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Currency Recognition Using Image Processing

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Abstract
The circulation of counterfeit currency has become a growing concern in modern financial systems, especially in developing countries where cash transactions remain dominant. Traditional methods for detecting fake banknotes mainly rely on manual inspection or dedicated hardware devices such as ultraviolet detectors. These methods are often costly and not easily accessible to common users. In this project, an automated system for Indian currency recognition and counterfeit detection based on digital image processing techniques is presented. The proposed approach uses image acquisition, preprocessing, segmentation, feature extraction and classification to identify and verify currency notes. Statistical and edge-based features are extracted from the currency images and compared with reference feature sets stored in a database. The system is implemented using MATLAB and is evaluated on different denominations of Indian currency. Experimental results indicate that the proposed method is capable of recognizing genuine notes and detecting suspicious notes with satisfactory accuracy, making it suitable for low-cost and small-scale deployment.

Keywords: *CNN, MATLAB, Image Segmentation.*

1. Introduction

The rapid development of digital printing, scanning and image editing technologies has significantly increased the production of counterfeit currency around the world. India, where paper currency is widely used in daily transactions, faces serious economic and social challenges due to the circulation of fake banknotes. Counterfeit notes not only cause financial losses to individuals and businesses but also affect the credibility of the monetary system.

Traditionally, the verification of banknotes is carried out using manual inspection or specialized equipment such as ultraviolet lamps and automated currency counting machines. While such devices are effective in controlled environments such as banks, they are expensive and are not commonly available to small retail stores or individual users. Manual inspection also depends on human experience and can easily fail under poor lighting conditions or when counterfeit notes are carefully fabricated.

Recent advancements in digital image processing and computer vision have made it possible to develop automated and software-based currency recognition systems. Such systems analyze the visual characteristics of banknotes and identify patterns, textures, edges and security features that are difficult to replicate accurately in fake notes. By using cameras or scanners, the currency image can be captured and processed in real time, providing a flexible and low-cost alternative to traditional verification methods.

This project focuses on the development of an image-based recognition system for Indian currency notes. The system aims to identify the denomination of the note and verify its authenticity by extracting discriminative visual features and comparing them with known reference patterns. The proposed solution can be extended to mobile platforms and can also be adapted for other countries' currencies.

2. Aim and Objectives

2.1 Aim

The main aim of this project is to design and implement an automated system that can recognize Indian currency notes and detect counterfeit notes using digital image processing techniques.

2.2 Objectives

The objectives of the project are as follows:

- To capture images of Indian currency notes using a scanner or digital camera.
- To preprocess the captured images to remove noise and enhance important visual details.
- To segment important regions of interest from the currency image.
- To extract meaningful statistical and edge-based features from the segmented regions.
- To store reference features in a database for training and comparison.
- To classify the test image and determine whether the note is genuine or fake.
- To evaluate the performance of the system in terms of recognition accuracy.

3. Motivation

Despite the increasing use of digital payment systems, cash remains an essential mode of transaction in India. A large portion of the population, particularly in rural and semi-urban areas, still relies heavily on physical currency. However, access to professional currency authentication equipment is limited in such regions.
The motivation behind this project is to provide a software-based solution that can be used with ordinary imaging devices and personal computers. Image processing allows the analysis of currency features such as texture patterns, security threads, micro-lettering areas and intensity variations. These characteristics can be exploited to distinguish genuine notes from counterfeit ones without requiring expensive hardware.
Furthermore, the availability of powerful image processing tools in MATLAB enables rapid prototyping and testing of algorithms. This makes it possible to develop an efficient and practical system that can later be converted into a mobile application for public use.

4. Literature Survey
Several researchers have proposed different approaches for currency recognition and counterfeit detection using image processing and pattern recognition techniques. Previous studies have explored the use of texture analysis, color-based features, key-point matching and machine learning classifiers.
Some works have employed ultraviolet and fluorescence-based systems integrated with embedded hardware for use in automated cash deposit machines. These systems provide reliable detection but require specialized sensors and controlled environments.
Other studies have focused on feature-based recognition using algorithms such as SIFT, SURF and ORB. These methods detect distinctive key points on the currency image and perform matching with reference templates. Feature-based approaches have demonstrated strong performance in recognizing currency under moderate variations in scale and rotation.
Statistical feature extraction methods, including histogram-based features and gray level co-occurrence matrices, have also been widely used to describe texture patterns present on banknotes. These features capture information about the distribution and spatial relationship of pixel intensities, which are useful for differentiating genuine and counterfeit notes.
Although many approaches show promising results, most existing methods either require expensive hardware or lack robustness under varying lighting conditions and image quality. The present work attempts to combine statistical and edge-based features in a single framework to improve recognition reliability while maintaining low system cost.

