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# Indian Currency Denomination Recognition and Fake Currency Identification

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# Indian Currency Denomination Recognition and Fake Currency Identification

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**Abstract.** Visually impaired and senior citizens find it difficult to identify different banknotes, driving the need for an automated system to recognize currency notes. This study proposes recognizing Indian currency notes of various denominations using Deep Learning through the CNN model. While not recognizing currency notes is one issue, identifying fake notes is another major issue. Currency counterfeiting is the illegal imitation of currency to deceive its recipient. The current existing methodologies for identifying a phony note rely on hardware. A method completely devoid of hardware that relies on specific security features to help distinguish a legitimate currency note from an illegitimate one is much needed. These features are extracted using the boundary box region of interest (ROI) and Canny Edge detection in OpenCV implemented in Python, and the multi scale template matching algorithm is applied to match the security features and differentiate fake notes fromlegitimatenotes.
**Keywords:** CNN, Fake currency, Open CV, Deep Learning

## 1. Introduction

The Indian currency system includes banknotes and coins, among which banknotes are the primary form of currency used in abundance. Senior citizens experience presbyopia, a natural loss of the ability to focus, which causes difficulty identifying the denomination of banknotes. With introducing additional currency notes post demonetization in India, blind people have not been accustomed to the fresh notes, and identification of notes is a hassle. Scammers use this to their advantage to dupe the blind and elderly and give them the wrong denominations.

With the demonetization of old ₹500 and ₹1000 notes, new ₹500 and ₹2000 currency notes were introduced, which brought lots of hardships to the visually impaired. It was difficult for them to recognize the new notes. A system to recognize the correct denominations of the currency notes is much needed, and this study proposes to do just that by using deep learning.

Most of the currently existing methods for verifying the validity of a banknote rely on hardware systems with Ultraviolet light. These hardware systems are only available in banks and not accessible to vendors or the general public. We propose a system to identify counterfeited notes through scanned images by applying multiscale template matching implemented using OpenCV in Python.

Currency counterfeit detection is an essential task as the security features present in a currency note that help identify its genuineness have changed with introducing new currency notes—a new system to identify the counterfeit notes taking into accord the new security features is required.

According to [1], In 2019-20, the Reserve Bank of India (RBI) has detected 31,969 fake Rs 200 notes and 30,054 fake new Rs 500 notes. These amounts account for only those phony notes detected by the RBI. Fake notes seized by police and are still in circulation undetected are unaccounted for. The official guidelines and security features to identify fake notes by RBI can be accessed at [2].

The counterfeit notes scale back the worth of actual cash in circulation. They additionally increase the costs of various products. Black promoting is more a cause of counterfeit currency. It is a neighbourhood of a vicious circle of corruption that keeps wearing at each the economy and, therefore, the individuals' trust. Even though the demonetized currency was discarded, the problem of counterfeit notes isn't absolutely eradicated. The challenge of searching for counterfeiters is an arduous task because of their swift adaptation and proficiency within advanced technology. Since most counterfeit notes were detected in commercial banks, a fake currency detection system would help prevent such extreme measures within the future.

## 2. Related Work

In [3], the authors extracted features using the local binary pattern technique and classified Ethiopian banknotes using the Support Vector Machine algorithm. Their proposed system identifies fake currency notes by checking the intensity of wide strip, thin strip, and watermarks, which are unique features present in Ethiopian banknotes.

In [4], the authors extracted the latent image from the banknote and applied HOG encoding for feature extraction, and then classified the notes using SVM classifier and k-means algorithm. They implemented their proposed method in C++ using the OpenCV library.

The authors in [5] have developed a device based on an embedded Raspberry Pi board that captures still images of banknotes using an external camera. These are then processed through edge detection, segmentation, extraction of the region of interest and then classified using the KNN algorithm with 88% accuracy.

The authors in [6] have developed a three-layer CNN model to identify counterfeit notes of denominations ₹200, ₹500, and ₹2000. Their proposed method includes edge detection, image segmentation, and filtering, and pattern matching.

In [7], the authors collected Malaysian Ringgit banknotes in various orientations and compared the classification results from KNN, SVM, Decision Tree Classifier and Bayesian Classifier, and Alex Net model. They concluded that the Alex Net model's performance significantly degraded throughout various orientations ofthe banknotes, whereas SVM and Bayesian Classifier gave better results.

The authors in [8] have developed a real-time currency note identification and audio output system using Raspberry Pi. They have also performed Brute Force image classification using OpenCV and implemented it in Python and have compared it with CNN-based classification. CNN proved to be more efficient than Brute Force classification.

In [9], the transfer learned Alex Net model is used to learn the features layer by layer and identify fake currency notes.

The authors in [10] have proposed infrared spectroscopy for characterizing and distinguishing fake and genuine euro notes.

