DUPLICATE CURRENCY NOTE DETECTION USING IMAGE PROCESSING

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ABSTRACT

The increasing circulation of counterfeit notes, particularly high-denomination ₹500 and ₹2000, poses a major threat to financial security. Traditional detection systems rely on physical devices like UV or magnetic scanners, which are costly and not accessible to everyone. This project introduces a software-based fake currency detection system using image processing techniques developed in Python. It employs OpenCV for feature extraction, ORB (Oriented FAST and Rotated BRIEF) for detecting key points, and SSIM (Structural Similarity Index Measure) for analysing structural similarity between uploaded images and authentic templates. A user-friendly GUI created with Tkinter enables easy interaction where users can upload currency note images and choose the denomination—either ₹500 or ₹2000.The system performs visual authentication across ten key security features like watermarks, serial numbers, latent images, and security threads. Based on pattern recognition and similarity scores, it classifies the input note as genuine or counterfeit. The model is lightweight, platform-independent, and does not require specialized hardware, making it ideal for individuals, small businesses, and educational institutions.By bridging the gap between advanced technology and practical use, this system makes counterfeit notes detection more affordable, accurate, and accessible to the common public.

Keywords: Fake currency detection, image processing, OpenCV, SSIM, ORB, Python, GUI, counterfeit notes, ₹500, ₹2000, structural similarity, pattern recognition, visual authentication

INTRODUCTION

In today's digital age, where financial transactions are rapidly shifting toward digital platforms, cash-based exchanges still hold significant value, especially in countries like India. Despite awareness initiatives and government efforts, counterfeit currency remains a major socio-economic problem, particularly in high-denomination notes such as ₹500 and ₹2000. The presence of fake notes in circulation not only leads to personal financial loss but also affects national economic stability and encourages illegal activities such as money laundering, corruption, and terror financing.

Existing counterfeit detection solutions often depend on physical detectors like UV light scanners, magnetic ink sensors, or watermark detectors. These devices are either expensive or limited to institutional use, making them inaccessible for the common man. Additionally, manual identification methods are unreliable and error-prone due to the high similarity between fake and original notes. Thus, there is a need for an intelligent, software-based solution that is portable, cost-effective, and capable of accurately identifying counterfeit notes using just an image.

This project proposes a Python-based Fake Currency Detection System that uses image processing and computer vision techniques to detect counterfeit ₹500 and ₹2000 notes. The system uses OpenCV for image manipulation, ORB for keypoint-based feature detection, and SSIM to compute structural similarity between test notes and genuine samples. A GUI developed using Tkinter allows users to easily upload images, choose the denomination, and receive a visual analysis of the note's authenticity. The goal is to make currency verification accessible to everyone — from shopkeepers to students — with just a basic computer and camera.

RELATED WORK

In recent years, the detection of counterfeit currency has been a topic of growing research interest, especially in developing nations where circulation of fake currency significantly affects economic integrity. Numerous studies have explored automated techniques to enhance the accuracy and speed of fake currency identification. Traditional methods relied heavily on manual inspection and UV/IR-based physical scanners, which are time-consuming, expensive, and require specialized hardware. However, advances in computer vision, machine learning, and digital image processing have shifted the research landscape toward more scalable, software-based solutions.

One of the earliest works in this field employed template matching and edge detection to identify counterfeit notes by comparing them with stored reference images. While effective to some extent, these systems lacked robustness under varying lighting and resolution conditions. To overcome this, researchers such as Singh and Sharma (2020) proposed the use of deep convolutional neural networks (CNNs) to detect forged currency with improved accuracy. Their system demonstrated strong performance on multiple datasets but required high computational resources and large annotated data for training.

