A Novel Approach for Detection of Counterfeit Indian Currency Notes Using Deep Convolutional Neural Network

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Abstract In recent years, the Indian economy has shown rapid growth among all other major economies. India has been tragically reviled with issues like corruption and black currency, fake money notes is additionally major issues to it, in spite of a strong security feature are endorsed by RBI to print original currency. The advancement of color printing technology helped local racketeers and foreign racketeers to print a large amount of counterfeit Indian currency notes in the market. Albeit counterfeit money is being printed with accuracy, it likely is distinguished with some effort. In this paper, the proposed model efficiently detect the counterfeit Indian currency notes by adapting three-layered Deep Convolutional Neural Network (Deep ConvNet) , and achieved an accuracy of 96.6%.

Keyword: Counterfeit detection, Currency note, Image processing, Deep Convolutional Neural Network (Deep CNN)

1. Introduction

Rapid growth in technology can help the banking sector to modernize; this brings a profound requirement for automatic counterfeit money detection in automatic teller machines and automatic products merchant machines [5]. For bank staffs, there is a “Cash Sorting Machine” that helps them to identify different kinds of currencies. Cash sorting machines are accurate and highly efficient. However, for the common
citizen, to identify counterfeit currency notes they have to keep a lot of different characteristics of currency note in their mind. However, RBI drills down about the feature and anti-fakes labels of monetary forms. Even for that, it's not possible for anyone to be 100 percent self-confident about the manual recognition of real currency.

In 2016, before demonetization, the three most denomination currency notes accessible for use were Rs 100, 500, and Rs 1,000, after the demonetization the three most denominations were ₹2000, ₹500, and ₹200 leaving out Rs 100 [4]. In [4-7, 20-22] characteristics of the different denominations are enclosed as shown in figure 1.

![Figure 1. Specimen Copy of Rs 2000 Currency note [Source 20-22]](image1)

In 2016 after dissolving old notes Rs500 and Rs 1000 by the government of India the new ₹2000, ₹500, and ₹200 note was brought into the banking system, ₹2000, ₹500, and ₹200 includes new security along with old security features, as seen in figure 2 the seventeen security features can help us distinguish between a real money note and a counterfeit one [7]. Murthy et al demonstrated [20-21] salient features of the ₹2000 currency note [4-7]. The new Rs 2000 money note was brought into the financial framework in November 2016 after the former one was rejected by the administration of India dissolve.

![Figure 2. Dimension of the 2000 banknote 66 mm x 146 mm [Source 20-22]](image2)
Artificial Intelligence (AI) is being utilized in numerous fields that incorporate designing game applications [9], [25], health care [14], [23] finance [18], [26], and so forth. Counterfeit currency note detection, serial number identification [24] of the currency notes, features identification and extraction can be done using AI-based deep neural networks [19]. Samsung Galaxy M31 with a rear camera of 64MP used to create a dataset consists of ₹2000, ₹500, and ₹200 Indian currency note. To detect the counterfeit currency notes, deep neural network with three layered is developed, and features are extracted using Convolutional neural network.

In this paper, three layered CNN based model results are analyzed in terms of training and testing accuracy. The key contributions of the proposed work are as per the following:

1. To identify counterfeit currency with high accuracy a Deep Convnet model has been developed.
2. A web-based and mobile phone application developed to identify the counterfeit currency.

The rest part of this paper focus as section 2 represents a state of art related to the problem statement, whereas section 3 focused on Indian currency dataset creation, section 4 illustrates the proposed methodologies and Deep Convnet architecture, section 5 demonstrates observations and analysis of the result, section 6 exhibits the conclusions and future work of concluded paper.

2. State-of-Art: Overview

Automatic detection of Indian cash notes has raised a huge amount of research awareness in recent years especially because of its gigantic expected applications [10], in [22] paper the author proposed a system to recognize counterfeit currency notes. They have classified currency notes based on a set of unique features like dominant color, aspect ratio and then they adapted Fourier descriptors to extract image features, and later image segmentation, dilation, color space conversion, etc are carried out [1].