5. System Overview
The proposed currency recognition and counterfeit detection system consists of the following major stages:

1. Image acquisition
2. Image preprocessing
3. Image segmentation
4. Feature extraction
5. Classification and decision making

The system operates on images of Indian currency notes obtained using a scanner or a digital camera. The overall objective is to extract reliable features from the input image and compare them with previously stored features of genuine notes.

6. Image Acquisition
In the first stage, the currency image is captured using a digital camera or scanner. Proper illumination and background are maintained to minimize shadows and reflections. The captured image is stored in RGB format and is supplied as input to the processing pipeline.

7. Image Preprocessing
Preprocessing is performed to improve the quality of the captured image and to reduce the influence of noise. The main preprocessing operations include:

- Conversion of RGB image to grayscale
- Noise removal using smoothing filters
- Contrast enhancement to improve visibility of fine details

These steps ensure that important features of the currency note are preserved and are clearly distinguishable during later stages of analysis.

8. Image Segmentation
Image segmentation is used to isolate important regions of the currency note that contain discriminative information. Segmentation divides the image into meaningful regions based on intensity values and structural characteristics.
In this work, segmentation is performed to extract regions that contain security features, texture patterns and denomination-related information. Accurate segmentation reduces the influence of irrelevant background regions and improves the quality of extracted features.

9. Feature Extraction
Feature extraction is a crucial step in any pattern recognition system. The goal is to represent the currency image using a compact and informative feature vector.
In the proposed system, two major categories of features are extracted.
9.1 Statistical Features

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Statistical features describe the distribution of pixel intensities in the image. First-order statistical features are obtained from the gray-level histogram of the segmented region. These features include:

- Mean
- Variance
- Skewness
- Kurtosis
- Energy
- Entropy

These features provide information about brightness distribution, contrast and randomness in the image.
Second-order statistical features are computed using the gray-level co-occurrence matrix. These features capture spatial relationships between neighboring pixels. Commonly used features include:

- Correlation
- Homogeneity
- Angular second moment
- Entropy
- Maximum probability
- Inverse difference moment

Together, these features effectively characterize the texture patterns of currency notes.

9.2 Edge and Shape Features

Edges represent important structural boundaries in an image. Edge detection algorithms are applied to extract contours and prominent structures present on the currency note.
From the detected edges, shape-related features such as region area, convex area, solidity, extent, circularity and eccentricity are computed. These features provide additional information about the geometry of printed patterns and symbols present on the currency.

10. Classification and Matching

After feature extraction, the resulting feature vector of the test image is compared with reference feature vectors stored in a database. The reference data are created from genuine currency images during the training phase.
A similarity-based classification approach is used to determine the closest matching reference sample. If the similarity score falls within an acceptable threshold, the note is classified as genuine; otherwise, it is flagged as suspicious or fake.
The extracted features and trained data are stored in MATLAB MAT files, which allow efficient access and comparison during the classification process.

11. Software and Hardware Requirements

11.1 Software Requirements

- Operating system: Windows
- Software environment: MATLAB
- Image processing toolbox

11.2 Hardware Requirements

- Processor: Intel-based system
- RAM: Minimum 2 GB
- Storage: 20 GB or more
- Digital camera or scanner

12. Experimental Results and Discussion

The proposed system was tested on multiple images of Indian currency notes belonging to different denominations. The input images were first preprocessed and segmented. Statistical and edge-based features were then extracted and compared with the stored reference data.
The experimental results show that the system can correctly identify the denomination of the currency and detect most counterfeit samples used during testing. The use of combined statistical

