Fake Currency Detection using Image Processing

Project submitted to the

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for the partial fulfillment of the requirements to award the degree of

Bachelor of Technology

In

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School of Engineering and Sciences

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Certificate

Date: 25-Nov-24

This is to certify that the work present in this Project entitled "**Fake Currency Detection using Image Processing** " has been carried out by **[Siddharth , Moesha , Sravya , Aksith]** under my/our supervision. The work is genuine, original, and suitable for submission to the SRM University – AP for the award of Bachelor of Technology/Master of Technology in **School of Engineering and Sciences**.

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Acknowledgements

We are appreciative of our advisor, Dr. Ravi Kanth Kumar, who has served as our mentor and advisor throughout the project, providing us with guidance on the precise nature of our research.

Next, I want to sincerely thank our college, SRM University AP, for giving us the opportunity to do research as part of our course work. We had to learn to think critically and to extend our horizons by this experience.

We have recently developed an interest in research, so when we learned about this opportunity, we were thrilled to seize it. We also considered how it would benefit us should we decide to pursue a master's degree abroad by helping us secure a research publication in our names.

We are also appreciative of this project because everyone was able to contribute in some way, which made it easier to complete and finish quickly.

Our main worry was that we might graduate from college with a degree that only included our academic standing. However, when we learned that our college was giving us the chance to conduct research under supervision or guidance, it made us feel better about ourselves outside of our coursework. We will be conducting research as part of our curriculum, and with the right guidance, we also hope that the research paper we will submit for the final will be published and be of great assistance to us.

I also want to sincerely thank Dr. Ravi Kanth Kumar, the Project organizer. Thank you so much, sir, for helping us approach or meet with our faculty members on a regular basis and showing them our progress. We also appreciate you setting deadlines for activities like monthly assessments and report submissions, which really forced us to consider devoting some of our time to the project and moving forward accordingly.

We sincerely appreciate you allowing us to thank each and every participant in Project and for directing us in the right direction.

Abstract

The increasing prevalence of counterfeit currency poses significant challenges to financial systems worldwide. This project, *Fake Currency Detection Using Image Processing*, presents a robust and automated approach to identifying counterfeit currency notes by leveraging advanced image processing techniques. The system evaluates a given currency note against a set of predefined features using Structural Similarity Index (SSIM) for template matching and ORB (Oriented FAST and Rotated BRIEF) for feature extraction and comparison.

The solution is designed to detect key security features such as watermarks, microtext, and emblematic symbols, ensuring the reliability of currency authentication. The framework includes modules for preprocessing, feature-based analysis, and classification, which collectively determine whether a currency note is genuine or counterfeit. The results are presented in an intuitive format, including visualizations of matching patterns, statistical analysis of SSIM and ORB scores, and probabilistic assessments.

This system is scalable to different denominations and adaptable for real-world applications, including banking, retail, and automated teller machines (ATMs). By integrating image processing with statistical evaluation, the proposed solution offers a cost-effective and efficient alternative to traditional counterfeit detection methods, ensuring enhanced security in currency transactions.

Keywords: Fake Currency Detection, Image Processing, Structural Similarity Index, ORB(Oriented FAST and Rotated BRIEF) , Feature Extraction

KEY OBJECTIVES

 Develop an Automated Detection System

- Create a system capable of distinguishing between genuine and counterfeit currency notes using advanced image processing techniques.

 Feature-Based Analysis

- Focus on identifying critical security features such as watermarks, microtext, emblems, and symbolic patterns specific to the currency denomination.

 Implementation of Image Processing Techniques

- Utilize **Structural Similarity Index (SSIM)** for similarity evaluation between the input note and predefined templates.
- Employ **ORB (Oriented FAST and Rotated BRIEF)** for robust feature extraction and matching.

 Classification and Evaluation

- Classify notes as "REAL" or "FAKE" based on thresholds for SSIM scores and ORB feature matches.
- Perform a statistical analysis to compute probabilities of authenticity.

 Visualization and Interpretation

- Provide visual outputs, including match overlays and evaluation matrices, to aid user understanding and interpretation of results.

 Scalability and Adaptability

- Ensure the system is scalable for different denominations and adaptable to various currency designs across regions.

