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Multilayered Vision-Based Currency Authentication

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Abstract: ***Counterfeit currency threatens financial security and everyday transactions, and manual verification is slow and error-prone for ordinary users. This paper presents the design, implementation and experimental demonstration of a multilayered vision-based currency authentication system. A camera captures the note inside a guided capture window, the image is pre-processed and passed to a machine-learning classifier that identifies the denomination along with a confidence score, and the result is combined with additional system checks, to reach a final genuine or fake verdict. The verdict is transferred through a Python serial interface to an Arduino, which displays the result on an OLED module. The prototype was tested with a live camera feed, and representative outputs for a genuine Rs. 500 note and a fake Rs. 500 note were obtained on the terminal and the OLED display. The system offers a simple, low-cost and real-time solution for currency verification.***
Keywords: Computer Vision, Currency Authentication, Fake Currency Detection, Machine Learning, Image Process, Feature Extraction, Arduino, OLED Display.

I. INTRODUCTION

Currency plays an important role in daily financial transactions. The circulation of counterfeit or visually altered notes causes financial loss to individuals and businesses. Identifying such notes manually is difficult for common people, since many users are not aware of the security features present in currency, and human inspection is time-consuming and may lead to mistakes. Recent work has applied image processing, machine learning and deep learning to this problem, using features such as the RBI logo, security thread, watermark and identification marks. Other studies have cloud integration and mobile applications to improve reliability and accessibility.

This work presents a vision-based system for verifying currency notes in real time. A camera captures the image of the note, the image is processed to improve quality and standardize its size, and a trained classifier identifies the denomination and reports a confidence value. The classification is combined with additional authenticity checks, to decide whether the note is genuine or fake. The decision is sent over a USB serial link to an Arduino, which displays the result on an OLED module so that the user receives an instant, readable output.

The main contributions of this work are: (i) a guided live-capture interface that triggers the camera when the note is held steady, (ii) a machine-learning denomination classifier with confidence reporting, (iii) a multilayer decision stage that fuses vision (iv) an Arduino-based OLED output unit for stand-alone indication.

II. RELATED WORK

Image-processing approaches extract security features such as the watermark, security thread, RBI logo and identification marks using segmentation, grayscale conversion and edge detection, and compare them with genuine templates using MATLAB or OpenCV . Classical machine-learning approaches use KNN, SVM, Random Forest and Logistic Regression on extracted features and are evaluated with precision, recall and F1-score. Deep-learning approaches, mainly CNN and VGG16 models, learn features directly from note images and report higher accuracy than conventional methods.

Several studies use extra sensing and deployment strategies. Visible and UV images, texture analysis with Local Binary Patterns, dimensional checks and colour profiling are combined with an SVM classifier for ATM and POS use in while LED wavelengths is reviewed in . Web, cloud and mobile implementations are discussed in Surveys in and compare these techniques and note the limits of conventional methods. However, many existing systems rely on a single method or on fixed hardware, and comparatively few present a complete low-cost chain from capture to embedded output. This motivates the proposed multilayered system.

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Table I. Comparison Of Existing Studies

Ref.	Methodology	Features used	Classifier / tool
[1]	Image processing	Watermark, thread, ID marks	Segmentation, edge detection (MATLAB)
[2]	ML + image processing	Extracted note features	KNN, SVM
[3]	Image processing	RBI logo, thread, ID marks	DTCWT, feature fusion, MSE
[4]	OpenCV	Grayscale, segmentation	Template comparison
[5]	Deep learning	Dataset images	CNN
[6]	Deep learning + cloud	Captured images	Deep CNN
[7]	Supervised ML	Image features	SVM, RF, LR
[8]	Visible + UV imaging	Texture, size, colour	SVM
[9]	Deep learning	Note images	CNN, VGG16
[10]	MATLAB features	Thread, watermark, variance, skewness	Canny, template matching, SVM
[11]	Visible + UV imaging	LBP texture, dimensions, colour	SVM (99.2% reported)

III. PROBLEM IDENTIFICATION AND OBJECTIVES

The following problems motivate this work: circulation of counterfeit currency causing financial loss; difficulty in manual verification of notes; existing systems that rely only on fixed hardware methods; lack of intelligent and adaptive detection systems; and the need for a low-cost and efficient solution.

The objectives are: to design a multilayer currency authentication system; to implement computer vision for feature extraction; to classify notes using machine-learning techniques; and to provide real-time output for authentication.