In [11], the authors have compared the performances of SIFT, ORB, SURF, KAZE, and BRISK algorithms in the detection of counterfeit Indian currency.

The authors in [12] have applied latent image extraction to identify fake Indian currency notes and have classified them using K-means and SVM classifiers.

In [13], the authors have used colour-based denomination recognition for Indian currency notes and verification of genuineness using pattern matching, implemented in MATLAB.

## 3. Proposed Method

There are two phases in our proposed method. The first phase is to classify the currency note based on denomination and the second phase is to check whether the note is counterfeited.

*3.1. Classification based on denomination*

We have used the dataset from [14], which comprises 4002 images of Indian paper currency notes in ₹10, ₹20, ₹50, ₹100, ₹200, ₹500, and ₹2000 denominations. Theclassification process is detailed in the following steps, as shown in Fig. 1.

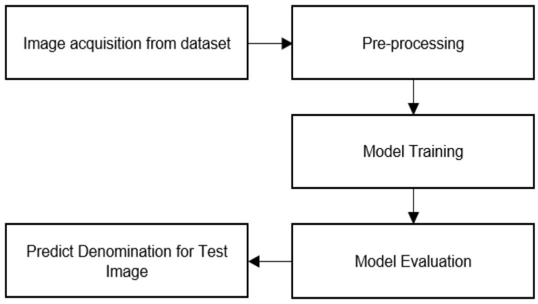


**Figure 1**: Classification Process

*3.1.1. Pre-processing*

- We resized these images and converted them into NumPy arrays of shape 100x200x3 where the first two dimensions represent the height and width of the images, respectively, and the third dimension represents RGB pixel values.
- For the next step in pre-processing, we have normalized the pixel values so that they lie in the 0-1 range.

*3.1.2. Model Creation and Training*

- We have used a three-layer CNN model with Rectified Linear Unit (ReLu) activation function and two Max Pooling layers. The convolutional layers extract features from the images, and the ReLu function preserves the non-linearity of the pixels in the pictures.
- The pooling layers progressively reduce the spatial size of the image.
- Finally, SoftMax activation is used on the output layer to assign the denominations. The layers of the model are shown in Fig. 2.

*3.1.3. Model Testing*

- Test image input is taken through the Jupyter File Upload system. The denomination with the highest probability predicted by the model is considered as the final output.

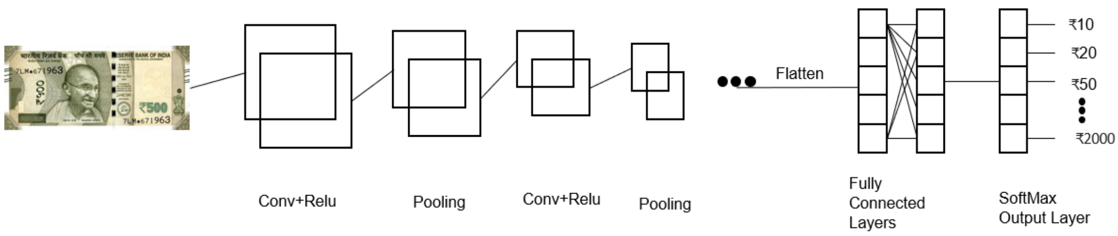


**Figure 2**: Layers in CNN model

*3.2. Counterfeit Verification*

In the second phase of our proposed model, we have used Multi-scale Template Matching with OpenCV, implemented in Python. Fig. 3 depicts the steps involved in this process.

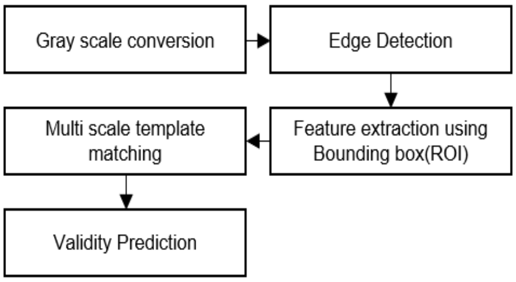


**Figure 3:** Steps in Counterfeit verification

*3.2.1. Feature Extraction*

- We take an image of a genuine currency note, convert it to grayscale. Canny edge detection isthen applied, and the security features are extracted using the bounding box Region of Interest (ROI) in OpenCV. This process is repeated for every denomination.
- The region of interest is a polygonal cross-section of an image that contains essentials features. The ROI is usually enclosed by an imaginary rectangle known as the bounding box. Bounding box and region of interest are usually used for object detection.