 Cost-Effective and Efficient Solution

- Develop a low-cost yet highly effective solution suitable for industries like banking, retail, and vending systems.

Introduction

Money drives economic activities like manufacturing, circulation, and consumption. It serves as a foundation for investments and savings, making it crucial in today's dynamic society. However, the economy faces challenges such as the creation and use of counterfeit currency, which negatively impacts the public. Counterfeit currency, especially in denominations like ₹500 and ₹1,000, is difficult to distinguish from genuine notes, affecting everyone from small vendors to larger establishments.

Counterfeit money has global implications and is a significant issue in India. Banks reported losing ₹16,789 crores in 2016–17 due to fraud, as per the Reserve Bank of India's (RBI) fraud monitoring report. The RBI's annual report for 2021–22 highlighted an alarming increase in counterfeit notes across various denominations, including a 101.9% rise for ₹500 (new design) notes and a 54.6% rise for ₹2,000 notes.

Counterfeiting contributes to inflation and damages the economy. Fake Note Detection Machines are a common tool for identifying counterfeit money, but these devices are typically only available in banks, making them inaccessible to the general public.

Digital image processing offers a viable solution to this problem. By leveraging techniques that process and analyze digital images, specific features such as watermarks and patterns can be identified. For example, watermarks on counterfeit currency are created using opaque ink and specific dyes, making them detectable with proper analysis. Tourists and individuals unfamiliar with local currency are particularly vulnerable, emphasizing the need for accessible detection systems.

The proposed system for detecting counterfeit ₹2,000 Indian notes is practical and affordable. It preprocesses digital images, analyzes predefined features, and determines the authenticity of the currency. This system could benefit not only individuals but also various industries, enhancing the reliability of financial transactions.

TOOLS AND TECHNOLOGIES USED

1. **Programming Languages**
   - **Python**: For developing the detection algorithm due to its vast libraries and ease of use in image processing.
   - **MATLAB**: (Optional) For advanced image processing tasks and algorithm prototyping.
2. **Libraries and Frameworks**
   - **OpenCV**: For image processing, feature extraction, and analysis.
   - **NumPy**: For numerical operations and matrix handling in image analysis.
   - **Pillow (PIL)**: For image manipulation and preprocessing.
   - **Scikit-image**: For additional image processing functionalities.
   - **TensorFlow/PyTorch**: (Optional) For implementing machine learning models to enhance accuracy in distinguishing genuine and counterfeit notes.
   - **Tesseract OCR**: For text extraction from notes (if textual features are included in verification).
3. **Development Tools**
   - **Jupyter Notebook**: For interactive development and testing of algorithms.
   - **Integrated Development Environment (IDE)**: Such as PyCharm, Visual Studio Code, or MATLAB IDE for streamlined coding.
   - **Git**: For version control and collaboration.
4. **Hardware**
   - **Camera or Scanner**: For capturing high-resolution images of currency notes.
   - **Computing Device**: Laptop or PC with adequate processing power to run image processing algorithms.
   - **GPU (Optional)**: For accelerating machine learning or deep learning models.
5. **Operating System**
   - **Windows/Linux/MacOS**: Compatible across all platforms.

These tools and technologies form a robust framework for building and implementing the fake currency detection system.

