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Fake Indian Currency Detection

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Abstract*: The proliferation of counterfeit currency poses a significant threat to both individuals and the national economy. While existing fake currency detection tools are primarily accessible to banks and large enterprises, everyday people and small businesses remain susceptible. Thus, this project aims to delve into the security features of Indian currency and develop a software solution leveraging advanced image processing and computer vision techniques to detect and neutralize counterfeit notes. Counterfeiting currency poses a genuine menace to both the populace's well-being and the nation's economic stability. Although counterfeit currency detection tools exist, their accessibility is typically confined to banking institutions and corporate entities, leaving ordinary citizens and small enterprises susceptible to fraud. Thus, this project endeavours to examine the diverse security attributes of Indian currency and subsequently craft a software-driven apparatus capable of discerning and nullifying counterfeit Indian currency through sophisticated image processing and computer vision methodologies. Notably, this currency authentication system will be meticulously crafted using the Python programming language within the Jupyter Notebook framework.

***Keywords*: Fake currency, counterfeit detection, image processing, feature extraction, Brute force matcher, ORB detector.**

I. INTRODUCTION

The proliferation of counterfeit currency, produced through illegal replication of authentic manufacturing processes, poses a significant challenge for nations worldwide. Counterfeit money diminishes the value of legitimate currency and can lead to inflation by artificially inflating the money supply. Manual verification of currency notes is laborious, error-prone, and time-consuming, necessitating an automated solution for efficiently processing large volumes of currency with accuracy.

In response to this need, this project proposes a fake currency detection system employing various image processing techniques and algorithms. Specifically designed to authenticate Indian currency notes of denominations 500 and 2000 rupees, the system comprises three primary algorithms. The first algorithm entails image acquisition, pre-processing, greyscale conversion, feature extraction, image segmentation, and comparison utilizing advanced image processing methods like ORB and SSIM [9][10]. The second algorithm verifies the bleed lines on the currency notes, while the third authenticates the number panel.

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The processed output is then presented for each currency note, offering a seamless and accurate means of currency authentication.

A. Commonly Used Security Features to Detect Fake Notes

1. Bleed lines: Angular bleed lines on 500 and 2000 rupee notes, located in the left and right corners, are embossed in raised print. The 500-rupee note has 5 bleed lines, while the 2000-rupee note has 7.
2. Security Thread: A color-shifting security thread with the inscription "Bharat" (in Hindi), "RBI," and "2000" (or "500" for the 500-rupee note). The thread changes from green to blue when tilted.
3. Latent Image: When the note is held at a 45-degree angle, latent images of the number "2000" or "500" become visible.
4. Watermark: A watermark of Mahatma Gandhi and an electrotype of the numeral "2000" or "500."
5. Denominational Numeral: A see-through register displaying the denominational numeral "2000" becomes visible when the note is held against light.
6. Portrait of Mahatma Gandhi: A portrait of Mahatma Gandhi with "RBI" inscribed on his spectacles, readable with a magnifying glass.
7. Number Panel: Numerals ascending in size are printed on the top left and bottom right sides.
8. Denominational Numeral: A "500" or "2000" in Devanagari script is located to the left of Mahatma Gandhi.
9. Ashoka Pillar: An Ashoka Pillar is present in the bottom right corner.
10. Guarantee and Promise Clause: The RBI's guarantee and promise clause is printed in Devanagari and English in the top left and right corners, respectively.
11. RBI Seal: The RBI seal is positioned just below the Governor's signature, along with other features printed in intaglio.
12. Denominational Value in Words: The currency note's value in Devanagari script appears in the top central region.

II. LITERATURE REVIEW

[1] This study presents an automated system devised to distinguish between genuine and counterfeit Indian currency notes. Such a system holds significant utility not only within the banking sector but also across various other domains. India has witnessed a surge in fake currency notes, particularly in denominations of 100, 500, and 1000 rupees, owing to advancements in technology facilitating scanning, color printing, and duplication. The proposed model initiates with image acquisition followed by preprocessing steps involving cropping, smoothing, and adjustment, subsequent conversion to grayscale, image segmentation, feature extraction and reduction, and ultimately, image comparison.

