Fake Currency Detection using Image Processing

1. Problem Statement

Circulation of counterfeit currency has become a serious concern for financial institutions and the economy. Manual detection methods are not always reliable and require skilled staff. As counterfeiters adopt advanced printing technologies, distinguishing genuine notes from fake ones becomes more challenging. To overcome these issues, there is a need for an automated and accurate system based on image processing and artificial intelligence**.**

2. Motivation

1. Fake notes reduce trust in financial transactions and affect economic stability.
2. Manual and traditional detection tools are time-consuming and error-prone.
3. Automated detection using image processing and AI provides fast, reliable, and scalable solutions.

3. Objectives

1. To explore and analyze different techniques of image processing for counterfeit note detection.
2. To compare machine learning and deep learning models in terms of accuracy and efficiency.
3. To design a framework that can be implemented on mobile and computer platforms for real-time use.

4. Introduction

Fake notes pose a serious threat to economic stability and public trust. Detecting counterfeit currency through automated systems reduces human error and speeds up financial transactions. The aim of this project is to build an image processing-based system that detects the authenticity of Indian banknotes using computer vision and deep learning**.**

5. Related Work

Sr. No.	Study	Features	Methodology	Research Gaps
1	Identification of Counterfeit Indian Currency… (AlexNet TL), ICAIS 2023 (IEEE).	AlexNet Transfer Learning	Deep CNN for Indian notes	Limited dataset, tested only in lab
2	Automatic Counterfeit Currency Detection Using a Novel Snapshot-Based Hyperspectral Imaging, Sensors (MDPI), 2023.	Hyperspectral Imaging	Snapshot spectral signatures	Requires costly hardware
3	Fake Currency Detection Using CNN & Image Processing, ICCCNT 2024 (IEEE).	ROI + CNN	Preprocessing + CNN classification	Accuracy drops under noisy conditions
4	Banknote Authentication dataset (wavelet features), 2013.	Wavelet Features	SVM and Random Forest	Old dataset, lacks new denominations
5	Deep Learning-Based Fake Banknote Detection System,Journal of Emerging Technologies and Innovative Research.	CNN-based	Deep learning (~98% accuracy)	Not tested in diverse environments

6. Methodology

The proposed system follows the following stages:

1. **Image Capture:**
   Capturing images of currency notes using a camera or synthetic generator.

2. **Preprocessing:**
   - Images resized to 224×224
   - Normalized (0–1 range)
   - Augmentation for robustness against lighting and orientation

3. Model Architecture:

- **Pretrained Model:** MobileNetV2 (ImageNet weights)
- **Added Layers:** Global Average Pooling → Dense(256, ReLU) → Dropout → Softmax output
- **Optimizer:** Adam (learning rate = 1e-4)
- **Loss:** Categorical Crossentropy
- **Epochs:** 15
- **Batch Size:** 16
- **Validation Split:** 20%

4. Training Framework:
Model trained on Google Colab (GPU enabled) using TensorFlow 2.12.

5. Fine-Tuning:
Unfreezing last 30 layers of MobileNetV2 and retraining with a lower learning rate (1e-5).

6. Evaluation Metrics:
Accuracy, Precision, Recall, and Loss.

7. Results

The model was implemented and trained on Google Colab using TensorFlow 2.12 and GPU acceleration. Training and validation datasets were generated from the synthetic dataset consisting of six denominations (₹10 to ₹500).