Cash recognition is a significant undertaking in various automated payment services and used to sort the cash notes of a diverse country [12]. Mr. Engdaw et al designed a currency detection system; they have extracted image features using local binary pattern techniques got an accuracy of 93% using the classifier SVM. In [3] paper author proposed a detection method visual Bag of Words (BoW), to segment the background from the foreground they implemented Grabcut algorithm and got 96.7% accuracy after testing 2584 images. Scanned currency is transformed into grayscale after transformation image identification can be done using the edge detection techniques, threshold values are compared to recognize currency note [11].

In [5], [6] demonstrated how to extract features such as identification mark, numeral watermark, floral design, micro –lettering, and security thread from the image using the sober operator which worked well with less computation time, they have shown how to extract hidden feature from the latent image. Sahana, Murthy, et al adopted image processing methodologies to catalog and validate Indian currency,
for the different denomination of Indian currency (₹10, ₹20, ₹50, ₹100, ₹500, ₹2000) diverse features are extracted based on size, prominent color, identification marks, etc [2].

In [8] the author demonstrated how to extract features with HSV color space using MATLAB[28,29]. Multilayer perceptron with Radial-Basis Function are organized to possess unidirectional hyperlinks [9]. Mitoses are identified by a pathologist with the help of Hematoxylin and eosin stain images (H&E) [13, 14].

3. Data set preparation

Samsung M31 mobile model with a 64MP rear camera used to create a dataset of Indian currency notes with a denomination like ₹200, ₹500, ₹2000. The data set consists of 218 images of original and fake cash notes with and without stains, the size of the data set increased to 306 after augmentation such as distortion, rotate, zoom, tilt are applied to the image captured through a mobile camera.

4. Methodology

The proposed three-layered CNN model shown in figure 4, perfectly works to identify counterfeit Indian currency denomination (₹200, ₹500, ₹2000). The proposed system includes method edge detection, image segmentation, filtering, etc. To make the system more reliable currency characteristics are feed into the model. In Deep Convnet Indian currency notes are given as an input data set to the model. The model programmed based on Deep CNN techniques and includes a user-friendly Web interface to upload the image as shown in Figure 6. Displaying the results either original or fake currency notes. Figure 3 represents the flow of the proposed CNN model and the major steps are:

1. Capture the image from the camera or upload the image from the local the drive, the format of the image can be JPEG/PNG.
2. Data pre-processing, smoothing image and removing noise.
3. Edge detection, segmentation, and pattern matching.
4. Print the result (Fake or Original).
**Figure 3.** Flow diagram of the proposed model Deep Convnet

Convolution Neural Network (CNN) enhances image resolution and helps to increase the resolution of the old manuscript [15]. In the proposed model to identify the counterfeit India currency note, we trained the model using Deep CNN, with three Convolution layers as shown in figure 4. We use two fully connected layers to classify the note, to get the probability of the currency note either fake or original.

**Figure 4.** Identifying Counterfeit Currency note -2000 using Deep ConvNet

5. Result in analysis

Initial training was performed on the whole training dataset with an equal learning rate of 0.001 for all layers. Initially, 306 images are used to train the network for 200 cycles; network has been re-trained for 300 cycles to increase the training accuracy score from 84.4 to 96.9%. The table below outlines the outcomes that were created from the model, the success rate of the model to recognize the Indian currency notes original or fake is 80%. Out of 10 cases, the proposed model failed in two cases unable to recognize original currency notes with more stains. We can increase the success rate by enhancing the data set size with more captured images.

