A FRAMEWORK FOR PRECISE RECOGNITION OF INDIAN PAPER CURRENCY NOTE FOR VISUALLY IMPAIRED USERS

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ABSTRACT

With the increasing proliferation of advance technologies, there is an increasing possibility for assisting the visually impaired user with daily work. This paper has attempted to contribute a cost-effective technique in similar direction by introducing a framework that can automatically recognize the currency and can speak out the denomination for the visually impaired users. The prototype designed in Matlab considers the real-time feed of Indian paper currency notes of all the available denominations and applies three different types of algorithms to achieve the objective of performing recognition of currency. The prototype was tested on 20 different samples in different orientation of same currency under the denomination of Rs.10, Rs.50, Rs.100, Rs.500, and Rs.1000. The outcome of the study has been also found to have highly reduced storage and time complexity with precise recognition rate.

Keywords: Currency recognition, Indian Currency, Digital Image Processing, Orientation, Recognition Rate

I. INTRODUCTION

The extension of cutting edge managing account administrations in modern banking system requires the requirements for programmed money distinguishment and verification framework, subsequently urging numerous analysts to grow high precision, dependable and high handling rate systems. To identify the realness of coin note there are two systems i.e. first line review system and second line assessment strategy. First and foremost line review strategy incorporates changed thickness watermarks, bright fluorescence, intaglio printing, micro-text and visualization while the second line examination strategies incorporate isocheck/isogram, fiber based declarations of genuineness, shading and peculiarity investigation. Initially line examination technique is utilized for on-spot confirmation of notes yet is less demanding to fake than the second line investigation strategy while the second line review system requires an additional gadget to perform the assessment. The primary test for cash distinguishment is to distinguish coin note in a group of money notes where there is a likelihood of discovering diverse section note. Additionally a strong framework ought to have the capacity to perceive worn, blurry, ruined and even harmed note amid dissemination by person. Distinguishing the realness and distinguishment of money note has ended up imperative these days as a result of the predominating fake exercises as it hampers our economy. It is extremely helpful in the keeping money framework and in addition in other business applications. There are numerous techniques used to recognize validness and to perceive a note

which is being examined in this paper and everyone has its own goal and noteworthiness. In this paper we have talked about numerous devices that can be utilized to perceive diverse gimmicks of a note. Since a thing can't be impeccable and has specific impediment. So determination of gimmick and the choice of apparatuses to perceive that specific peculiarity are basic. To beat this limit and building an intuitive framework with high velocity, exactness and shabby is another test. The significant system of this framework is picture examination and picture transforming, which are a piece of cognitive and software engineering. Picture transforming is a sign handling after preprocessing. The yield can be either a picture or a set of qualities or parameters identified with the picture. Really the picture is dealt with as 2-dimensional flag and applies some standard sign preparing procedures with picture handling strategies included. Picture examination is an implies that the significant data from a picture is extricated principally from computerized pictures by method for advanced picture preparing strategies.

The research gap or the open issues of the proposed study identified are as follows: Some of the prior studies e.g. [1] [2], [3], [4] etc. has focused using neural network mainly for performing currency recognition.

- Neural networks are difficult to design. One must determine the optimal number of nodes, hidden layers, sigmoid function, etc.
- Neural networks are difficult to model analytically because a small change in a single input will affect the entire network,
- There is a great computational burden associated with neural networks. Neural networks require a large sample size in order to empirically fit data

Some of the prior studies e.g. [5] [2] have adopted optical character recognition system that have difficulty differentiating between characters, such as the number zero and a capital "O." Even if the scanned image of the original document is high-quality, additional steps must occur to clean up the OCR text. It is very labor-intensive to correct the errors created by OCR. Certain studies e.g. [6] have used Principle Component Analysis (PCA) for performing feature extraction. However, the prime issues in such implementations are that in PCA, the covariance matrix is difficult to be evaluated in an accurate manner and even the simplest invariance could not be captured by the PCA unless the training data explicitly provides this information. The other set of the studies e.g. [5] [6][7][8] etc. are quite similar with minor change in the techniques being adopted. Hence, this paper presents a unique and simple technique that uses digital image processing and performs recognition of Indian currencies on multiple orientation condition. Section 2 discusses about the problem identification followed by Section 3 that illustrates the proposed aim and objectives. Research methodology of the proposed system is discussed in Section 4 followed by Algorithm description in Section 5. Result discussion is done on Section 6 followed by conclusion in Section 7.

