

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INTRODUCTION

In Sri Lanka, visual impairments affect a considerable percentage of the population in various ways. Current estimates suggest that there are approximately 150,000 blind or partially visually impaired individuals in Sri Lanka. Visual impairments significantly impact the quality of life of these people and limit many day-to-day activities, especially handling cash money during financial transactions. Currently, the visually impaired community is using various traditional techniques, which are not very effective, to identify different denominations of currencies. Moreover, visually impaired people in Sri Lanka face a major challenge due to the introduction of new bank note series, because available features for blind people to identify denomination are not very effective. Currency notes are often printed on different sized paper or with different tactile qualities to enable people with visual disabilities to touch and recognize. However, at present, in Sri Lanka, these user-friendly features for the visually impaired are limited. There is only one feature available for visually impaired people to identify the denomination of various banknotes which is a series of embossed dots, which can be sensed by touch. (Figure 1) But these dots become worn out with usage. Also consecutive denominations only differ by 5 mm from each other and the difference is limited to length. This 5 mm length difference is not sufficient for the visually impaired to identify various denominations of new currency notes.

Figure 1. Blind recognition dots (Source: http://www.cbsl.gov.lk)

To address this issue, several steps have been taken to develop low cost, portable, hand held bank note recognizers. However, none of these handheld systems cater to Sri Lankan currency identification and most of the systems are specially developed for the United States and Canada. These systems are based on charge coupled device / contact image sensor (CCD/CIS) technology. The most popular device in U.S, the iBill Talking Banknote Identifier (Orbit Research, 2013) is a compact device that announces a note's value by voice, pattern of tones or patterns of vibrations. Users insert a bill into the device and press the button on the device's side to have the denomination identified. The currency reader does not identify foreign or counterfeit banknotes. Another system, Tel-money is using the same technology as used in the iBill. Tel-Money is a voice output based paper money identifier designed for individuals who are blind or having low vision. It reads U.S. currency in denominations from 1 to 100 dollars. The user slides the currency into the money identifier, and then presses a button, and the unit reads the bill's denomination. The Canadian Bank Note Reader (CNIB, 1996) has a voice output and recognizes all Canadian bank notes currently in circulation and those expected to begin circulation over the next few years. However, these foreign devices are unique to their countries.

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In Sri Lanka, one currency note recognition device has been designed and implemented as a final year undergraduate project and this system employs a light dependent resister array located at various points over the bank note's area (Wickramasinghe, 2013). There are pre-determined reference intensity levels defined to detect each color in the banknotes. The length of the note is also measured using IR sensors which are located in a line. In this system, the drawbacks are that the system is very large and not portable as well as it takes considerable time to perform the classification. Another proposed system for currency note detection in Sri Lanka (Gunaratne, 2008) operates on image processing technology which too does not satisfy the applicability criteria because of its non-portability. Therefore, in this paper we propose an efficient, portable and a cost effective bank note recognizer for Sri Lanka.

METHODOLOGY AND DESIGN

The proposed system in Figure 2 consists of two main sub units namely the detection unit and the processing unit. The detection unit detects the color (in R, G, B) of two edges simultaneously using two color sensors and the obtained data are classified using the k-Nearest Neighbor classification (Duda, 1973). The detection points are the edges of both sides (Figure 3) and allow the generated reference data sets to be named as domains. There are 8 domains for each bank note denomination and 48 (48 R, G, B data sets) domains for all 6 denominations (20, 50, 100, 500, 1000 and 5000 rupee). These are to be summarized and included in the program memory as the training set. Moreover, the system consists of a detection system with an array of photo diodes or photo transistors to detect intensities in relation to each bank note denomination and this increases the accuracy of the detection.

