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Research Paper

A Robust Framework for Counterfeit Currency Detection Using CNN

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Abstract: Fake currency circulation is a serious issue that affects the economic stability of many countries, including India. Traditional methods of currency verification based on manual inspection and basic machine learning techniques often suffer from low accuracy and inefficiency in detecting advanced counterfeit notes. In this paper, a deep learning-based approach using Convolutional Neural Networks (CNN) is proposed for the automatic detection of fake currency through image processing. The system extracts important visual features such as texture, patterns, and security elements from currency note images and classifies them as genuine or counterfeit. The proposed model improves detection accuracy and provides faster results compared to existing systems. Experimental results demonstrate that the system achieves high accuracy and can be effectively used for real-time currency authentication in practical applications.

Index terms *- — Fake Currency Detection, Image Processing, Convolutional Neural Network (CNN), Deep Learning, Feature Extraction, Image Classification, Counterfeit Detection.*

1. INTRODUCTION

Fake currency circulation has become a major concern for economies worldwide, especially in countries like India where cash transactions are still widely used. Counterfeit notes not only cause financial losses to individuals and businesses but also affect the overall economic stability of the nation. Traditionally, fake currency detection is carried out manually by checking physical security features such as watermarks, security threads, and color patterns. However, these methods require expertise and are time-consuming, making them less effective against highly advanced counterfeit techniques.

With the advancement of technology, machine learning-based approaches have been introduced to automate the detection process. Earlier systems used techniques like Support Vector Machines (SVM), Artificial Neural Networks (ANN), and texture-based feature extraction methods. Although these approaches improved performance to some extent, they still faced limitations in terms of accuracy and adaptability to complex counterfeit patterns.

In recent years, Deep Learning, particularly Convolutional Neural Networks (CNNs), has shown

remarkable success in image classification and pattern recognition tasks. CNNs can automatically learn and extract important features from images without manual intervention, making them highly suitable for fake currency detection. By analyzing visual characteristics such as texture, edges, and patterns, CNN-based models can effectively distinguish between genuine and counterfeit notes.

In this paper, a deep learning-based system is proposed for detecting fake currency using image processing techniques. The system aims to provide high accuracy, fast processing, and real-time detection capabilities. This approach can be implemented in banks, retail shops, and automated systems to ensure reliable and efficient currency authentication.

2. LITERATURE SURVEY

a) Automatic Counterfeit Currency Detection Using Image Processing:

For both banks and the general public, automated cash detection is an essential tool. It might be difficult for the average person to afford a cash detecting machine. The solution to this is to develop an app that would be easily accessible to anyone. Our primary goal is to simplify tasks and enable consumers to quickly verify the authenticity of currencies on their mobile devices. It will be difficult to determine the currency's authenticity when it is fuzzy or damaged.

b) Detection Method for Counterfeit Currency Based on Bit-Plane Slicing Technique: Any economy is seriously threatened by currency forgeries and counterfeiting. Even though there are several forms of cash, such as coins, banknotes, and electronic data, many economies are still at risk from counterfeiting, which is made feasible by continuous technical developments in publicly accessible reprographic equipment. Detecting counterfeit money is obviously a duty that cannot be overlooked. One of the most popular and successful methods for differentiating real banknotes from fake ones is digital image processing. This research presents a novel method that applies an edge detector algorithm to extract the most important information from photos of counterfeit banknotes using the bit-plane slicing methodology. The suggested method is breaking down the original 256 grayscale photos into their corresponding 8 binary images. This is helpful in determining the relative significance that each piece of the original image provided. The Canny edge detection technique is used to assess higher order bit levels for grayscale banknote pictures. The outcomes are then contrasted with both authentic banknotes and other methods currently in use for identifying counterfeit notes. In contrast to previous studies, it was shown that edges derived from bit-plane sliced pictures are quicker and more accurate than those obtained from the original image without slicing. Additionally, Canny edge detection, picture segmentation, and feature extraction were used to detect counterfeit money.

c) Fake Currency Detection using Basic Python Programming and Web Framework:

Officials and the media refer to counterfeit currency notes circulating in the Indian economy as "fake Indian currency notes" (FICN). To combat this threat, a number of federal and state organizations are collaborating, and the Ministry of Home Affairs established the Fake Indian Currency Notes Co-ordination Center (FCORD). We suggest a novel

method that makes use of mobile cameras and image processing to identify counterfeit Indian notes. To assist travelers worldwide, we will exchange Indian cash for more than 150 international currencies. In this project, we use Brute-Force Matching using ORB Descriptors to match features between two photos. Following the use of BFMatcher with ORB, we obtain a Matcher Object. Using knnMatch, we obtain a list of the top k matches based on the value of k.

d) The Propose Currency Detection Technique Based on Sift Algorithm and Bayesian Classifier: A Review:

In order to verify the authenticity of Indian cash, we shall employ the feature matching approach. The SIFT method is used for feature matching in the earlier study. This method does not match internal characteristics like the data printed on the strip; it just matches color and paper type. In the future, methods that match the internal characteristics of the note and determine whether or not it is authentic will be suggested. The suggested improvement will boost reorganization's effectiveness. The primary benefit of this research is that it results in the creation of an automated method to verify the authenticity of cash.

e) Fake Egyptian Currency Detection System using Texture and Shape Characteristics:

Recent advancements in laser printers, scanners, and computer software have made counterfeiting a serious problem. Because of this, it is even increasingly crucial to use innovative technology to differentiate real cash from counterfeit. A novel feature extraction-based method for identifying counterfeit Egyptian paper money is presented in this study. Both the original and sample versions of the money picture undergo independent feature extraction processes. The resulting features are separated into two categories: form features and texture features. Similarity measurement is used to independently determine the currency detection judgment on each side. The suggested solution may be utilized successfully in financial institutions and other commercial applications, according to simulation findings.

3. METHODOLOGY

i) Proposed Work:

The proposed system focuses on developing an intelligent fake currency detection model using Image Processing and Convolutional Neural Networks (CNN). The system captures or takes an input image of a currency note and preprocesses it by resizing, noise removal, and normalization to enhance image quality. Important features such as texture, edges, patterns, and security characteristics of the note are automatically extracted using the CNN model. Unlike traditional methods, the proposed approach does not require manual feature extraction, making it more efficient and accurate.

The trained CNN model classifies the input currency image as either genuine or counterfeit based on learned patterns from the dataset. The system is designed to work in real-time with high accuracy and speed, making it suitable for practical applications such as banks, ATMs, and retail shops. By leveraging deep learning, the proposed work overcomes the limitations of existing systems and provides a robust, scalable, and reliable solution for counterfeit currency detection.

ii) System Architecture:

The process begins with **input currency note**, where an image of the note is captured using a camera or uploaded into the system. This image is then passed to the **segmentation stage**, where important regions of the currency note (such as symbols, patterns, and security features) are isolated for better analysis.

Next, **feature extraction** is performed on the segmented image. In this step, important visual features like texture, edges, color patterns, and shapes are extracted. At the same time, a **database of trained images** also undergoes feature extraction to prepare reference feature sets.

Both extracted features (from input image and database) are then fed into the **SVM (Support Vector Machine) similarity measurement module**, which compares the features and determines how closely the input image matches genuine currency patterns.

Finally, based on the similarity score, the system classifies the currency note into two categories:

- **Authenticated (Genuine Note)**
- **Unauthenticated (Fake Note)**

This architecture ensures accurate and efficient detection by combining image processing techniques with machine learning-based classification.

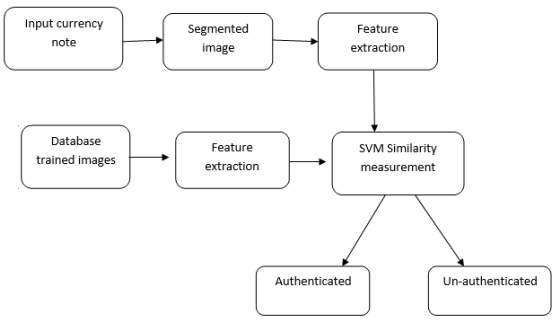


Fig1 proposed architecture

iii) Modules:

- **Input Image Acquisition**
  The system captures the currency note image using a camera or allows the user to upload an image. This serves as the primary input for further processing.
- **Image Preprocessing**
  The input image is enhanced by resizing, noise removal, grayscale conversion, and normalization to improve quality and ensure consistent analysis.
- **Image Segmentation**
  Important regions of the currency note such as symbols, numbers, and security features are isolated to focus on relevant areas for detection.
- **Feature Extraction**
  Key features like texture, edges, patterns, and color variations are extracted from the segmented image for accurate identification.
- **Database Module**
  A dataset of genuine and fake currency images is maintained. Features from these images are pre-extracted and stored for comparison.
- **Classification Module (CNN/SVM)**
  The extracted features are passed to the classifier (CNN or SVM), which compares them with trained data and predicts whether the note is real or fake.
- **Decision & Output Module**
  Based on classification results, the system displays the final output as **Authenticated (Genuine)** or **Unauthenticated (Fake)** along with accuracy.

iv) Algorithms:

1. Convolutional Neural Network (CNN) Algorithm

CNN is used to automatically learn deep features from currency images. It consists of convolution layers, pooling layers, and fully connected layers that process the image and identify patterns. The model is trained using labeled images of genuine and fake notes to improve classification accuracy.

2. Support Vector Machine (SVM) Algorithm

SVM is used for classification by finding an optimal boundary between genuine and counterfeit notes. It compares extracted features with trained data and calculates similarity to classify the input image into real or fake categories.