II. PROBLEM IDENTIFICATION

The problem statement of the proposed project is – To design a robust prototype that can perform efficient and reliable recognition of the Indian currency notes applicable for Visually Impaired Subject (VIS). The problem identifications of the proposed study are as follows:

- Presence of noise while capturing the image of currency note and mitigating them.
- Computing extent of the threshold to be used for color matching for different type of denomination under challenging physical condition of notes (dented, skewed, variable illumination etc.

III. PROPOSED AIM AND OBJECTIVES

The proposed project work to be carried out targets to design a prototype that can perform recognition of Indian currency notes using image processing techniques exclusively for visually impaired subject (VIS). The objectives of the proposed project are as follows:

- To acquire image of real-time Indian currency and perform digitization to create a dataset.
- To adopt simple image pre-processing steps for removing noise, performing normalization, and enhance the input image if required.
- To perform localization of the currency note from the input image using standard canny edge detector.
- To perform recognition of the processed input image using color matching.
- To generate voice of the identified currency note for better supportability of VIS.

IV. METHODOLOGY

The proposed project work considers experimental based development methodologies to ensure that objectives cited in Section 1.6 are fulfilled. The base idea of this project was inspired from the significant work carried out by Aggarwal and Kumar by the title "*Indian Currency Note Denomination Recognition in Color Images*" which was published in IEEE-ICDSE and International Journal on Advanced Computer Engineering and Communication Technology in 2012. Therefore, the proposed system chooses to initiate the work carried by Aggarwal and Kumar bring out more productive contribution by introducing novel features. For better comprehensibility, the methodologies to be adopted in the proposed project work are categorized into 5 stages, which are as discussed below:

Phase-1-Image-Acquisition: In this phase, various Indian currency notes e.g. Rs. 1, Rs. 2, Rs. 5, Rs. 10, Rs. 20, Rs. 50, Rs. 100, Rs. 500, and Rs. 1000 will be collected. The considered currency notes will be subjected for digitization either using scanner or using HD image capturing device. All the digitized images are then stored as dataset as three dimensional array for the purpose of comparing with the queried image for validation. Each element of array stores an unsigned 8 bit integer (0-255). This captured image undergoes series of image processing techniques and accomplishment of this stage will successfully achieved 1st objective of project.

Phase-2-Pre-processing: This stage of the project work attempts to make the image more suitable for undergoing the series of techniques to be subjected in consecutive stages. As the project work considers real-time input images of Indian currencies, so there is quite a possibility that source image may have some artifacts that may reduce the performance of the system to perform evaluation. Hence, this step will adopt noise removal based on the extent of the noises to be explored. It will also be subjected to normalization as well as contrast enhancement depending upon the actual condition of the digitized input image of the currency note.

Phase-3-Localization: This is one of the crucial stage of the project development, where the success of the outcome will depend on. This stage will attempt to perform localization of the currency note from the input image. As the image will be captured from scanner device or HD image capturing device, the background of the image will come along in the digitization phase of Phase-1. Hence, the system will adopt background subtraction technique (or segmentation) that will attempt to quantify background from foreground. Therefore, this phase adopt standard canny edge detector which is highly resilient against noise and ensure higher

probability of identifying weak and strong edges. After setting up threshold, the system starts comparing it with number of pixels being identified.

Phase-4-Recognition: This stage of the project work will focus on the performing recognition of a queried image of a currency note (which is not present in the existing database) using color matching technique. The Color Threshold module is used to remove parts of the image that fall within a specified color range.

Phase-5-Contribution: Supportability for VIS: This phase of the study will implement novel techniques as a part of contribution to the proposed project to append certain value added features. The proposed project will be enhanced for a voice output to be exclusively designed for individuals who are blind or who have low vision. The system will be designed with higher scalability to recognize all Indian currencies currently in circulation. This added feature will make tasks such as recognizing the values of different rupees easier for visually impaired people. The application will first prompt users to capture an image of the holding bill, and the captured image will be transferred to the prototype computing device. Then the computing device will process the image in order to recognize the currency. Once the value of the currency denomination is determined, the computing device will select the appropriate audio file to play to the users. However, it is important to note that we designed the project with the assumption that the user is aware that the bank note is a Indian currency, and has the ability to get hold of an prototype computing device whether through their own power or the help from others.