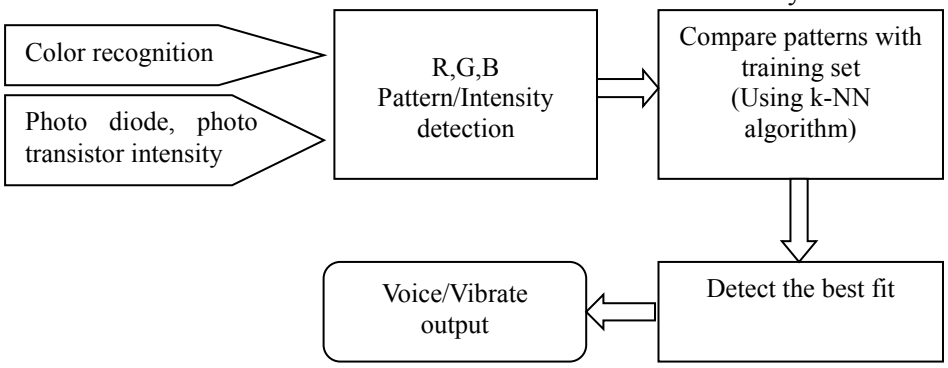

Figure 2. Block diagram of the proposed system

To develop the training data set, 20 banknotes were selected as the sample size under each denomination and the centroids of the R,G,B valued domains were calculated. However, the sample size of the 5000 rupee banknotes was not very effective because most of 5000 rupee denominations are not different in condition and are "new". According to the nearest neighbor method the Euclidean distance (Kreyszig, 1973) between the sensed parameters of the note to be recognized and the centroids of each domain was calculated and compared. The note was then classified under the domain corresponding to the least Euclidian distance.

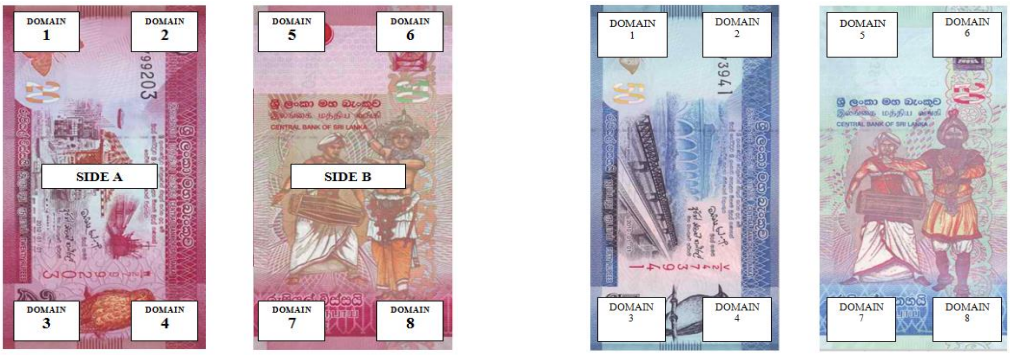

Figure 3. Detection points of bank notes (for 20 & 50 rupee)

Figure 4 shows the developed system's physical implementation and Figure 5 lists the operational flow of the system.

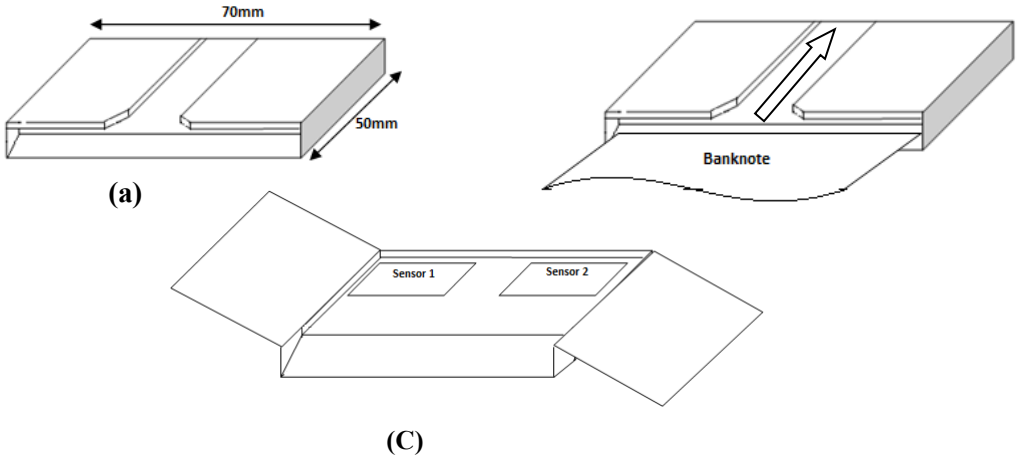

Figure 4. (a) Physical view **(b)** System for inserting banknote **(c)** Sensor locations