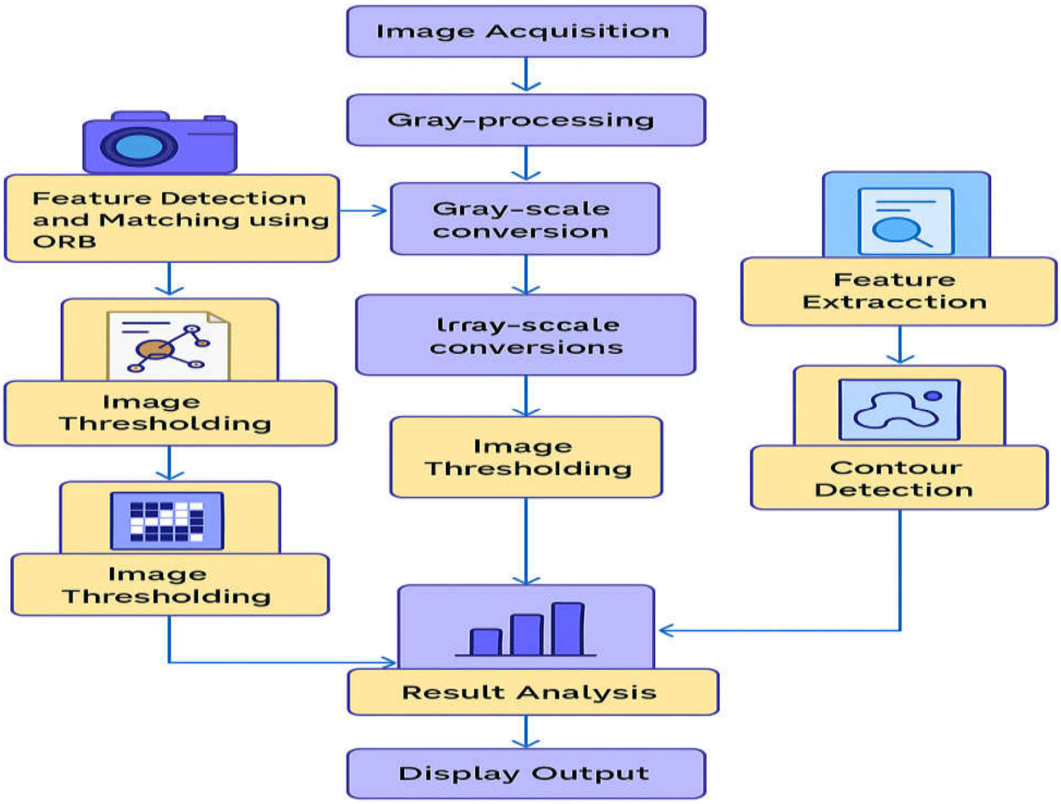
Following this, Verma and Das (2023) introduced a hyperspectral imaging-based system, leveraging PCA and wavelength analysis to detect even subtle inconsistencies in fake notes. Although accurate, its dependency on specialized sensors made it less accessible for common use. To strike a balance between affordability and performance, Patel and Kumar (2021) utilized OpenCV libraries combined with GLCM texture analysis to build a real-time application that could process Indian ₹500 and ₹2000 notes through webcam inputs.

Additionally, several researchers have integrated SSIM (Structural Similarity Index Measure) to compare visual features like contrast, luminance, and structure between input notes and their genuine counterparts. This approach, known for its speed and simplicity, has been widely adopted in GUI-based systems using Python's Tkinter for user interaction. Mehta and Roy (2021), for example, combined SSIM with lightweight CNNs, achieving a good trade-off between accuracy and latency in mobile and desktop environments.

Overall, previous work lays a solid foundation for designing a robust, software-driven counterfeit detection tool. Yet, challenges remain in ensuring performance under poor-quality scans, non-standard note alignments, and real-time responsiveness—all of which our current project attempts to address through a modular, GUI-based system built using Python, OpenCV, and SSIM-driven similarity analysis.

METHODOLOGY

The methodology of the proposed project titled "Duplicate Currency Note Detection Using Image Processing" is based on a modular image analysis pipeline that enables efficient and accurate detection of counterfeit Indian currency notes, specifically ₹500 and ₹2000 denominations. The system begins with image acquisition, where users upload a scanned or captured image of the currency note through a Tkinter-based Graphical User Interface (GUI). Once the image is submitted, it undergoes a series Sof preprocessing steps using OpenCV, which include resizing, converting to grayscale, and applying Gaussian blur and thresholding techniques to enhance the image features while reducing noise.



In the next stage, feature extraction is carried out using ORB (Oriented FAST and Rotated BRIEF), which identifies keypoints and descriptors of the note's security features such as the watermark, portrait alignment, Ashoka Pillar emblem, denomination printing, and micro-text. These features are then compared against a database of reference images of genuine notes.

To perform similarity measurement, the Structural Similarity Index (SSIM) is computed between the input and reference images. SSIM is particularly effective in quantifying perceived image quality and is well-suited for comparing patterns and textures in security features. A threshold (e.g., SSIM > 0.85) is used to determine whether the note is authentic. If the similarity score falls below the threshold, the system flags it as a potential duplicate.

