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Sri Lankan Currency Recognition Device for Visual Impaired People

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Abstract: The identification of several currency denominations is not an easy task for people with visual impairments. In this document I present a Currency Recognition Device that can be used to help blind and visually impaired people to recognize the new range of Sri Lankan bills and verify whether if it is fake or not. The proposed system is based on simple image processing utilities and machine learning algorithms. The basic techniques used in this proposed system include image pre-processing, feature extraction and finally, the matching templates between the captured image and data set. The system easily identifies various currency conditions including occlusion, rotation, scaling, cluttered background, illumination change, and worn or wrinkled bills and counterfeit bills. The proposed system applies to Sri Lankan paper currencies, including six types of paper money. Therefore, in this supposed system I propose an efficient, portable and profitable banknote recognizer for Sri Lanka.

Keywords: Visual impairment, currency, recognition, Fake Detection

Introduction

Visual impairments overwhelm a significant percentage of the population in several ways in Sri Lanka. According to current estimates, there are about 150,000 blind or visually impaired people in Sri Lanka. (Murthy et al., 2018). Being impairments of visually considerably affect the quality of life of those people and restrict many daily activities, especially the use of money in financial transactions. It is very easy for them to be deceived by others. Today, these community uses several traditional methods to identify different currencies, which are not very effective, to identify different currency denominations. The monetary notes of Sri Lanka vary according to the images on two faces compared to the monetary notes in other countries. These images are quite complex and reflect the ancient heritage and culture of Sri Lanka. In addition, the introduction of a new series of banknotes poses a major challenge to the visually impaired in Sri Lanka, due to the functions available to identify the denomination are not effective for them. Visually impaired people have only one feature to recognize the value of different banknotes, which is a series of embossed dots that can be felt by touch.("Sri Lankan rupee," 2019) But these dots get worn out with use. In addition, consecutive denominations only differ by 5 mm from each other and the difference is limited to the length. This difference of 5 mm in length is not enough for people with visual impairment to identify several denominations of new bills.("Money and Costs in Sri Lanka - Lonely Planet," n.d.)

Despite intensive research in this field, many issues related to the currency recognition system remain unanswered even in Sri Lanka.

Literature Review

Currency recognition for blind people is one of the most popular research problems that have developed in several ways. Many techniques have been used to implement the identification of several denominations worldwide. Such as, a scanning device that uses sensor and segregation devices, identification using signal processing methods and applications based on image processing techniques.

A. Sensor Based Device

U.S.S.Perera and D.N.balasuriya proposed a bank note recognizer for visual impaired people in Sri Lanka.(Perera and Balasuriya, n.d.) The detection unit and the processing unit are main units in this device. The detection unit detects the color of two edges (from R, G, B) using two color sensors. As well as to increases the detection accuracy, system is equipped with a detection system with array of photo diodes or a group of photo transistors to detect intensities relative to each denomination. Then obtained data are classified with training data set using the k-Nearest Neighbor classification. As the training set, each banknote has 8 domains. So, all 6 denominations (20, 50, 100, 500, 1000 and 5000 rupee) has 48 domains. The Euclidean distance between the sensed parameters of the bill to be identified, according to the nearest neighbor method and compared with training data set. Then note detect. Finally, the output sends to the person as voice or vibrate. The system has an overall accuracy of 87.27%. But the drawback of this system is less effective in classifying the Rs.500 note which was erroneously classified as Rs.20. Unfortunately, the system cannot identify old series of bank notes and counterfeit bank notes.

B. Identification using Image processing technique

SLCRec is a desktop application for Sri Lankan currency notes that proposed by Gunaratna and others.(Gunaratna et al., n.d.) The proposed framework consists of two phases namely image processing phases and neural network phases. To start with, the scanned currency notes are converted into gray scale from file format to pixel values. By having a linear combination of the previous values, a new set of values is generated from the original gray scale pixel values. Transformation function is used for this transformation. After that, performs edge detection to extract the identity of the image. Therefore, a special linear transformation function is used to remove noise on gray scale images, retrieve only the relevant characteristic patterns, re visualize prominent shapes in distorted image conditions, and obtain a fair representation of edges. Feature extraction is done by dividing an edge detected image into 20 rows in a height direction. This detected information is then extracted and processed into a model for the neural network. There are four classes coming out in the classification stage which are Rs.100, Rs.500, Rs.1000 and Rs.2000 notes. A three-layer back propagation neural network is presented with the number of edges detected in sequence of notes and the classification is accepted into four classes. Network is given expected outcome when notes with similar or slight differences are presented for classification. The system showed similar returns for reverse sides. It doesn't give superb edge detection for the 100-rupee notes at several times. Despite the fact that the system is not to identify forged notes. Network generalization doesn't work as well as one sided trained network. In addition, this system cannot identify new series of banknotes.