[2] This study details an automated system developed in MATLAB for detecting counterfeit Indian paper currency notes, leveraging feature extraction techniques within the HSV color space and other image processing methodologies. The proposed architecture comprises several key steps: Image Acquisition, Gray-Scale Conversion, Edge Detection, Image Segmentation, Characteristic Extraction, Comparison, and Output. During the project setup, a camera captures images of currency notes for analysis by the MATLAB program installed on a computer. This algorithm is tailored for denominations of Indian currency notes including 100, 500, and 1000 rupees. Upon analysis, if the note is found to be genuine, an appropriate message is displayed on the screen; conversely, if it is counterfeit, the system provides corresponding feedback.

[3] This paper introduces a hybrid model for detecting counterfeit Bangladeshi currency notes, implemented using MATLAB. The model combines three distinct image processing algorithms: Optical Character Recognition (OCR), Hough Transformation, and Face Recognition (MSD), aimed at achieving improved detection outcomes. The proposed model follows a systematic approach consisting of six fundamental steps: data collection, pre-processing, edge detection, feature extraction, identification, and output generation. Despite a slightly longer processing time, the hybrid model exhibits a remarkable accuracy of 93.33%, surpassing the performance of individual algorithms when tested separately.

[4] This paper explores two methods for detecting counterfeit currency notes: hyper spectral imaging analysis and feature extraction comparison. Hyper spectral imaging involves using various colored lights, including Ultraviolet (UV), Normal LED, Red LED, Green LED, and Blue LED, across different wavelengths from 360 nm to 800 nm. These methods are implemented using MATLAB, incorporating image processing algorithms for counterfeit note detection. Experimental findings suggest that the implemented techniques yield nearly accurate results in distinguishing between fake and genuine currency notes.

[5][6][7][8] This paper elucidates the process of recognizing and verifying paper currency utilizing image processing techniques. The proposed methodology encompasses various stages including Image Acquisition, Feature Extraction and Comparison, Texture Features, and Voice Output. The system is bifurcated into two segments: the initial segment focuses on identifying the currency denomination through image processing, while the subsequent segment delivers oral output to inform visually impaired individuals about the denomination of the note in their possession. The desired outcomes entail both textual and vocal representations of the recognized and verified currency.

III. METHODOLOGY

1. Dataset Preparation:
- Compile a dataset containing images of both genuine and counterfeit currency notes, along with images depicting various security features of each note.
- Organize the dataset into sub-categories for Rs. 500 and Rs. 2000 currency notes, each containing images of real and fake notes, as well as multiple images representing each security feature.

2. Image Acquisition:
- Obtain high-quality images of test currency notes using a digital camera or scanner, ensuring proper resolution, brightness, and clarity.

3. Pre-processing:
- Resize the acquired images to a fixed size for uniformity in subsequent computations. o Apply Gaussian blurring to smoothen the images and reduce noise, thereby enhancing the efficiency of the system.

4. Gray-scale Conversion:
- Convert the pre-processed images to grayscale to simplify computation, as grayscale images have a single channel compared to the three channels of RGB images.

5. Algorithm-1: Feature Detection and Matching (Features 1-7):
- Utilize the ORB algorithm for feature detection and matching. o Define search areas within the test currency image to facilitate template detection.
- Highlight detected features using markers for clarity.
- Extract detected features, crop corresponding areas within the test image, and apply grayscale conversion and Gaussian blurring. o Compare matched portions of the test currency image with templates using the Structural Similarity Index (SSIM) method for accurate identification of corresponding features.

6. Algorithm-2: Authentication of Bleed Lines:
- Implement a method to authenticate bleed lines on currency notes, comparing the detected lines with predetermined patterns for genuine notes.

7. Algorithm-3: Authentication of Number Panel:
- Develop an algorithm to authenticate the number panel on currency notes, comparing the detected panel with predefined characteristics of genuine notes.

8. Integration and Output:
- Integrate the algorithms to create a comprehensive currency authentication system. o Display processed outputs for each currency note, indicating authenticity or detecting counterfeit notes.

9. Evaluation:
- Evaluate the performance of the system using a test dataset containing a mix of genuine and counterfeit currency notes. o Assess the accuracy, efficiency, and reliability of the system in detecting fake currency.

10. Optimization and Refinement:
- Fine-tune the algorithms and parameters based on evaluation results to improve system performance and accuracy.
- Address any identified limitations or challenges in the methodology through optimization and refinement efforts.