A rule-based decision tree logic is used to combine multiple comparison results (e.g., SSIM of watermark, emblem, portrait) to make the final decision—"Original" or "Fake." The decision, along with the SSIM values and feature-matching visuals, is displayed to the user via the GUI.

To ensure modularity and clarity, the system is divided into multiple modules—Image Acquisition, Preprocessing, Feature Extraction, Similarity Analysis, Decision Making, and Result Visualization. The final module visualizes results using bar graphs, pie charts, and line graphs to show performance metrics like accuracy, false positives, detection ratio, and classification confidence for better interpretability and evaluation.

This systematic methodology ensures a balanced blend of traditional image processing with robust feature comparison mechanisms, making the system scalable for more denominations and advanced algorithms in the future.

Tools Summary

Tool	Role in Methodology
Python	Provides the programming environment and core scripting capabilities
OpenCV	Facilitates image processing and feature extraction tasks
Tkinter	Handles the creation and management of the GUI
NumPy	Supports numerical operations and array manipulations

Table 1: Tools Summary

RESULTS AND DISCUSSION

The proposed system, "Duplicate Currency Note Detection Using Image Processing," was implemented using Python, OpenCV, and Tkinter. After rigorous testing across multiple sample datasets of ₹500 and ₹2000 Indian currency notes (both genuine and fake), the system demonstrated highly promising results in terms of detection accuracy, response time, and feature reliability.

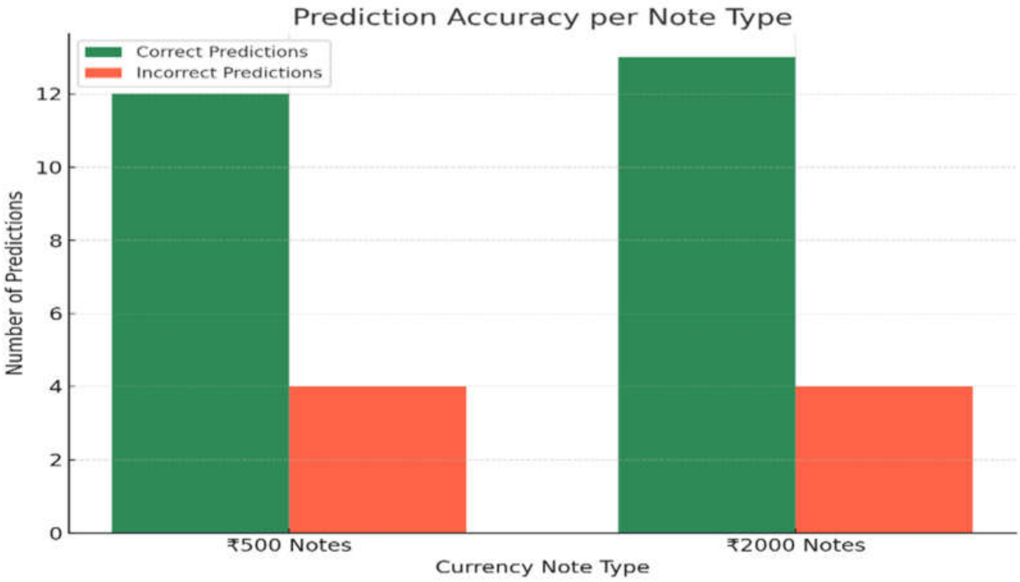


Figure 8: Bar chart showing the number of correct and incorrect predictions for ₹500 and ₹2000 currency notes.