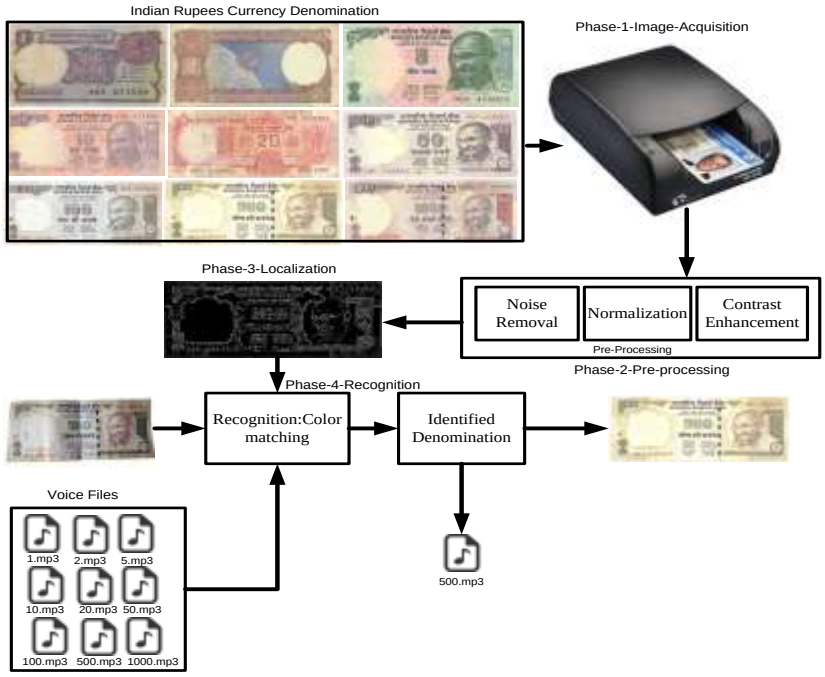


Fig. 1: Proposed Methodology of Project

V. ALGORITHM DESCRIPTION

The proposed system is designed on Matlab and consists of various components to accomplish the objectives of recognizing the Indian currency. The implementation of the proposed system is carried out by following the usual steps of digital image processing e.g. acquisition of an image, image pre-processing, extracting features, etc. More detailed explanation of the algorithms being implemented is discussed below:

5.1 Algorithm for Image Acquisition

Input: Image of currency, Snapshot of currency

Output: Digitizing the input file and accomplishing image (frame) acquisition

START

1. Extract analog input data, time, and event information from data acquisition engine.
2. IF input_type=image
   - 2.1 I_{input}= read the original image.
   - 2.2 Convert the read image (I_{input}) to grayscale.
3. IF input_type=video
   - 3.1 I_{input} = Construct a video input object.
   - 3.2 View the default color space used for the data
   - 3.3 Set the colorspace to RGB
   - 3.4 Configure video input object trigger properties
   - 3.5 Get the frame data
4. Show the input in axes.

END

The Algorithm-1 is basically responsible for considering the input to the proposed framework designed on Matlab. There are two types of input files viz. i) Image of the currency note taken from datasets and ii) taking a video snapshot of currency note in real-time. The proposed system processes both the type of the input files in following manner e.g. i) Processing for image: the image file is directly taken as input and subjected to *imread* method in Matlab for reading the image file. Finally the original input image file is subjected to digitization, which will be further subjected to various algorithms for the purpose of recognizing Indian currency. ii) Processing for image: In this case, the system starts the integrated video capturing device, where the user is supposed to hold the currency notes infront of the camera. The system takes a quick snapshot of the currency, finally forming a digitized image (or frame) for further subjecting to algorithm.

5.2 Algorithm for Segmentation of Currency

Input: Digitized input Image (I_{input})

Output: Segmented Image (I_{seg})

START

1. Create a function for performing segmentation
   - 1.1 Input arguments: Digitized input image (or frame) I_{input}
   - 1.2 Output arguments: Segmented Image (I_{seg}) and Angle of Rotation (A_{Rot})
2. Convert I_{input} to grayscale.
3. Perform binarization for outcome in step-2
4. Fill image regions and holes
5. Morphologically open binary image
6. Measure Orientation properties of image regions
7. Concatenate arrays along specified dimension for Step-6 and measure A_{Rot}.
8. Rotate the image using $A_{Rot.}$

9. Binarize the outcomes received in Step-8.

10. Fill image regions and holes for outcomes received in Step-9

11. Morphologically open binary image for outcomes received in Step-10.

12. Perform Image Segmentation (I_{seg}) by using min and max size of elements present in matrix formed in Step-11.

END

The above algorithm discusses about the significant steps of segmentation of the digitized input file to the system. For this purpose, a function is created in Matlab considering input argument of digitized image whereas the output arguments are in the form of segmented image and angle of orientation. The digitized input image is converted to greyscale, which is then further converted to binary image based on 0.3 threshold value (chosen by trial and error method). The binarized regions of image are then filled with holes, which are further subjected to morphological operations by removing from a binary image all connected components (objects) that have fewer than 500 pixels, producing another binary image. The resultant binary image is again subjected to evaluation for orientation properties of the regions. Finally, the concatenation operation is applied (1-dimension) for the recently accomplished binarized image to get angle of rotation. The algorithm then performs compensation of the orientation by using the method *imrotate* in opposite direction to counterbalance the view of orientation. Similar operation for binarization, image region filling, and morphological operation is performed to get the minimum and maximum value of the matrix. The segmented image is thereby accomplished in such way.