11. Documentation and Reporting:
- Document the entire methodology, including dataset preparation, algorithm implementation, evaluation results, and optimization steps. o Prepare a comprehensive project report highlighting the methodology, findings, conclusions, and recommendations for future enhancements or research directions.

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IV. RESULTS AND DISCUSSIONS

A. Results

The proposed currency authentication system employs image processing techniques to authenticate input currency note images. These images undergo processing through various algorithms, where each extracted feature is meticulously scrutinized. The results are determined as follows:

- Algorithm 1 (Features 1-7): This algorithm computes the average and maximum Structural Similarity Index (SSIM) scores for each feature. A feature is deemed authentic if its average SSIM score surpasses a predefined threshold (to be determined through testing). Alternatively, a feature passes if its maximum SSIM score is notably high, likely exceeding 0.8.
- Algorithm 2 (Features 8-9): This algorithm calculates the average number of bleed lines present on the left and right sides of a currency note. A feature passes if the average number of bleed lines closely approximates 5 for Rs. 500 notes and 7 for Rs. 2000 notes.
- Algorithm 3 (Feature 10): This algorithm determines the number of characters within the number panel of the currency note. The feature is authenticated if the detected number of characters equals 9 for at least one threshold value.

A. Performance Analysis: The performance analysis of the system was conducted using a variety of currency note images, encompassing both genuine and counterfeit specimens. The dataset included real and fake notes of denominations Rs. 500 and Rs. 2000. The accuracy was determined based on the number of features passed. For real notes, an accuracy of 79% was achieved, while for fake notes, the accuracy reached 83%.

B. Time Analysis: The system, implemented in Python within the Jupyter Notebook environment, exhibits efficient processing times. When printing all data related to feature examination, including over 100 images, the system takes approximately 35 seconds per input image. However, if only final results are displayed, the processing time reduces to just 5 seconds per input image. Thus, in practical terms, the model takes around 5 seconds to provide results for each input image.

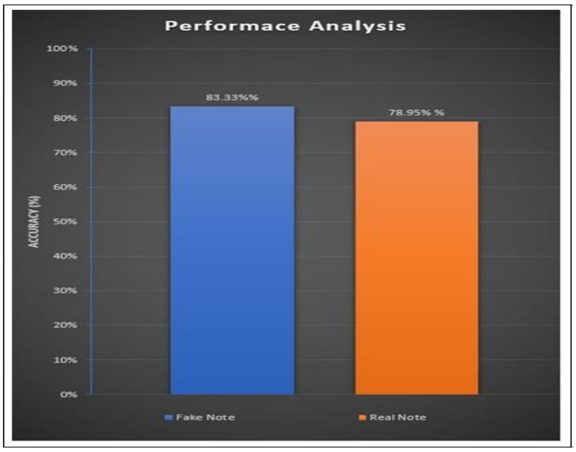

Fig. 1: Performance Analysis Graph

B. Discussion

Certainly! Let's delve into the discussion on detecting and recognizing fake Indian currency notes:

1. **Methodologies and Techniques:** Various methodologies and techniques have been explored in research and projects to detect fake Indian currency notes. These include image processing algorithms, machine learning models, and hybrid approaches. Each technique has its strengths and limitations, with some focusing on feature extraction and others on pattern recognition.
2. **Performance Evaluation:** Evaluating the performance of detection models is crucial to understand their effectiveness. Metrics such as accuracy, speed, and robustness are commonly used to assess the performance of these models. While some studies report high accuracy rates, others face challenges in real-world scenarios due to variations in currency designs and counterfeit sophistication.
3. **Challenges and Limitations:** Detecting fake currency notes poses several challenges, including variations in currency designs, image quality issues, and the sophistication of counterfeiters. Additionally, the need for real-time processing in banking and retail environments adds complexity to the detection process. Ensuring the reliability and accuracy of detection models in the face of these challenges is a key area of focus.
4. **Data Availability and Dataset Challenges**: The availability and quality of datasets play a crucial role in training and testing detection models. However, obtaining diverse and representative datasets can be challenging due to privacy concerns and legal restrictions. Additionally, ensuring the accuracy and reliability of labeled data is essential for building effective detection systems.
5. **Ethical and Legal Implications:** Deploying fake currency detection systems raises ethical and legal considerations, including privacy concerns, algorithmic biases, and compliance with regulations. Ensuring transparency and accountability in the development and deployment of these systems is essential to address these concerns and maintain public trust.
6. **Future Directions and Research Opportunities:** Future research in fake currency detection could focus on developing novel algorithms, integrating blockchain technology for secure transactions, and leveraging advanced sensors for physical currency authentication. Collaborative efforts between academia, industry, and government agencies can drive innovation and address emerging challenges in this field.
7. **Practical Applications and Deployment Challenges:** While fake currency detection systems have applications in banking, retail, and law enforcement, deploying these systems at scale presents challenges. Integration with existing infrastructure, costeffectiveness, and user acceptance are key factors to consider when deploying detection systems in real-world settings.
8. **International Collaboration and Standardization**: Collaborative efforts and standardization initiatives at the international level are essential for combating counterfeit currency globally.

