ARTIFICIAL NEURAL NETWORK TO RECOGNIZE AN INDIAN CURRENCY NOTE USING UNIQUE IDENTIFICATION MARK

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Abstract: Artificial neural network has a vast application and has been successfully applied to a broad spectrum of data intensive application such as financial, data mining, medical, operational analysis, industrial, science etc. This increase in application is due to its ability to solve problem where the relationship are quite dynamic or non linear. Therefore in this paper we have used ANN to recognize Indian currency note using one special feature of Indian currency note known as Identification Mark (I.D mark). The I.D mark is of different shape for different currency note except for Rs 10 where there is no identification mark present. In the proposed method first we define a window size based on the common region where there is I.D mark. Then based on the window size we have segmented the I.D mark from the currency note. After this Fourier Descriptor is used to extract the feature from the segmented portion. Then the identification of this extracted feature is done by using ANN.

Keywords: Identification Mark(I.D mark); Fourier Descriptor; Artificial Neural Network(ANN)

1. Introduction:

A lot of work has been done in the field of automatic currency recognition and also various methodologies have been proposed to automatically recognize an Indian currency note. Most of the work done is based on finding the dominant color, texture, aspect ratio etc. But the main problem lies on the fact that there is an increase in the error rate in recognition of old currencies note as the color get faded due to wear and tear. Therefore financial institutions as well as visually impaired section of the society are in need of the system that can calculate note irrespective of the denominations given. Thus such a system introduced would undoubtedly enhance the socio-economic dimension of the country.

The various methodologies or the techniques that have used to recognize the Indian currency note are based on the security features present on the currency note. An example of the security features present on the Rs 100 currency note is shown in the Fig. 1.

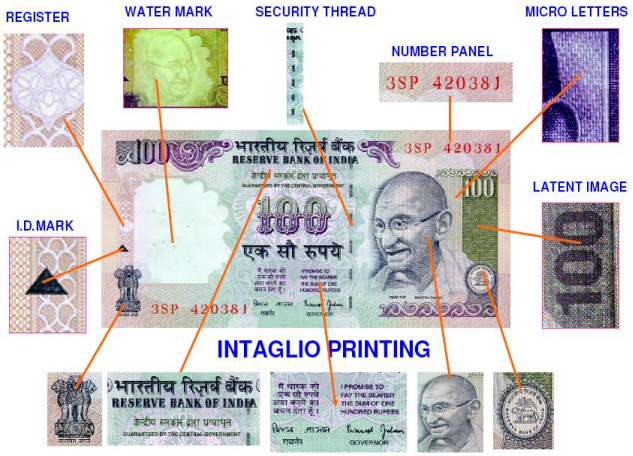

Figure 1: Security features in a banknote [1].

In context to image processing there is another feature of the currency note known as dominant color. Each Indian currency denomination has dominant color. Dominant color is the color component present in maximum. For e.g Rs 500 currency note has "Green" as dominant color.

There is one another non-discriminating, most important and the unique feature of the currency note known as I.D mark. The I.D mark is different for different currency note as shown in the Fig. 2 below.

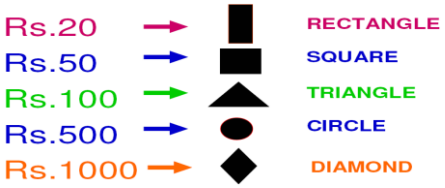

Figure 2: Identification mark for various denominations [1].

In this paper we have proposed a method to recognize a currency note based on the one important feature i.e I.D mark.

In this process we have first localized the currency note. Then we segment the portion of the note wherein the I.D mark is present. After this the Fourier Descriptor of the shape of the I.D mark is obtained by using the Discrete Fourier Transform of the shape. To classify the shape of the currency note the Fourier Descriptor of the shape is fed as input to the ANN. ANN classify the shape and then based on the classification we recognized a currency note.

2. Related work:

A lot of work has been done in the field of currency note recognition. In this section we will come across some of the related works in this field.