KEY ATTRIBUTES - Features of Currency

All features of Indian currency 2000 showing in fig

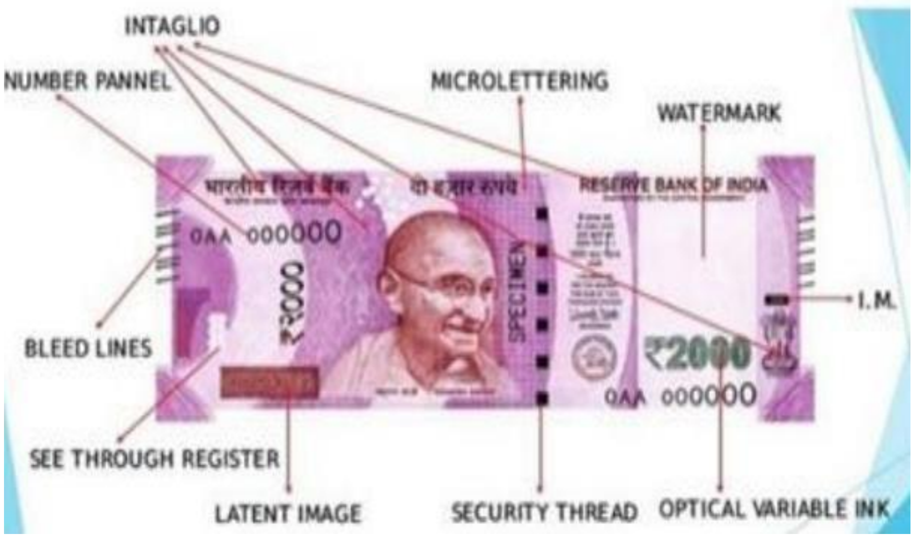

Fig 3.1: All security features of Indian currency 2000[3]

Portrait of Mahatma Gandhi at the Center:

The intaglio printing of the portrait of Mahatma Gandhi at the center of the currency.

Fig 3.2: Portrait of Mahatma Gandhi[1]

Security Thread:

When held up to the light, the security thread, which has "RBI" and "Bharat" inscribed on it continually, can be seen at the left side of the watermark.

The photo of the Mahatma has a security thread on one side.

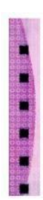

Fig 3.3: Security Thread[1]

See through Register:

The denomination numeral is displayed in the see-through register. Both sides of this register are printed. One side of the two sides is hollow, and the other side is filled with material. The micro lettering has been written horizontally along this register. The note has a latent image on the left side. Moreover, this register is shown above the latent image. When viewed in contrast to the light, this register appears as a single design.

Fig 3.4: See through Register[1]

On the right side of the coin there is a picture of the Ashoka pillar.

Fig 3.5: Ashoka Pillar[1]

Identification Mark:

Just over the Ashoka's pillar symbol, there is an identification mark.

Fig 3.6: Identification Mark[1]

Guarantee Clause:

Located to the right of Mahatma Gandhi's image, the guarantee clause is signed by the governor and includes a promise clause that is printed in intaglio.

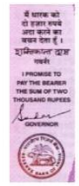

Fig 3.7: Guarantee Clause[1]

Currency Numeral with the Rupees Symbol:

Fluorescent ink will be used for printing. When viewed from different perspectives, the numerals change.

Fig 3.8: Currency Numeral with the Rupees Symbol[1]

Government of India:

The words "Government of India" are printed at the top of the one rupee note, directly over the Devanagari-script number one.

Fig 3.12. Government of India[1]

Flowchart:

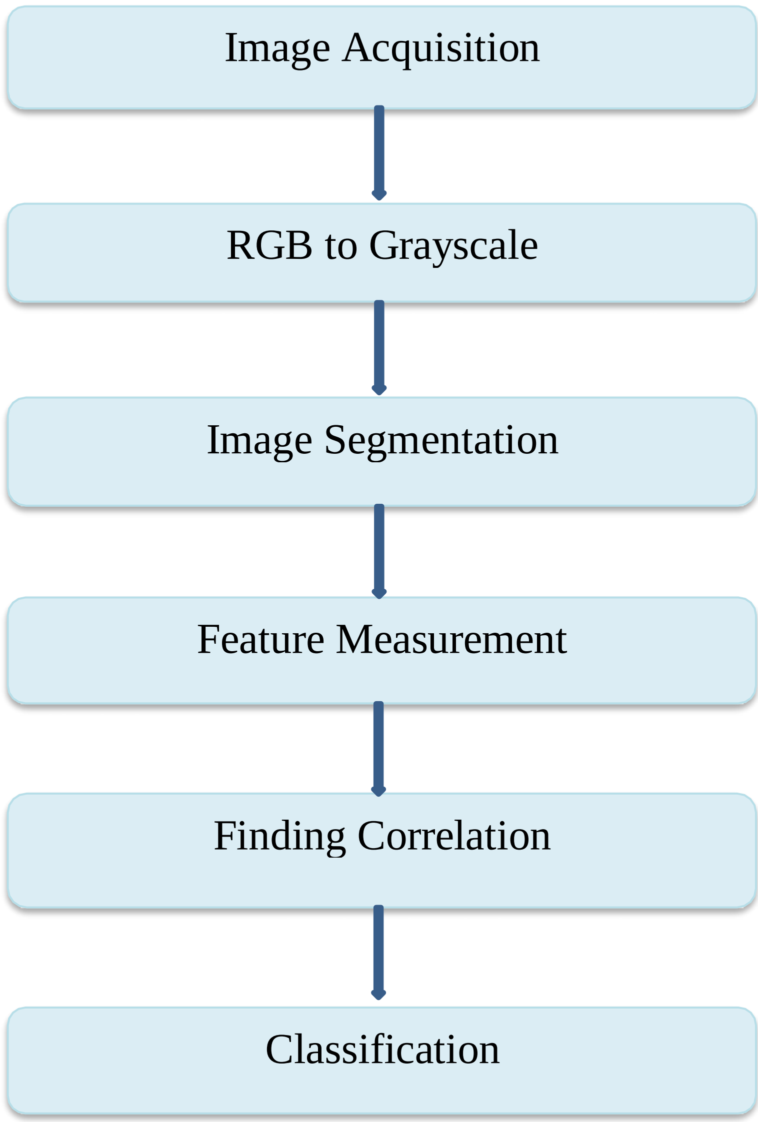
Image Acquisition
RGB to Grayscale
Image Segmentation
Feature Measurement
Finding Correlation
Classification