Fig: Denoised image

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Fig Gray Scale Image

Fig: Edge Detection

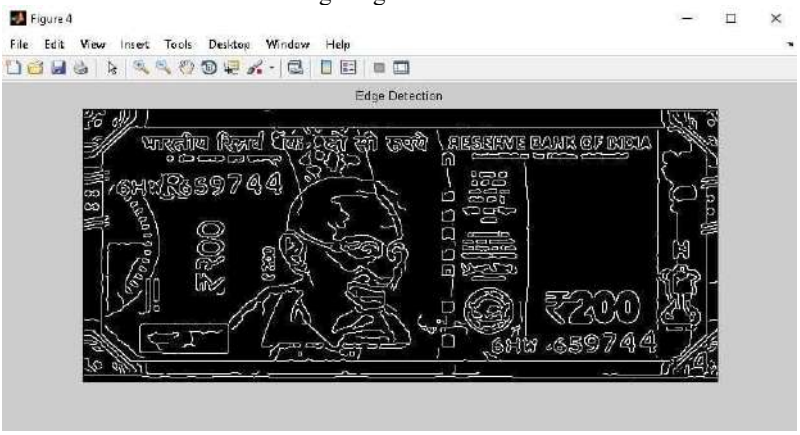

Fig ROI Extraction-Texture and Statistical Features

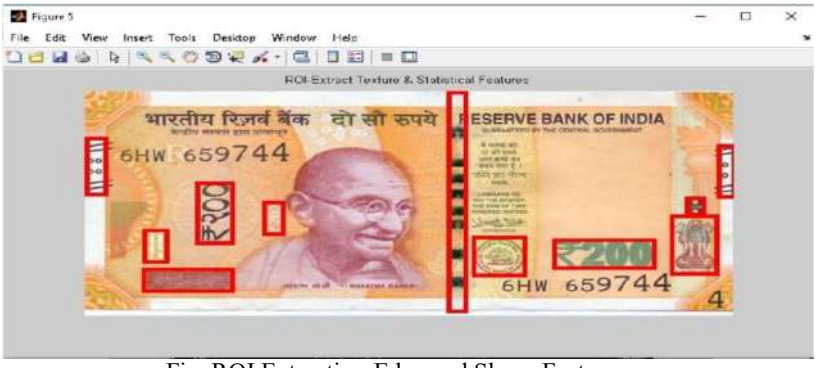

Fig ROI Extraction-Edge and Shape Feature

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Fig Detection Result

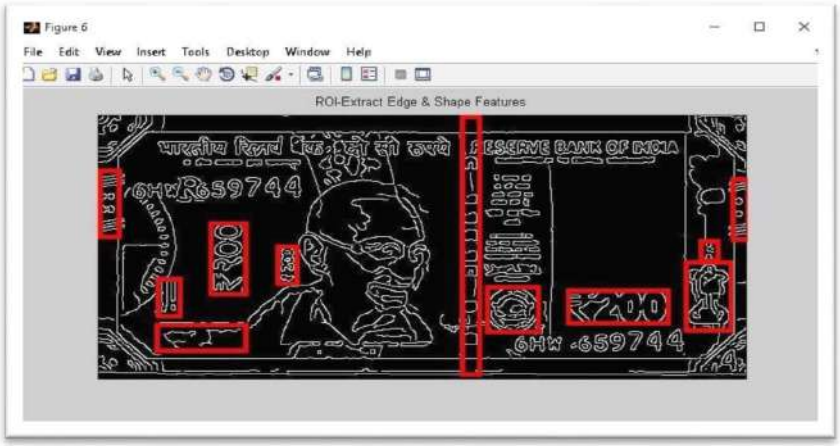

Fig Detection Result

Fig Currency Recognition

and structural features improves robustness when compared with methods that rely solely on color or single-feature descriptors.

An overall recognition accuracy of approximately 95% was observed under controlled lighting and image acquisition conditions. Performance degradation was noted when images were captured under poor lighting or when the notes were severely folded or damaged.

13. Advantages

- Provides fast and automated currency recognition.
- Does not require specialized ultraviolet or magnetic sensors.
- Can be implemented using low-cost hardware.
- Suitable for extension to mobile and embedded platforms.
- Can assist visually impaired users through audio-based feedback systems.

14. Limitations

- Performance depends on image quality and illumination conditions.
- Severely worn or damaged notes may reduce recognition accuracy.
- The current implementation requires controlled acquisition conditions.
- Large variations in currency design may require retraining of the system.

15. Applications

The proposed system can be used in the following applications:

- Banking and financial institutions for preliminary verification.
- Cash deposit and counting machines.
- Retail stores and commercial establishments.
- Mobile applications for public use.
- Assistance tools for visually impaired individuals.
- Automated kiosks and vending machines.

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16. Conclusion

In this project, an image processing based_toggle system for Indian currency recognition and counterfeit detection has been presented. The proposed method uses statistical and edge-based feature extraction techniques to analyze the visual properties of banknotes. A feature matching strategy is employed to classify currency images and identify suspicious samples.

The experimental evaluation demonstrates that the system is capable of recognizing multiple denominations and detecting counterfeit notes with satisfactory accuracy. The low-cost and software-oriented nature of the system makes it suitable for practical deployment in small-scale and educational environments.

17. Future Scope

Future work may focus on integrating advanced machine learning and deep learning models to improve classification accuracy under challenging conditions. The system can also be extended to support foreign currencies such as US dollars and euros. In addition, the development of a smartphone-based application can significantly improve accessibility and real-world usability.

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