Vipin Kumar Jain et al.(2013) employed a method where they have used digital image processing techniques to find the region of interest and after that Neural Network and pattern recognition techniques is used for matching the pattern[2]. By using pattern recognition Seth Mc Neillin has done recognition of coin with different background. First they have segmented the coin from background using Nechba's code and then extracted features by convolving texture templates with each image. Here the author uses five set of data and got 94% accuracy [3]. In the paper [4] the author proposed a component based framework for banknote recognition by using Speeded Up Robust Features (SURF). Here the image is divided into components and then matching is done. The SURF features are invariant to conditions of image occlusion, image rotation, changes of scaling, illumination and the viewpoint. The proposed algorithm achieves 100% accuracy. Rumi Ghosh and Rakesh Khare represented a currency recognition system using Neural Network. For efficient classification they have used color, texture and size as three features to recognize the currency note. The proposed method achieves 97.34% accuracy [5]. Color histogram method is used when we have to segregate between the range of color and the prominent color. The major limitation of color histogram is that the color histogram describes which color is present and in what quantity but doesn't provide spatial information [6]. In the paper [7] they have made a review on the recent developments on the currency note recognition system. Based on the review they have found that most of the techniques used for recognition is Artificial Neural Network. Hanish and Padam has done currency note recognition using color images. First they have localized the currency note using scan line algorithm. In the experiment they have got 96% accuracy. The system can be made more efficient by using template matching [8]. In the paper [9] Pragati D. Pawar and Shrikant B. Kale converted RGB color image into HSV color space because it is more close to human conceptual understanding of color. Here the features color histogram, hue, saturation and intensity value are used to recognize the currency note. John R. Smith and Shih Fu Chang proposed a technique for color image retrieval in which images are extracted on the basis of color content of the image. The color indexing algorithm uses back projection of binary color sets to extract the color region from the image. It overcomes the problem with the color histogram [10]. In the paper [11] they have proposed a method to recognize Pakistani currency note using KNN classifier that is a nearest neighborhood classifier. Parminder Singh Reel et al. has done currency note recognition based on heuristic analysis of the character and digit of serial number. Heuristic analysis of color separates character and non-character elements on color basis [12].

3. Proposed methodology for Indian currency note recognition:

Recognition is process of identifying objects in an image. In our recognition process we have used unique Identification Mark to recognize an Indian currency. The different steps in currency recognition are:

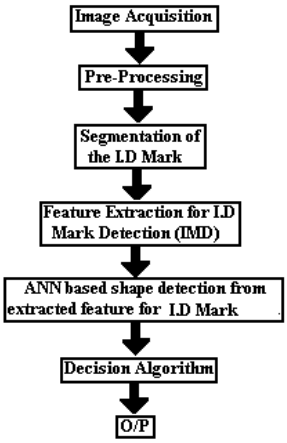

Figure 3: Flow diagram of proposed methodology.

The various steps involved are explained below:

- **Image Acquisition:**
  In this process image of the currency note is acquired using a 14 MP digital camera. For the experimentation purpose we have taken a database of images of each Indian currency notes (Rs 20, 50, 100, 500 and 1000) consisting of old, new, blurred and faded notes.

- **Image Pre-processing:**
  It is a process to enhance some features important for further processing. In image pre-processing the size of the image is reduced and noise is removed that may appeared in the image while transferring. Here the background subtraction is also done and currency note is localized.

- **Segmentation of I.D Mark:**
  By going through the different notes thoroughly we have found that the alignment of watermarking, denominational number, security thread, latent image and I.D Mark is not same on the five notes. So we have to find the common region of the I.D Mark. This is done by aligning the note on the left side as shown below.

Figure 4: Common region to segment I.D Mark.

- **I.D Mark feature extraction:**

After segmenting the I.D Mark feature extraction of the I.D Mark is done using Fourier descriptor. There are different techniques that exist for shape descriptions of an image. The most common boundary based shape descriptors are chain codes, moments, wavelet descriptor, curvature scale space and Fourier Descriptor. Fourier descriptor finds applications in contour coding, invariant 2-D shape recognition, classification of chromosomes, aircraft identification and scene analysis etc. Fourier Descriptor technique is reported to give best result because it allows both well representation and well normalization [13].