| S.N o. | Training set | Validation set | Cycles | Epoch | Training accuracy | Input | Probability Fake | Probability Original | Expectation meet | Remark |
|-------|--------------|----------------|--------|-------|-------------------|-------|------------------|---------------------|------------------|--------|
| 1     | 245          | 61             | 300    | 43    | 96.9              | 2000_test_ing.jpg (original) | 0.559 | 0.441            | Fail                | Original note with stains (Portrait) |
| 2     | 245          | 61             | 300    | 43    | 96.9              | 500-6.jpg (original) | 0.001 | 0.999            | Success             | ------               |
| 3     | 245          | 61             | 300    | 43    | 96.9              | 500-4.jpg (Fake) | 0.835 | 0.165            | Success             | ------               |
|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| 4 | 245 | 61 | 300 | 43 | 96.9 | 2000.jpg (original) | 0.356 | 0.644 | Success | ------ |
| S.No. | Training set | Validation set | Cycles | Epoch | Training accuracy | Input | Probability Fake | Probability Original | Expectation meet | Remark |
|-------|--------------|----------------|--------|-------|------------------|-------|------------------|---------------------|-------------------|--------|
| 5     | 245          | 61             | 300    | 43    | 96.9             | 2000-3.jpg (Fake) | 0.755            | 0.245              | Success            | ------ |
|       |              |                |        |       |                  | 2000_test_input.jpg (original) | 0.423            | 0.577              | Fail               | Original note with stains (Portrait) |
| 7     | 245          | 61             | 200    | 29    | 84.4             | 500-6.jpg (original) | 0.006            | 0.994              | Success            | ------ |
| 8     | 245          | 61             | 200    | 29    | 84.4             | 500-4.jpg (Fake)    | 0.750            | 0.250              | Success            | ------ |
| 9     | 245          | 61             | 200    | 29    | 84.4             | 2000.jpg (original) | 0.411            | 0.589              | Success            | ------ |
| 10    | 245          | 61             | 200    | 29    | 84.4             | 2000-3.jpg (Fake)   | 0.540            | 0.460              | Success            | ------ |

5.1 Sample data set images of Indian currency

![Sample data set images of Indian currency](image)

5(a) Original currency Rs 500

5(b) Edge detection of Rs 500

5(c) Original currency note Rs 200 with stains

5(d) Fake currency note Rs 2000

**Figure 5.** Display sample Indian currency note of denomination Rs 2000, Rs 200, and Rs 500
5.2 Web application

The proposed model deployed on a web application, which requests the end-users to upload the image of a currency note as shown in figure 7. Once an image uploaded web application reads the image and returns the probability value then it displays the result as shown in figure 8, original note or fake note or re-upload the image again. In the proposed model for original currency note probability value should be above 90 percent, for fake currency probability value can be below 70 percent, for probability value between 70 to 90 displays a message to rescan the image once again.

![Figure 6. Display 40 epoch - model accuracy and loss](image)

**Figure 6.** Display 40 epoch - model accuracy and loss

![Figure 7. A user interface to identify the fake Indian currency notes](image)

**Figure 7.** A user interface to identify the fake Indian currency notes

After successful verification of the uploaded image figure 8, displays the result.

![Figure 7a) Home screen to run the model](image)

7a) Home screen to run the model

![Figure 7b) User Interface to upload currency notes](image)

7b) User Interface to upload currency notes

![Figure 7a) User interface that verify the note](image)

7a) User interface that verify the note

![Figure 7b) display warning message](image)

7b) display warning message
7c) Display fake currency note along with a warning message tear it immediately

7d) Display an alert message along with original currency note

Figure 7. Display the results either fake note (or) original note (or) rescan the image

6. Conclusions and Future Work

Distinguishing the credibility and detection of currency notes has become significant these days as a result of the predominant deceitful exercises as it hampers the nation’s economy. There are numerous strategies used to distinguish legitimacy and to perceive a money note which is being talked about in this paper and each one has its own goal and significance. The proposed model considered with a minimal effort that can be utilized to recognize various features of a cash note and consummately works for Indian money Rs 200, 500, and 2000. In this paper 306 images are considered after augmentation out of which 80% used for training and remaining 20% used for validation, the learning rate is 0.001, and the model finally achieved an accuracy of 96.6 with a success rate of 80%, the proposed model can separate the features even the note has scribbled on it. Since a thing can't be impeccable and may have constraints. Along these lines, the determination of features, picking appropriate tools to identify a specific feature is vital to overwhelm this obligation, and building an intelligent framework amid negligible cost, exactness, and fast is a novel challenge.
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