Hasanuzzaman and others have proposed a component-based framework for the recognition of US Bills using speeded up robust features (SURF).(Hasanuzzaman et al., 2012) This system is designed as a portable device for blind users by employing a portable camera or a camera on a phone, and images are captured in open environments with a large selection conditions including partial occlusion, highly cluttered background, rotation, change of scale, illumination change, and wrinkling. The data set includes positive and negative images (background images without banknote). First, SURF extracts the monetary characteristics of each query image. These characteristics are combined with the precalculated SURF characteristics of the reference regions of the basic truth image in each category of banknotes. A total of 14 images of seven categories of bills ($ 1, $ 2, $ 5, $ 10, $ 20, $ 50 and $ 100) with the front and back are taken as ground truth images. The number of matching features is compared with the automatic thresholds of each reference region to determine the category of bills. Then, the system issues the recognition result. If there is a currency in the camera view it use guide the blind user to correctly aim at the target, called spatial clustering. The supposed algorithm gains 100% true recognition accuracy for all seven categories and 0% false recognition rate. When the resolution of a query image is very low, the system cannot detect considerable points in the invoice. In addition, the proposed method cannot recognize the images of bills taken with severe blurred movements and bills with only one or none of the visible components.

A mobile application has used the image processing technique to recognize Egyptian banknotes for people with visual impairments. Noura A. Semary and others proposed this system. There are several techniques in this prosecco.(Semary et al., 2015) First, image acquisition. In this phase, the digital camera captures the image as an RGB image and converts to the grayscale version. Then, eliminate the noise in the image and quality is improve using the Gaussian blurring in the Pre-processing. To extract the paper money from the background, the image is being converted to the binary version. This is done by image segmentation phase. Then, the histogram equation is used to change the contrast based on the image's histogram, change the brightness of the image and making the image more visible. In the ROI extraction phase, paper money is resized to the height of the data set. Finally, template matching based on the cross correlation between the captured image and the data set (values 1, 5, 10, 20, 50, 100 and 200 have been scanned on both sides). The application begins to read the database of saved currency notes and then begins to capture the fronted scene. Once both horizontal edges are detected, there is a vibrate effect to inform the user about the correct identification of money. After a while, a sound pronounces that the correct value in Arabic is hear. Experimental results show that the proposed method can recognize Egyptian paper money with high quality reaches 89%.

Rémi Parlouar has developed an assistive device to identify currency notes for blind people.(Parlouar et al., n.d.) The device is used webcam to capture image and use Spikent software to analysis the image. They use object models of a single image sample per invoice to recognize the € 5, € 10, € 20 and € 50 euro bills. In order to be preserve the selectivity in classification, they have selected each sample in a particular region of each currency, which contained characteristic projections that differ sufficiently from one currency to the other. To cover all orientations each sample was rotated by 12 ° steps. Finally, this results in 120 training samples for the four invoices. In the training model, the device was able to detect a range of three to ten centimeters on each bill (near the plastic strip) at a rate of five images per second, regardless of the orientation of the bill. As a classification of false positives had not been observed in the context of this experiment, at the 100% accuracy since all invoices were correctly identified. The drawback of the system is that the device takes longer to find the plastic strip and fold the bill than the device actually use.

Suriya Singh and others adopt a computer-based approach to mobile devices and develop an application that can be run on low-end smartphones to recognize the currency of people with visual impairments.(Singh et al., 2014) They consider the bills of Indian National Rupee. Application recognizes the notes in two major steps. First, image segmentation is to reduce irrelevant characteristics that would affect to make decisions. Second, to classify the currency in the image, use an illustration pipeline. After segmentation, it detects SIFT key points within the foreground area of the image. Then, the application performs a tf-idf-based score of all the images in the data set using the inverted index and finds the ten best matches in the database. These images are spatially verified and reclassified. Then the audio message corresponding to the final result is played. If the result is wrong, the application again asks the user to capture another image. With this approach, applications have been able to report a recognition of 96.7% accuracy in the data set of the Indian rupee. The system gets incorrect answers, if the user's fingers cover part of the surface area, illuminating and fading the image and if the image is blurred or the currency is out of focus. There are two segmentation failures, one in which the background is not completely removed and the other is incorrectly marked as the bill background.