Sharing best practices, information, and resources can help improve detection capabilities and enhance coordination among stakeholders.

By addressing these points, stakeholders can gain a comprehensive understanding of the complexities and considerations involved in detecting and recognizing fake Indian currency notes, paving the way for effective solutions and strategies to combat counterfeit currency.

V. CONCLUSION

In conclusion, this paper presents a comprehensive fake currency detection model tailored for authenticating Indian currency notes of denominations Rs. 500 and Rs. 2000. Leveraging the OpenCV image processing library in Python3, the model meticulously examines 10 distinct features of the input currency note through three specialized algorithms. The process initiates with the user inputting the currency image via a user-friendly graphical interface (GUI), facilitating ease of operation. Through rigorous analysis, each feature undergoes thorough scrutiny, and the results are meticulously computed. The developed GUI further enhances user interaction by providing detailed insights into the analysis of each feature. Notably, the model demonstrates efficient processing, requiring only about 5 seconds to deliver results, particularly when unnecessary details are omitted, ensuring practical usability.

The performance evaluation showcases commendable accuracy rates, with the model achieving approximately 79% accuracy in detecting genuine currency and 83% accuracy in identifying counterfeit currency. These results underscore the effectiveness and reliability of the proposed model in discerning between genuine and counterfeit currency notes. Overall, this study contributes a robust solution to the pressing issue of counterfeit currency detection, offering a practical and efficient tool for safeguarding financial integrity. The model's ability to achieve high accuracy rates while maintaining swift processing times makes it a valuable asset for combating counterfeit currency proliferation, thereby bolstering confidence in the authenticity of Indian currency notes

DECLARATION STATEMENT

Authors are required to include a declaration of accountability in the article, counting review-type articles, that stipulates the involvement of each author. The level of detail differs; Some subjects yield articles that consist of isolated efforts that are easily voiced in detail, while other areas function as group efforts at all stages. It should be after the conclusion and before the references.

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Availability of Data and Material	Yes, It is relavant. The dataset used for this project was images of Fake and Real 500 and 2000 indian rupee notes.
Anthors Contributions	Each author has made an independent contribution to the article. The individual contributions of each author are presented below for clarity and transparency. Aneena Babu is the main contributor and Ms. Vineetha Sankar's is the project guide.

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Aneena Babu, currently pursuing Master of Science in Computer Science from the prestigious St. Albert's College (Autonomous), Ernakulam. Prior to this she had completed his Bachelor of Science degree in Computer Science from S N Arts and Science College, Kedamangalam. Her area of interests includes prominent fields like IoT, Networking, Software Testing, Software Developer, Front End Developer. She is given attention to details as well as she is able to think outside the box, she loves to solve problems and has been keenly observing the latest technology. When she is not studying or working on new projects, she enjoys to read books, explores the nature. she is an active member of the Computer Science community and coordinates in various events conducted.

Ms. Vineetha Sankar's career journey is a combination of academic excellence and industry experience. After completing her undergraduate studies from St. Teresa's College, Ernakulam she went on to pursue her M.C.A in Computer Applications from College of Applied Sciences, Palakkad, and made a smooth transition from the industry to academia. Her three years of working in the tech industry has undoubtedly helped her to develop her teaching methods and provide her students with real-world insights. Currently, Ms. Vineetha Sankar works as an Assistant Professor at St. Albert's College (Autonomous), Ernakulam where she contributes to the academic community beyond the classroom. Her commitment to teaching, research, and mentorship has enabled her to establish herself as an educator who is dedicated to developing the next generation of computer science professionals.

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