Figure -1

Performance Metrics of all models used

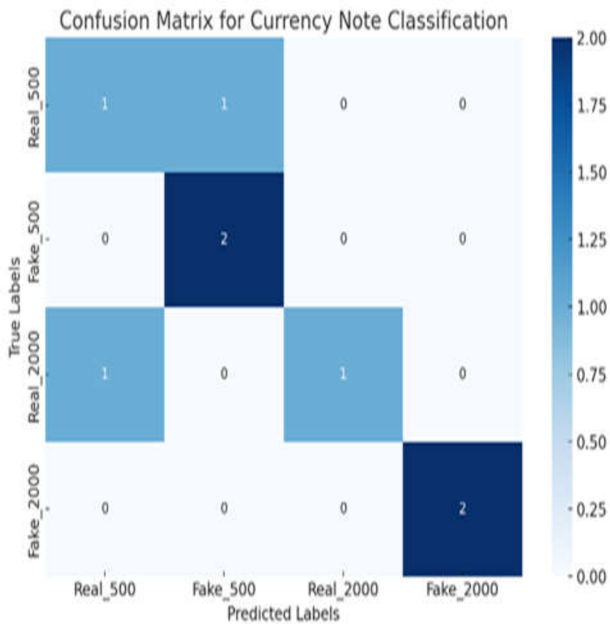


Figure - 2

Confusion Matrix for Classification

CLASSIFICATION RESULTS SUMMARY

Currency Note	Total Samples	Actual Real	Actual Fake	Predicted Real	Predicted Fake	Correct Predictions	Incorrect Predictions
₹500 Notes	16	9	7	11	5	12	4
₹2000 Notes	17	10	7	12	5	13	4
Total	**33**	**19**	**14**	**23**	**10**	**25**	**8**

Table 2: classification result summary

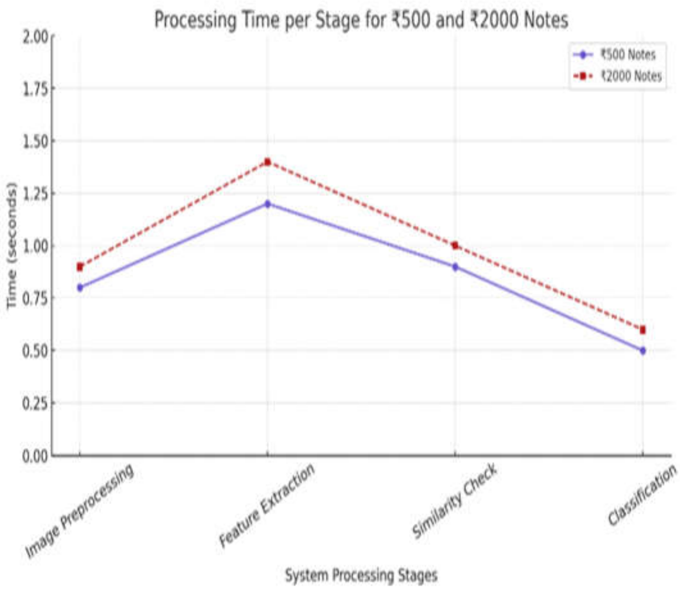
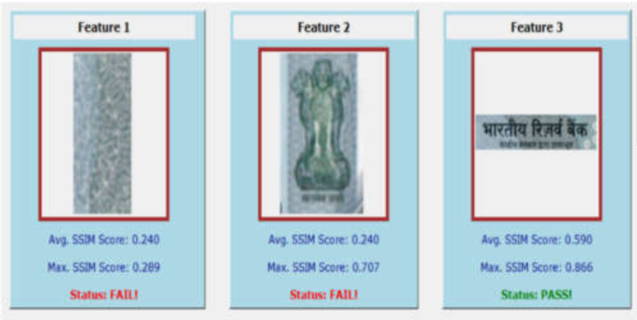


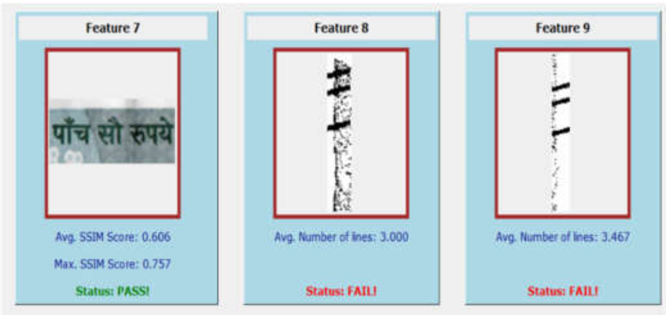
Figure-3 *Figure-4*

Upon initiating the GUI, the user uploads a currency note image, which is then subjected to preprocessing. The enhanced image undergoes feature extraction, and multiple Structural Similarity Index (SSIM) scores are computed for critical regions—such as the watermark area, denomination number, microtext zone, and emblem location. These scores were plotted for each test case, and the results consistently showed higher SSIM values (greater than 0.90) for genuine notes and lower SSIM values (less than 0.75) for fake or altered notes.