C. Google APIs

Seeing AI is a free application designed for the blind and low vision community.("Seeing AI | Talking camera app for those with a visual impairment," n.d.) This ongoing research project harnesses the power of AI to open the visual world and describe people, texts and nearby objects. The application requires iOS 11. The application allows you to recognize short texts, documents, products, people, currency, color, handwriting, light, images in other applications, photo browsing experience. Seeing AI is designed to help you achieve more by harnessing the power of the cloud and artificial intelligence. It is available in 70 countries, including Sri Lanka, as well as in supported languages, including English. This application is compatible with iPhone 5C, 5S and later and the best performance with iPhone 6S, SE and later models. The inconvenience of this application is only available in the App Store for iOS devices. Because most people in Sri Lanka do not use iOS devices.

LookTel Money Reader instantly recognizes the currency and gives voice output of the denomination, allowing people with visual impairment or blindness to identify and count bills quickly and easily.("LookTel Money Reader for iPhone, iPod Touch and Mac," n.d.) Point the camera of the iOS device to an invoice and the application will indicate the denomination in real time. The application is now available for iOS devices with iOS 4.0 and later versions and twenty-one bills are supported. LookTel Money Reader offers voice support for several languages, including English. LookTel Money Reader makes identifying invoices as easy as possible. It is not necessary to keep the iOS device still or capture a photo, since recognition occurs instantly, in real time. The application doesn't require an Internet connection, which means it will read money anywhere, anytime. The drawback of this application is that it is only for Apple devices. As well as it is not support for the Sri Lankan currency.

NantMobile Money Reader recognizes the currency and speaks the denomination, which allows people with visual impairment or blindness to identify and count bills quickly and easily.(Author, n.d.) The application will indicate the denomination of bank note in real time by pointing the camera of iOS device. Twenty-one coins are supported. The application does not require an Internet connection, which means you will read money anywhere, anytime. It can be used to sort money quickly and easily with independence and confidence. NantMobile Money Reader offers voice support for several languages, including English. Disclaimer is this application should not be used to detect fake currency nor should it be relied upon solely for the identification of money. The application must be used with discretion, to guarantee privacy, as it announces denominations and displays denominations in large print. The light on most iOS devices can illuminate enough money to be visible to some extent.

Cash Reader identifies the denomination of the bills for the largest amount of coins.("Cash Reader," n.d.) Point your camera at the money in hand and listen, see or feel its value. All bills supported by Cash Reader for some countries. The application is located in some languages. Open the application and place the currency in front of the camera. The denomination of the currency is read aloud instantly through the speaker of your device. At the same time, large contrast characters will appear on the screen. In silent mode, the denomination will be transformed into vibrations. This feature helps identify and count bills quickly even in noisy environments or when privacy is needed. Without the Internet, people can still use Cash Reader. After downloading the currency database, they do not need an Internet connection to read paper invoices, so user can now use the application anytime, anywhere. But this app is not available for Sri Lanka.

D. Identification using signal processing technique

The money detector is a device developed for the visually impaired people to identify the new range of bills in Sri Lanka.(Wickramasinghe and De Silva, 2013) The device use two unique manners to identifies the bank notes. The first way is using a Light Dependent Resistor (LDR) sensors and Light Emitting Diode (LED) to detect the bank note. They are programmed to detect the color patterns of monetary bills. In this detection technique, it receives five analog input values. At that point five digital values are match with the predetermined color intensity ranges according to different banknotes and specified LDR. If the color detection system values are in the right range, the device estimates the length of the bills. In this method, The IR sensors connect to pins of the microcontroller directly. It provides a digital signal to the note placed in the device. Both values are verified with pre-determined data set. Then reproducing the identification message. This message runs through the inbuilt speaker system or via an optional headset. If the note is erroneously placed or blank paper is inserted, a blunder message will be played to the user. The length detection phase gave 100% accuracy. The only drawback was if monetary note be placed incorrectly it will play the error message. According to the following results observed, the final product gave 96.67% accuracy rate.

Barani.S has proposed a currency identification device for of Indian denominations (CiID) to help people with visual impairments using IR sensors.(Barani, 2015) This device observe the voltage level variation in the several currencies and detection has been implemented. A photosensor is paired with each infrared emitter, and six emitter-sensor pairs are integrated into the device. These pairs of devices are placed opposite each other with the same position on both sides of money that inserted. The complete module consists of three units. Processing unit, output unit and sensor unit. The purpose of the sensing unit is to capture input invoice information from an array of infrared LEDs. This information transmits to a processing module by corresponding phototransistors.