METHODOLOGY FOR FAKE CURRENCY DETECTION

The fake currency detection process leverages **image processing** techniques and algorithms such as SSIM (Structural Similarity Index) and ORB (Oriented FAST and Rotated BRIEF). Here's a detailed breakdown of the methodology:

1. Dataset Preparation

- **Input Data**:
  - A dataset of scanned images of ₹2000 notes is prepared. These include features such as:
    - ₹2000 Symbol.
    - Indian Emblem.
    - "भारतीय रिजर्व बैंक" Symbol.
    - "RESERVE BANK OF INDIA" Symbol and other features.
  - Both real and counterfeit currency images are included for comparative analysis.
- **Storage**:
  - Each feature is stored in a dedicated folder within a structured directory.

2. Image Preprocessing

- **Steps**:
  - Images are resized to ensure uniformity for feature comparison.
  - Color images are converted to grayscale for simplified computations.
  - Noise in images is minimized using filters such as Gaussian blur to enhance feature visibility.
- **Visualization**:
  - Preprocessed images are displayed for verification.

3. Feature Detection Using Image Processing Techniques

Two primary techniques are used to detect and verify features in the currency notes:

A. Structural Similarity Index (SSIM)

- **Purpose**: Compares the structural features of two images to measure their similarity.
- **Steps**:
  1. Resize both the template and query images to the smallest common dimensions.
  2. Convert images to grayscale for structural comparison.
  3. Compute the SSIM score, which lies between -1 (completely dissimilar) and 1 (identical).
- **Output**:
  - High SSIM score indicates a close match between the note's feature and the template.

B. ORB (Oriented FAST and Rotated BRIEF)

- **Purpose**: Detects keypoints and descriptors in images for feature matching.

- **Steps**:
  1. Detect keypoints and extract descriptors from the template and query images.
  2. Use a brute-force matcher to compare descriptors and find matches.
  3. Apply homography to identify spatial transformations between template and query images.
  4. Count the number of ORB matches to assess similarity.
- **Output**:
  - A higher number of matches indicates stronger similarity between the images.

4. Feature-Specific Analysis

- For each feature (e.g., ₹2000 Symbol, Indian Emblem), the process is as follows:
  1. Load the currency image and corresponding feature templates.
  2. Perform SSIM analysis to calculate the structural similarity.
  3. Perform ORB analysis to identify and match feature keypoints.
  4. Log the results of SSIM scores and ORB match counts for each feature.

5. Thresholding and Decision Making

- **Threshold Values**:
  - SSIM Threshold: 0.1 (features with scores below this are flagged as fake).
  - ORB Matches Threshold: 120 (features with fewer matches are flagged as fake).
- **Evaluation**:
  - For each feature:
    - If the majority of templates fail the threshold checks, the feature is marked as **FAKE**.
    - Otherwise, it is marked as **REAL**.