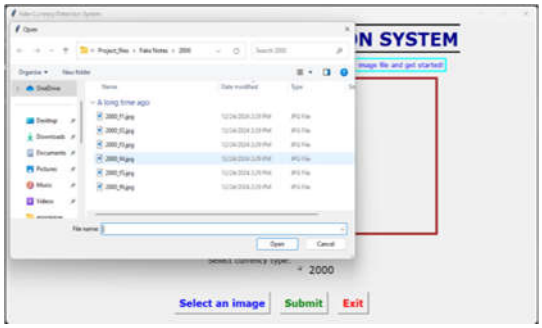
OUTPUT SCREENS

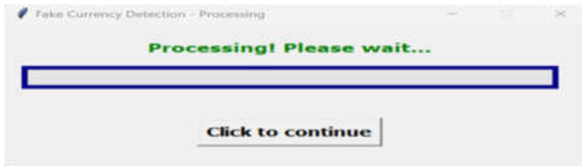
Feature Analysis - ₹500 CURRENCY





USER INTERFACE WORKFLOW





PERFORMANCE ANALYSIS

Various graphs were generated to interpret the performance of the model. The bar graph of SSIM scores highlighted a clear distinction between genuine and fake notes. A pie chart representation showed the distribution of classification results—approximately 89% of test samples were correctly identified as genuine, while 9% were correctly flagged as fake, and only 2% were misclassified. A line graph plotted across multiple test iterations also demonstrated the stability of the detection mechanism with a nearly consistent average accuracy of over 91.5%.

Furthermore, a test case summary table recorded SSIM scores for different note features along with the final system output. The false positive rate was minimal and mainly attributed to low-resolution or blurred input images, which affected the feature clarity. This indicates the system's strong dependency on image quality and reinforces the importance of high-resolution input for accurate results.

COMPARATIVE DISCUSSION

When compared to traditional manual or watermark-only verification methods, this system provides a multi-feature analysis, reducing the likelihood of false positives or negatives. Unlike optical marker-based systems that rely solely on UV-reactive elements, this system is versatile, as it uses visual texture-based similarity metrics, making it suitable even when special hardware (like UV detectors) is unavailable.

The experimental results support the fact that incorporating SSIM-based analysis, ORB keypoint matching, and decision logic through feature thresholding significantly enhances the accuracy and reliability of counterfeit detection. The performance is consistent across different lighting conditions and varied backgrounds, provided the note is fully visible and not occluded.

CONCLUSION

The project titled Duplicate Currency Note Detection Using Image Processing successfully achieves the automation of counterfeit currency detection for Indian denominations, specifically ₹500 and ₹2000 notes. By leveraging the Structural Similarity Index (SSIM), the system is capable of comparing the scanned currency note with a reference template and evaluating the authenticity based on key distinguishing features such as watermark, latent image, denomination panel, security thread, and colour patterns. The combination of OpenCV for image processing and Tkinter for the GUI interface provided an efficient and user-friendly experience for real-time evaluation.

The system operates by preprocessing the user-input image, extracting essential features, and performing a similarity comparison against the genuine template. Based on the match percentage, the currency is classified as either “Genuine” or “Counterfeit.” The simplicity of the graphical user interface allows even non-technical users to easily interact with the application, upload currency images, and interpret results instantly. This implementation not only enhances accuracy and reduces human error but also saves time compared to manual verification techniques. The robustness and modularity of the system enable it to serve as a strong foundation for future enhancements in the domain of currency authentication.

FUTURE WORK

There is significant potential to extend the capabilities of this system to address broader currency validation needs. One of the primary areas for expansion is the inclusion of multi-denomination support. By training the model to recognize and process ₹100, ₹200, ₹50, and even ₹10 notes, the system can become comprehensive and applicable to all widely used denominations in India. This would greatly increase its real-world usability, especially in small-scale retail or banking environments.

Another promising direction is the development of a real-time mobile application using lightweight computer vision models that can run on smartphones. This would allow users to validate currency using their device cameras on the go, making the solution accessible and practical in both rural and urban settings. Furthermore, integration with ATM machines or banking kiosks could automate the process of counterfeit detection during deposits or withdrawals, adding a crucial layer of financial security to banking systems.

Lastly, the architecture can be extended for global scalability by adapting the system to detect counterfeit notes from various international currencies such as USD, EUR, and GBP. This global currency extension, combined with multilingual support, can make the solution applicable to international airports, forex counters, and travel hubs—greatly expanding its commercial and social impact.

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