For a given shape signature S(t), t= 0,1,2,3,….L assuming its normalized to N points in the sampling stage, the Discrete Fourier Transform of S(t) is given by equation 1:

$$U_n = \frac{1}{N}\sum_{t=0}^{N-1} S(t)\exp\left(\frac{-j2\Pi nt}{N}\right), n = 0,1,2,N-1 \quad (1)$$

The coefficients U_n, n=0, 1, 2,…..N-1, are usually called Fourier Descriptors (FD) of the shape.

- **ANN based Shape Classification and Matching:**

The classification of the shape of the I.D Mark is done by using Artificial Neural Network (ANN).

ANN has been developed as generalizations of mathematical models of biological nervous systems and it functions same as human brain. The basic processing elements of neural network are artificial neuron or simply neurons or nodes. The ANN is an interconnected group of nodes where each node represents an artificial neuron and arrow represents a connection from output of one neuron to input of all the neuron in the next layer. The neurons are connected in a network from input to output layer. The connections are weighted and job for each node is to calculate some output value depending on weighted input values. Neural network basically consist of three layers i.e input, hidden and output layer. In the feed forward network, the signal flow is from input to output units strictly in feed forward direction.

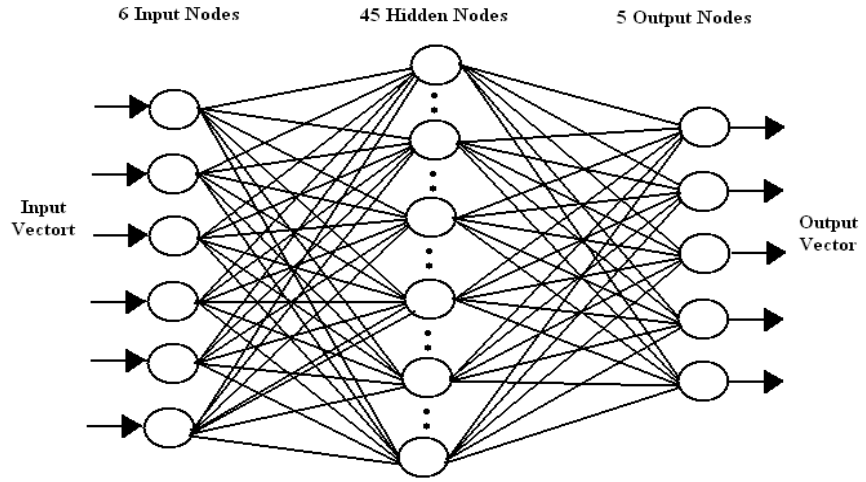

Figure 5: Structure of Artificial Neural Network.

The main function of ANN is to approximate the value of some unknown function. Learning algorithm is used to train the network to function in a more desirable way. The two different learning technique are supervised learning and unsupervised learning. The first method is unsupervised learning where we don't know if a certain input should map to some distinct output and let the network to train itself. The second method is supervised learning where we have a set of training data. The set contains some input

examples connected with correct output and the output value is often referred to as target value. In our project feed-forward back propagation neural network has been used for pattern association, classification and mapping. Back propagation is a method where with the help of derivatives and mean square error of the output makes a gradient search to find new values to the weights.

4. Proposed recognition algorithm:

The complete algorithm for our proposed Indian Currency Recognition is given below:

1. Obtain the image of the currency note
2. Extract the Region of Interest by thresholding method.
3. Obtain the dimension of the image.
4. Now segment the portion containing I.D. Mark.
5. Extract features using Fourier Descriptors.
6. Classify shapes using ANN Feed forward network.
7. Obtain IMD
   If
   *{"**Shape = Circle***
   IMD_{500}=1
   Else *IMD_{500}*=0
8. Repeat steps 5 to 6.
9. Obtain IMD
   If
   *{"**Shape = Triangle***
   IMD_{100}=1
   Else *IMD_{100}*=0}
10. Repeat steps 5 to 6.
11. Obtain IMD.
    If
    *{"**Shape = Square***
    IMD_{50}=1
    Else *IMD_{50}*=0}
12. Repeat steps 5 to 6.
13. Obtain IMD.
    If
    *{"**Shape = Rectangle***
    IMD_{20}=1
    Else *IMD_{20}*=0}
14. Repeat steps 5 to 6.
15. Obtain IMD.
    If
    *{"**Shape = Diamond***
    IMD_{1000}=1
    Else *IMD_{1000}*=0 }
16. If IMD_{500}=1,
    Then "Rs. 500 note detected"
    Elseif IMD_{100}=1**,**
    Then "Rs. 100 note detected"
    Elseif IMD_{50}=1,
    Then "Rs. 50 note detected"
    Elseif IMD_{20}=1,
    Then "Rs. 20 note detected"
    Elseif IMD_{1000}=1,
    Then "Rs. 1000 note detected"
    ELSE "NOT A CURRENCY NOTE".