*3.2.2. Multiscale Template Matching*

- Template matching is an image processing technique in which a template or a patch of an image is considered a feature whose presence is detected in another image.
- The template image merely slides over the input image, just like in 2-dimensional convolution. A set threshold value is decided prior to template matching. The template and patch of the input image beneath the template image area unit are compared. The obtained result is compared with the threshold. If the result is greater than the threshold, the template is marked as detected in the input image.
- Multiscale template matching accounts for the presence of a scaled version of the template within the original image.

*3.2.3. Counterfeit Prediction*

- The security features present in a genuine currency note are treated as templates, and the test input image is gone through multiscale template matching. If the security features are all correctly present within the currency note, it is predicted as genuine, and if it doesn't, it is predicted as a fake note.

**4. Results and Discussions**

The three-layered CNN model used for classifying currency notes based on denominations produced decent results with 98.50% accuracy with 15 epochs. Fig. 4 and Fig. 5 show the loss curve and accuracy curve for the CNN model, respectively.The training dataset is split in an 8:2 ratio for cross-validation. Multiscale template matching is applied to detect security features in the currency note. If the features are matched, it is detected as a genuine note, and if not, it is declared as a phony note.

For testing the model, the scanned image of a currency note is to be uploaded through Jupyter File Upload System as shown in Fig. 6, and its denomination is predicted by the model as shown in Fig. 7.

For counterfeit detection, the input image undergoes grayscale conversion, as in Fig. 8. Then Canny edge detection is performed on the image as in Fig. 9. Then the features extracted using ROI selection are used as templates for template matching. Upon successful matching of the security features, as shown in Fig. 10, it is classified as a genuine note, and if the templates do not match, i.e., the results of template matching are less than the threshold, then the note is classified as a fake note, shown in Fig. 11.

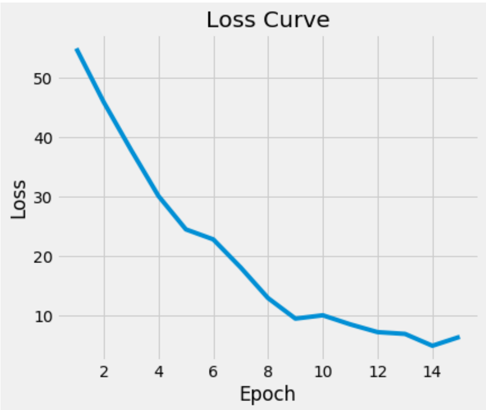


**Figure 4**: Loss Curve for CNN model

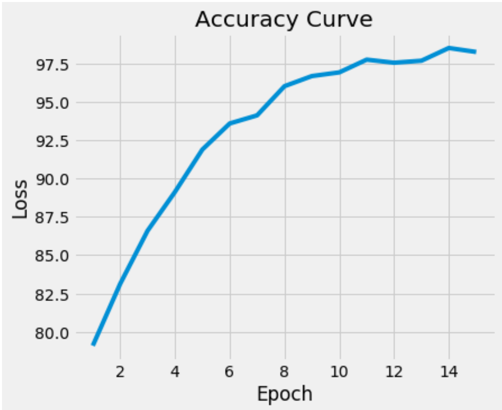


**Figure 5**: Accuracy Curve for CNN model

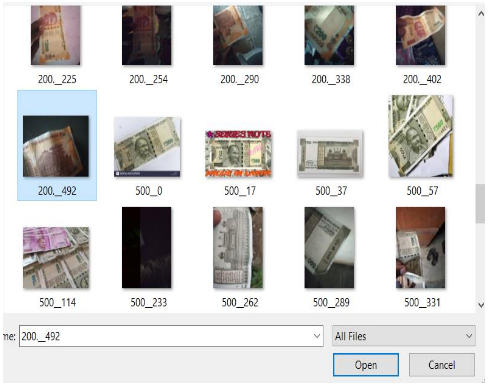


**Figure 6**: Uploading the test image


**Figure 7**: Prediction of the test image


**Figure 8**: Grayscale conversion of input image for counterfeit verification

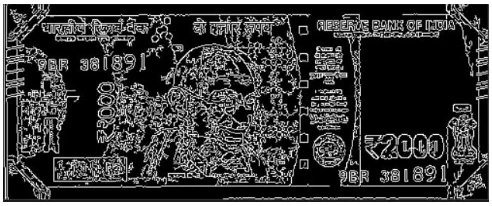

**Figure 9**: Canny Edge detection of input image


**Figure 10**: Template matching in a genuine currency note


**Figure 11**: Templates not matched in a phony note

## 5. Conclusion

In this study, we have proposed a system for Indian currency note classification based on denomination as well as counterfeit verification. Our proposed system can detect the denomination of the currency note with an accuracy of 98.50%. The Multiscale Template Matching system for currency counterfeit detection has its limitations. It can only detect the security features from the front image of the currency note. We aim to include the flip side features for counterfeit detection in the future.

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