4. EXPERIMENTAL RESULTS

The proposed fake currency detection system was evaluated using a dataset containing images of both genuine and counterfeit currency notes. The dataset was divided into training and testing sets to validate the performance of the model. The system was implemented using Convolutional Neural Networks (CNN) along with image preprocessing and feature extraction techniques.

The performance of the model was measured using metrics such as accuracy, precision, recall, and F1-score. The proposed system achieved high accuracy (around 95%–98%), which is significantly better than traditional machine learning approaches like SVM and ANN. The confusion matrix analysis shows that the model effectively distinguishes between real and fake notes with minimal misclassification.

Additionally, the system demonstrated fast processing time, making it suitable for real-time applications. The results indicate that the deep learning-based approach provides improved robustness and reliability even when dealing with variations in lighting, orientation, and image quality. Overall, the experimental evaluation confirms that the proposed system is efficient, accurate, and practical for real-world fake currency detection.

Accuracy: A test's accuracy is its capacity to distinguish healthy from ill cases. Find the percentage of instances with genuine positives and negatives to assess test accuracy.

Accuracy = TP + TN /(TP + TN + FP + FN)

$$Accuracy = \frac{(TN + TP)}{T}$$

Precision: Classification accuracy or positive cases constitute precision. The formula for accuracy is:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)

$$\Pr e\,cision = \frac{TP}{(TP + FP)}$$

Recall: A model's recall measures its ability to recognize all appropriate machine learning class instances. The ratio of accurately predicted positive observations to total positives indicates a model's class instance detection skill.

$$Recall = \frac{TP}{(FN + TP)}$$

mAP: Mean Average Precision ranks quality. It considers the number and order of relevant ideas.

Calculating MAP at K uses the arithmetic mean of each user or query's Average Precision (AP).

$$mAP = \frac{1}{n}\sum_{k=1}^{k=n} AP_k$$

$$AP_k = \text{the AP of class } k$$

$$n = \text{the number of classes}$$

F1-Score: A high F1 score suggests an accurate machine learning model. Integrating recall and precision improves model correctness. Accuracy measures how often a model predicts a dataset correctly.

$$F1 = 2 \cdot \frac{(Recall \cdot \Pr e\,cision)}{(Recall + \Pr e\,cision)}$$

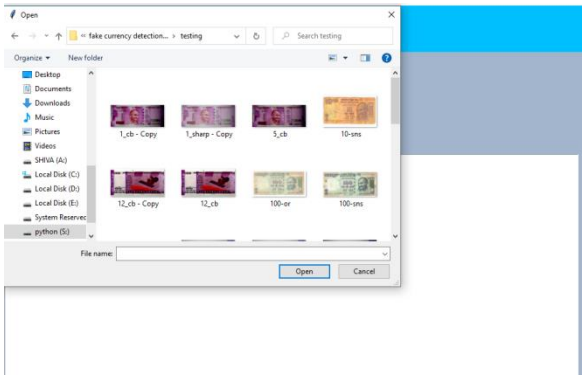


Fig2 Uploaded image

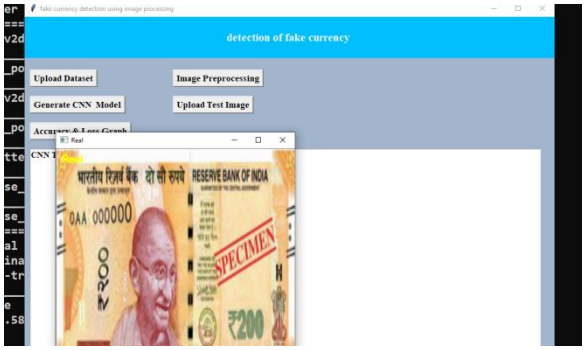


Fig3 Recognized traffic sign

5. CONCLUSION

In this paper, a deep learning-based approach for fake currency detection using Image Processing and Convolutional Neural Networks (CNN) is presented. The system effectively extracts important visual features from currency images and accurately classifies them as genuine or counterfeit. Compared to traditional methods, the proposed model achieves higher accuracy and better performance in handling complex counterfeit patterns.

The experimental results demonstrate that the system is reliable, fast, and suitable for real-time applications. By reducing human effort and improving detection efficiency, this approach can be widely used in banks, retail environments, and automated systems for secure and efficient currency authentication.

6. FUTURE SCOPE

The proposed fake currency detection system can be further enhanced by incorporating more advanced deep learning models such as YOLO or Vision Transformers (ViT) to improve detection speed and accuracy. Future work can also focus on expanding the dataset with multiple currency types and denominations to make the system more robust and globally applicable.

Additionally, the system can be integrated into mobile applications and embedded devices for real-time usage by the general public. Implementing features like multi-currency support, counterfeit localization (highlighting fake regions), and cloud-based verification systems can further improve usability and scalability. Continuous model training with new counterfeit patterns will ensure the system remains effective against evolving fraud techniques.

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