5. Results and discussion:

The experimental stage consist on classifying a test set of 115 images of Indian banknotes; 23 per class denomination.

In this set there are new, old, faded and worn out notes. The experimental results are as shown in Table 1.

Table 1: Success Rates.

Denomination	Success Rate
Rs. 20	96%
Rs.50	96%
Rs. 100	98%
Rs.500	98%
Rs. 1000	95%

Given below are some more experimental results of various stages. In Fig. 6, we have shown how the unique I.D. Mark for a 100 rupee note is segmented. Detection and classification of the shape of I.D mark for a 100 rupee note is shown in Fig. 7. In Fig. 8 shows the neural network training for 10,000 iterations.

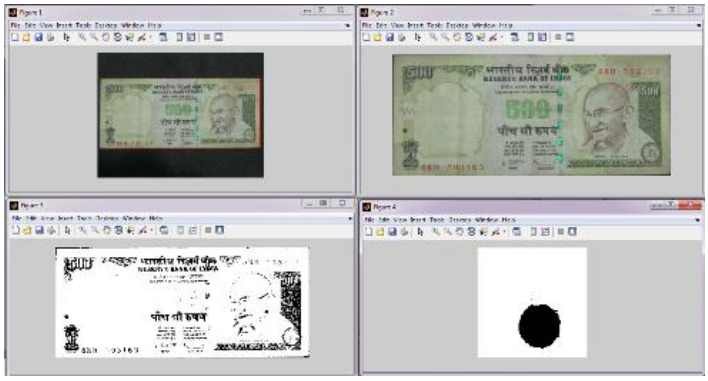

Figure 6: Segmentation of I.D.Mark.

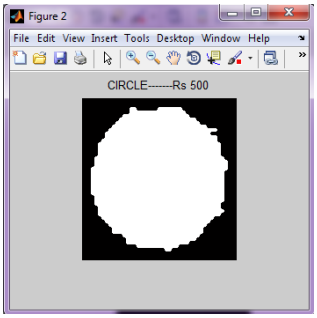

Figure 7: Detection of I.D. Mark in Matlab.

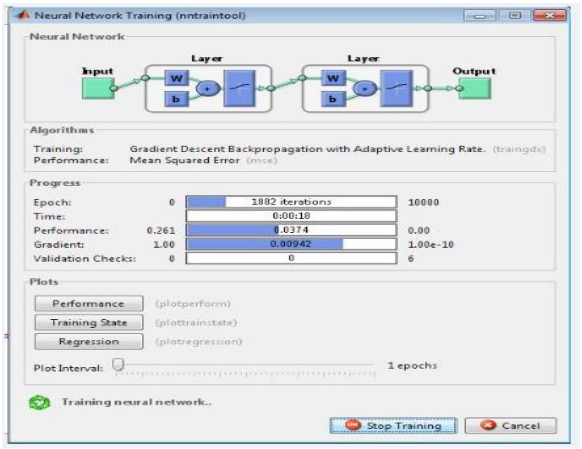

Figure 8: Neural Network Training.

The experimental results obtained based on the proposed method are satisfactory. Also Success rate is approximately 97% and the time complexity of our algorithm is 2.52 seconds. The method has been tested on a wide variety of notes keeping in mind the complexities.

6. Conclusion:

In this paper we have proposed a novel method for recognition of Indian Currency notes. Based on unique identification mark feature we have developed an algorithm to classify currency note. In the experimentation process we have achieved a success rate of approximately 97%. The processing time taken is 2.52 seconds. The recognition is invariant to image rotation as we have employed Fourier Descriptors for feature extraction of unique I.D. Mark. In Future we would like to extend the work in real time and also decrease the processing time.

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