6. Final Classification

- Count the number of features classified as **REAL** and **FAKE**.
- If the majority of features are fake, classify the note as **FAKE**; otherwise, it is **REAL**.

7. Visualization

- **Bar Chart**: Displays the count of real vs. fake classifications for each feature.
- **Pie Chart**: Shows the probability distribution between "REAL" and "FAKE" classifications.

8. Export and Reporting

- The results, including feature-wise classification and final decision, are saved as a CSV file for further analysis.

RESULTS

The project successfully detects the authenticity of the currency based on the values that are received from the ssim score and orb matches for each template of each feature of the note.

CONCLUSION

This project successfully demonstrates a systematic and practical approach to detecting counterfeit currency using digital image processing techniques. By leveraging **Structural Similarity Index (SSIM)** and **ORB (Oriented FAST and Rotated BRIEF)** feature matching algorithms, the system evaluates various security features of currency notes to classify them as real or fake. The methodology incorporates multiple steps, including feature extraction, similarity computation, and visual inspection, to ensure robustness and reliability in the results.

Key Outcomes:

1. **Feature-Based Detection**:
    - The project uses predefined security features of the ₹2000 Indian currency note, such as the watermark, Indian Emblem, and textual symbols, to differentiate genuine notes from counterfeits.
    - SSIM scores highlight structural similarity, ensuring precise detection of forgery in subtle details.
    - ORB matches provide feature-based validation, adding another layer of accuracy.
2. **Automation and Scalability**:
    - The system is capable of analyzing multiple features efficiently and can easily be extended to detect counterfeit notes of other denominations or currencies.
    - The modular structure of the implementation allows for the addition of new features or techniques, ensuring adaptability to evolving counterfeiting tactics.
3. **User-Friendly Visualizations**:
    - Stacked bar charts and pie charts provide clear insights into the analysis, helping users understand the evaluation results and probabilities for authenticity.
4. **Accuracy and Thresholding**:
    - The defined thresholds for SSIM and ORB ensure that the system provides reliable classifications.
    - The classification matrix distinguishes between "REAL" and "FAKE" notes with a balanced approach to minimize false positives and negatives.

FUTURE SCOPE

While the current project effectively detects counterfeit ₹2000 Indian currency notes using **image processing** techniques like SSIM and ORB, there are several avenues for improvement and extension that can be explored to further enhance its capabilities. Below are some potential future directions for this project:

1. Integration of Machine Learning Models

- **Deep Learning for Feature Extraction**: Incorporating deep learning techniques, such as Convolutional Neural Networks (CNNs), for automatic feature extraction can enhance detection accuracy. CNNs can learn to recognize even subtle differences between genuine and counterfeit notes that might be missed by traditional image processing methods.

2. Real-Time Detection System

- **Mobile and Embedded Systems**: The system could be implemented on mobile phones or embedded devices (e.g., Raspberry Pi) for real-time currency verification. This would allow users to quickly scan and verify currency notes using their smartphones or small-scale devices, making it more accessible to the general public.
- **Video Surveillance**: Real-time counterfeit detection could be incorporated into video surveillance systems, enabling automated checks for counterfeit currency during cash transactions at retail outlets, banks, or ATMs.

3. Multi-Currency Support

- **Global Currency Detection**: The system can be extended to support the detection of counterfeit notes from other countries. By training the system on different currency features, such as watermarks, security threads, and holograms specific to other currencies, the system could be adapted to detect counterfeits worldwide.
- **Dynamic Feature Extraction**: Instead of relying on static templates for specific features like the watermark or emblem, the system can use feature extraction techniques that adapt to various currencies and their respective security measures.

4. Incorporating More Complex Features

- **UV and Infrared Detection**: Some security features in currency notes are only visible under ultraviolet (UV) or infrared (IR) light. Incorporating hardware capable of capturing UV and IR images could add another layer of security to the counterfeit detection system.
- **Microprinting and Holograms**: Many modern currencies include microprinting and holographic patterns that are difficult to replicate. By enhancing the detection system to identify these features, the accuracy and reliability of the system can be significantly improved.