In the processing unit, the processor converts the sensor voltages into digital data. This digital data is compared to the data stored known bills currency. The processor determines the value of the currency, based on their similarities and differences. The database was created by maintaining the rupee in different orientations. The voice module will use output signals. The device is also tested with similar color fake bills. Therefore, according to the scan result, the accuracy is estimated at 86%. Since the light sensitive sensors used, the design of the device must such that the intensity of the light doesn't affect the device performance.

According to the review of existing systems, money recognition systems can be classified into two main areas, as follows: a scanner-based device, that using sensors and segregation devices. And applications, based on image processing and signal processing techniques. I discovered that image processing techniques and currency classification based on machine learning is one of the most used methods in camera-based devices. But the main problem with the camera-based device is that it cannot recognize the images of bills taken with severe blurred movements and bills with only one or none of the visible components. According to my study, The RGB color-based classification had also been used in a sensor-based device to classify monetary notes based on the fact that in each note, only one of these color components is exceptionally prominent. According to the review, the main problem with the scanner-based device is that blind people cannot place the currency correctly in the device. Otherwise, the system gives an incorrect output. However, some other technique is signal processing. In this model, the variation in the voltage level of several currencies is observed and detected to implement this device. Although there are several Google API's available in app stores. But all these applications can only run the iOS platform. As well as most of these systems can be identified with a particular currency that is unique for their country. In addition, systems cannot identify counterfeit bills.

According to the review of existing systems, most portable devices are camera-based devices with image processing techniques and machine learning algorithms. Just as profitability and portability are also high in those devices than in others.

Methodology

In order to design an effective banknote recognizer our first goal was to create a software phase to currency recognition. The proposed system consists of two phases. Image processing phase and machine learning phase.

Image Processing Phase

The system work on the image of currency note acquired by a digital camera under ultraviolet light. The image processing techniques that is applied here is as follows.

Acquisition of live image of monetary note by simple digital camera under ultraviolet light. The input image is pre-processed to remove noise and enhance the quality. Then characteristics features will be cropped and segmented of the paper currency. After segmentation, characteristics are extracted of the note. Then the output image is matching with training data set.

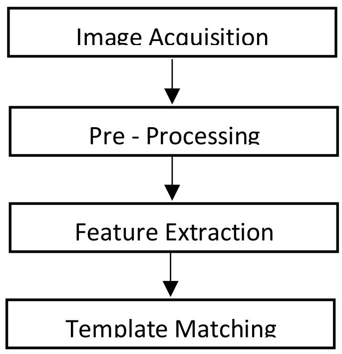

Figure 40. Image Processing Phase

Machine Learning Phase

The system matching the live image with training data set to identify denomination of currency. System trained using Convolutional Neural Network. There are six classes coming out in the classification stage and they are Rs.20, Rs.50, Rs.100, Rs.500, Rs.1000, Rs.5000. The neural network is trained with 6 kind of different currency notes acquired under UV light on different angles and different conditions. After training the data, validate it on the validation data. Once we are satisfied with the model's performance on the validation set, we can use it for making predictions on the test data. The machine learning techniques which is applied here is as follows.

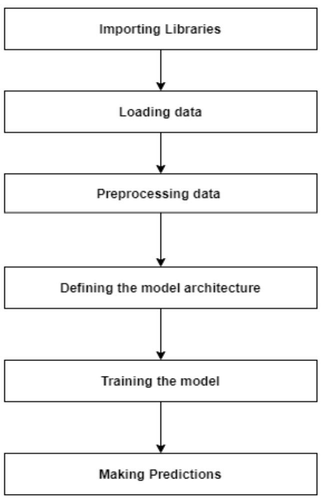

Figure 41. Machine Learning Phase

Conclusion And Future Works

Segregation and money counting are not painless work for the community without vision. Several countries have different bill identifications for people with visual impairments. Most countries don't have an adequate equipment to meets this purpose. The visually impaired people have its own identification technique, that solves their challenge in currency identification. To address this problem, I assumed a system to develop a currency recognition device to solve this crisis and make blind people feel secure and confident in financial business. In this supposed system, several steps have been taken to develop portable and low-cost banknote recognizers. Here, the currency is trained to be recognized and verified using image processing techniques and machine learning.

In future work, I will build the hardware component. The device is literally a simple computer that includes input, a processing session and output. The brain or the processor is Raspberry Pi module, because it gives low cost, compatibility and effective power consumption for this device. Firstly, currency note inserts into the device. Acquisition of image of currency note under ultraviolet light inside the device. It will avoid acquired blurred images and capture all the visible components. After image is matching with training data set. Finally, the device given voice output about Denomination of currency and If it is fake currency or not. User can hear the voice using headset also. My future work will focus on evaluating the proposed system to identify a currency recognize device for visually impaired people in Sri Lanka.

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