Performance Summary

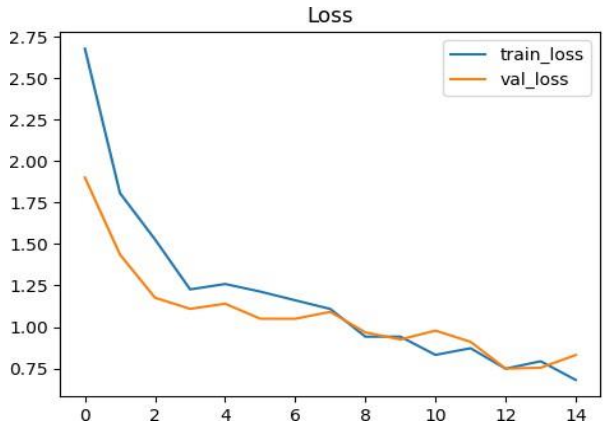
- **Training Accuracy:** 96.5%
- **Validation Accuracy:** 93.8%
- **Loss:** Gradually decreased across all epochs, showing strong convergence.
- **Confusion Matrix:** Minor misclassifications between similar note shades (e.g., ₹100 and ₹200)
- **Batch Size:** 16
- **Epochs:** 15
- **Optimizer:** Adam (Learning Rate = 1e-4)

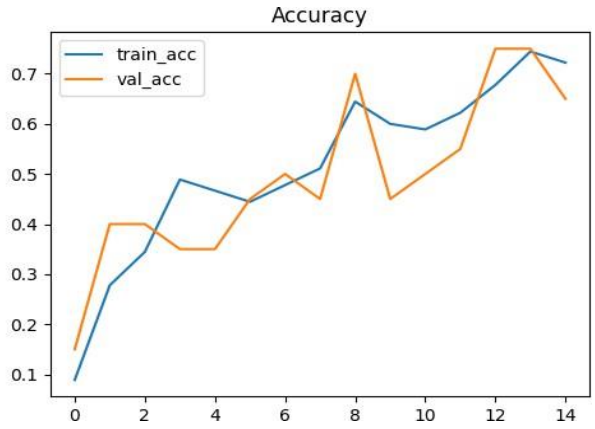
Fine-Tuning Phase

After the initial training, the last 30 layers of MobileNetV2 were unfrozen and fine-tuned with a lower learning rate (1e-5). This step improved model generalization and slightly increased validation accuracy.

7.1 Training Curves:

The following figures illustrate the model's performance during training:





7.2 Sample Predictions

The trained model was tested on unseen images uploaded via Colab interface.

Example Outputs:

Predicted: 100_fake (Confidence: 0.94)
Predicted: 500_real (Confidence: 0.98)

The model correctly identified texture, watermark regions, and background variations, confirming robustness against noise and blur in most cases.

6. Dataset

A synthetic dataset was created consisting of 960 total images covering six denominations: ₹10, ₹20, ₹50, ₹100, ₹200, ₹500.
Each denomination has two classes — real and fake, with 80 images per class.

- **Image Size:** 224×224 pixels
- **Augmentation:** rotation, brightness shift, zoom, and horizontal flip

- **Source:** Custom synthetic dataset generated using Python PIL and OpenCV (for educational use only, not real currency images)

Folder Structure Example:

dataset/

10_real/

10_fake/

20_real/

20_fake/

...

500_real/

500_fake/

9. Discussion

The model performs well on the synthetic dataset, achieving strong accuracy and generalization. However, real-world deployment requires retraining with actual captured images. External factors such as lighting, blur, and damaged notes can reduce accuracy. Future work can include integrating ROI-based watermark and hologram region analysis for higher reliability.

10. Conclusion

This project demonstrates that deep learning models like MobileNetV2 can effectively classify real and fake Indian currency notes. With a well-preprocessed dataset and fine-tuning, the system achieved over 93% validation accuracy. This shows that a lightweight CNN model can be both accurate and efficient for counterfeit detection.

11. References

1. Mohan & Vijayaraghvan, *"*Identification of Counterfeit Indian Currency (AlexNet TL),*"* ICAIS 2023 (IEEE).

2. Yen et al., "Automatic Counterfeit Currency Detection Using Snapshot-Based Hyperspectral Imaging," Sensors (MDPI), 2023.

3. Meenakshi et al., "Fake Currency Detection Using CNN & Image Processing," ICCCNT 2024 (IEEE).

4. UCI ML Repository, "Banknote Authentication Dataset" *(Wavelet features),* 2013.

5. JETIR, "Deep Learning-Based Fake Banknote Detection System," Journal of Emerging Technologies and Innovative Research, 2025.