5.3 Algorithm for Recognition of Currency

Input: Segmentation of queried Image (I_{seg}) and name of currency from dataset (Cname)

Output: Recognition of currency in form of string.

START

1. Create a function for recognizing currency

1.1 Input Arguments: Segmented image (I_{seg}) and Currency name (C_{name})

1.2 Output Argument: Recognized Currency in string

2. Perform resizing of the Iseg using the scale of 210 *x* 445

3. Convert the image to grayscale.

4. Perform Adaptive histogram equalization for the outcome of Step-3.

5. Load the dataset

6. For i=1:C_{name}

7. For j=1: size of dataset

8. Convert all images to grayscale

9. Perform Adaptive histogram equalization

10. Compute Correlation Coefficient between queried image and dataset image

11. Rotate the dataset image to 180^{o}.

12. Evaluate the maximum value for correlational matrix in Setp-10 and Step-11.

13Generate the output exactly based on matrix size of Step-12.

14. End

15. End

16. Recognize and Display the name of Currency in UI.

END

The prime responsibility of the proposed algorithm is to perform an effective recognition of an Indian Currency note. After the queried image is being segmented it acts as an input argument for this algorithm. The design of the algorithm is done by creating a function for recognizing Indian currency considering segmentation of queried image and name of currency from the dataset as the input argument, whereas output argument is just to recognize and show the value of the currency under observation. This algorithm performs resizing of the segmented image to the dimension of 210 x 445, which is then subjected to grayscale. The outcome is then subjected to adaptive histogram that enhances the contrast of the grayscale image by transforming the values using contrast-limited adaptive histogram equalization. It operates on small regions in the image, called *tiles*, rather than the entire image. Hence, the queried image is read, resized, converted to grayscale and performed equalization. On the other hand, this algorithm in-parallel checks the indexes of the dataset of image. The dataset basically consist of all the digitized and saved records of the image or real-time snapshots of a currency before starting up the process of querying. A nested loop is constructed for this purpose for controlling the length of the currency name and size of 2D-images available in the datasets. All the images in the datasets are now converted to grayscale as well as adaptive histogram equalization method. The next part of the processing performs computation of the correlation coefficient between segmented image (query-image) and grayscale image from the dataset, where both the images are matrices or vectors of the same size. The images in the datasets are also subjected to rotation to 180^{o}. The loop is iterated till it reaches its terminal point and now the system is in position to display the recognized image in the UI along with the display of currency value.

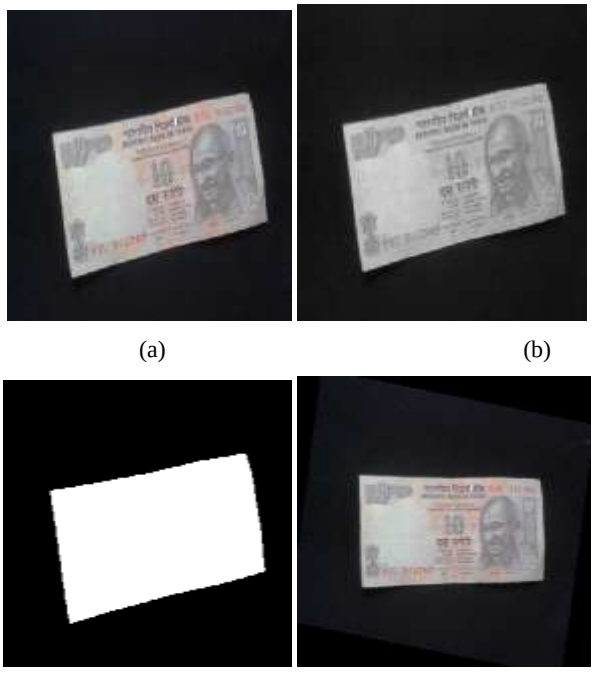
VI. RESULT DISCUSSION

The previous section has discussed the algorithms that have been implemented for the purpose of recognizing the Indian currency. The discussion of the result is carried out with respect to creation of dataset, segmentation process, and finally the currency matching process.

Outcomes for creating the dataset: The proposed system uses a normal webcam to capture the images from the real-time feed. For adding up complexities, the system uses both the sides of the currency as well as in multiple different orientations of the currencies. The outcome accomplished in this stage can be seen in Fig.2 that shows some of the patterns of orientation of currency by which the dataset is created. These images will be used for performing similarity check with the queried image of currency.