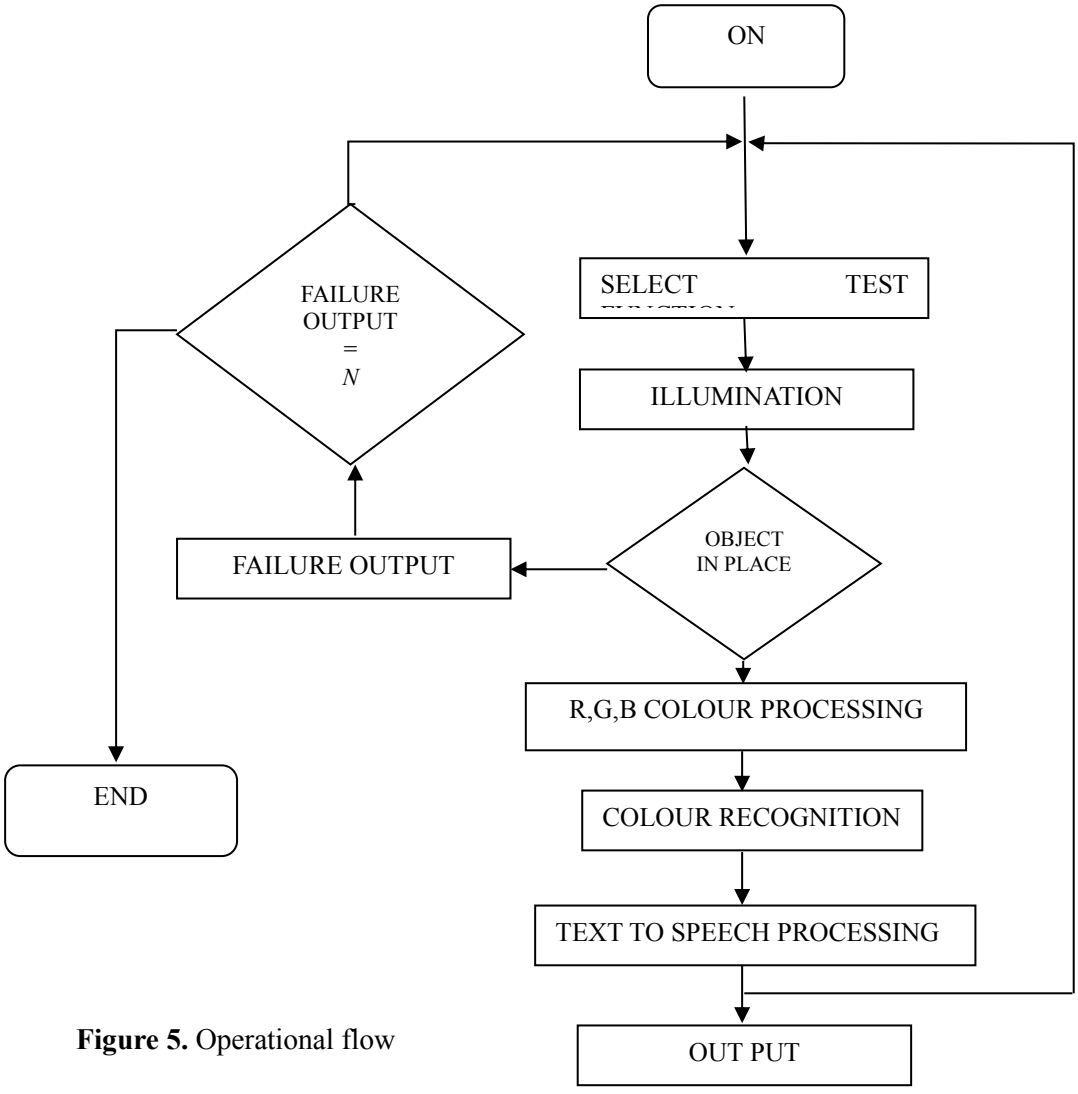

Figure 5. Operational flow

TEST RESULTS AND DISCUSSION

Table 1. Accuracy of identification

		Estimated Category					
	Accuracy	**20**	**50**	**100**	**500**	**1000**	**5000**
True Category	**20**	**90%**		**10%**			
	50		**100 %**				
	100	**10%**		**90%**			
	500	**50%**			**50%**		
	1000					**100%**	
	5000						**100%**

According to the test results for 52 bank notes, shown in Table 1, it is clear that the system is capable of maintaining high accuracies for most of the bank note recognitions. The system currently has an overall accuracy of 87.27%. This is comparatively less compared to the very high accuracies in non-portable systems in (Wickramasinghe, 2013) and (Gunaratne, 2008) where accuracies up to 98% can be attained. However, given the portability-accuracy trade-off, the proposed system is superior to others. It was also clearly observed that the system is less effective in classifying the Rs.500 note which was erroneously classified as Rs.20.

CONCLUSIONS AND FUTURE WORK

This proposed system will be of immense benefit to nearly 150,000 visually impaired people in Sri Lanka to identify the new bank note series. It will also help visually impaired people identify banknotes easily in less time. The proposed system has the added advantage of being lightweight and portable.

However, this system is not capable of identifying old series bank notes as well as counterfeit bank notes which is a possible future research direction. Furthermore, adding a fourth dimension to the input set to separate the Rs.500 note would be a potential future investigation area Also by increasing the sample size for the training set, more accurate domain centroids can be achieved which will result in more accurate classifications.

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