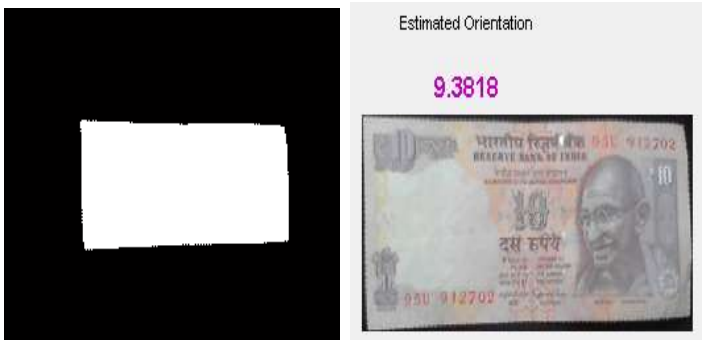
Fig. 2: Visual Outcomes of Dataset Creation

Outcomes for Segmentation Process: Fig.3 exhibits the outcomes of the segmentation process in the proposed system. Fig.3 (a) is the captured feed of input image of currency, Fig.3 (b) is the grayscale image of the same input image of currency, Fig.3 (c) is the segmented image of the grayscale image, Fig.3 (d) shows the correction of the orientation, while Fig.3 (e) shows the segmented portion of the rectified orientation. Finally, Fig.3 (f) shows the segmented currency in color with estimated orientation.



(a) (b)

(c) **(d)**



(e) (f)

Fig. 3: Visual Outcomes of Segmentation Process

Fig. 3. shows the more visual outcomes of the segmentation process, which is carried out in various orientation patterns. The experiment has been carried out for 20 different samples of same currencies (Rs.10, Rs.20, Rs.50, Rs.100, Rs.500, and Rs.1000). All the possible orientation position has been screened to evaluate the effectiveness of the outcomes. Hence, a successful segmentation process is witness in this process.

Outcomes for Currency Matching: Table 1 highlights the visual outcomes of the currency matching process. A total of 20 samples of similar currencies were used to perform the testing of the proposed system. The outcome shows that almost at every condition of orientation of the Indian currency, the proposed system is able to perform a precise detection. Table. 1 also show that currency (input) were maintained with different patterns of orientation with diverse values of angle to show precise recognition process of Indian currency.

Table. 1: Currency Matching Outcome

Input Currency	Detected orientation Angle	Recognized Currency
		
		
		
		

Outcomes for Sound for VIS: After the system performs effective and precise identification, the system generates a sound for the visually impaired users. The sound was found to be in very distinct and depends on the level of the volume of the integrated computer speakers. In future such systems can be incorporated on the machine that can perform precise recognition and generates a distinct pitch volume of sound for the currency that it has recognized.

Numerical Outcomes: From the previous section, various visual outcomes were discussed. This section discusses about the numerical outcomes. For the purpose of evaluating numerical outcomes, the proposed system is evaluated with respect to processing time as it is felt that such system should use less time to generate the outcomes.

Table. 2: Analysis of Processing Time

Currency	Processing time (Sec)
5	0.65
10	0.62
50	0.63
100	0.04
500	0.07
1000	0.63

Table 2 shows that all the 20 different samples of same currencies in multiple denominations are found to consume around 0.6 seconds of processing time, which is very less and almost instantaneous. Hence, lower time complexity can be ensured in this process. From the storage viewpoint also, the system only stores the few samples of data for performing testing of numerous denomination of queried currency image. Therefore, the proposed system ensures lower time and space complexity along with precise recognition of the Indian currencies.

VII. CONCLUSION

The proposed system is completely functional for true input of Indian currency. False input will provide noisy or redundant output. The proposed system is designed for the recognizing the Indian currency only and is not meant for performing recognition of the fake currency. The proposed system includes color feature, binarization, morphological features, geometric transform, orientation, edge boundaries, and lightening conditions. The scopes of the proposed system are as follows: i) The project work will support identification of only Indian currency denomination and not for other countries, ii) The prototype application considers only currency and not the coins, iii) The currencies to be considered for the experimentation will be only Rs. 2, Rs. 5, Rs. 10, Rs. 20, Rs. 50, Rs. 100, Rs. 500, and Rs. 1000 (INR), iv) The generated voice will be only in English. At present there are various vending machines installed in various public locations. Till date all the vending machine gives the product only based on coins and very few on currencies. Hence, out future work direction will be toward precise identification of coins in the vending machine.

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