IV. PROPOSED SYSTEM AND METHODOLOGY

The system captures the currency note image using a camera and performs preprocessing such as resizing and grayscale conversion. Feature extraction identifies important visual patterns, and machine learning classifies the note based on these features and reports the denomination with a confidence value. Simultaneously, to determine whether the note is genuine or counterfeit, and the final output is sent to the display unit. The overall arrangement is shown in Fig. 1.

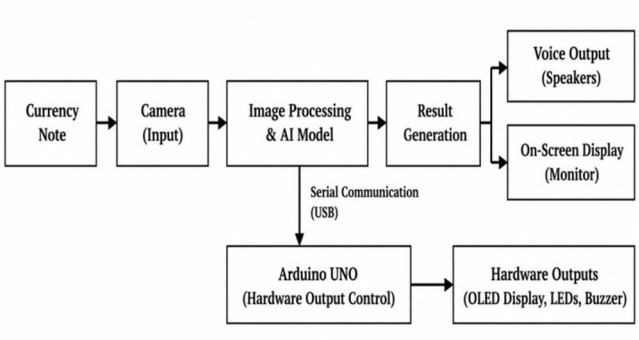


Fig. 1. Block diagram of the multilayered currency authentication system.

The operating sequence is given in the flow chart of Fig. 2. The user places the note in the guided capture window and holds it steady; the image is captured automatically after the hold time, or manually by pressing a key. After pre-processing and classification, the system checks whether the note passes all layers. A genuine verdict and a fake verdict are both transmitted to the Arduino for display.

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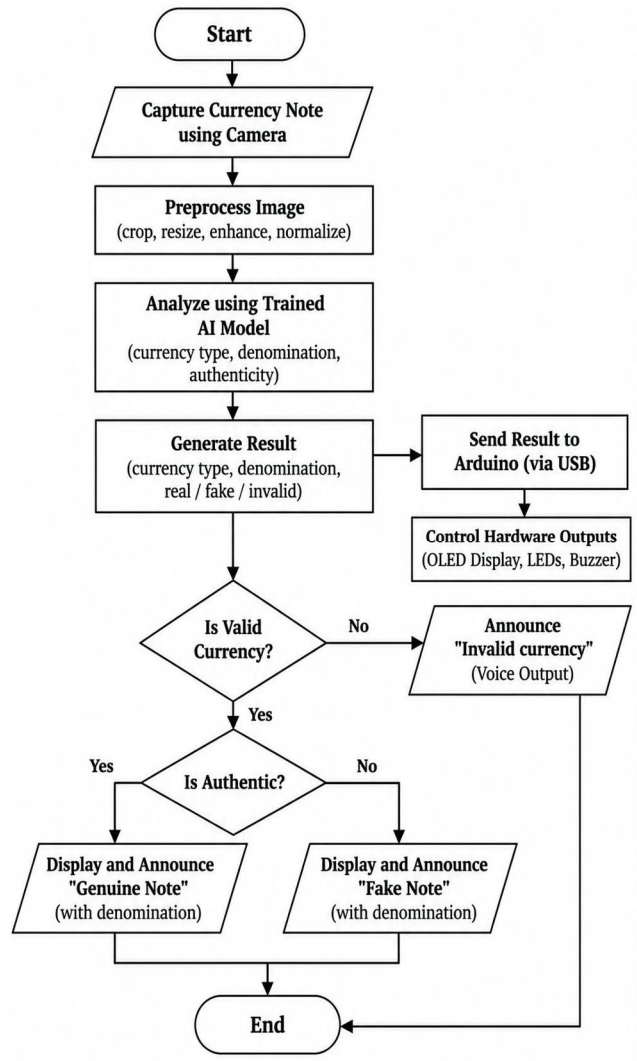


Fig. 2. Flow chart of the authentication process.

V. HARDWARE AND SOFTWARE IMPLEMENTATION

A. Hardware Components

The prototype uses a camera module for image capture, a a microcontroller for processing and control, an OLED display for result indication, and a power supply unit. The OLED module is connected to the Arduino through its VCC, GND, SCK and SDA pins on a breadboard (I2C interface), as shown in Fig. 5. A red indicator is also visible on the breadboard during the fake-note output.

B. Software Tools

The image-processing and machine-learning stages are implemented in Python with OpenCV, with MATLAB used for feature studies. The development environment is Visual Studio Code. A smartphone camera streamed to the computer through a webcam application acts as the capture device.

C. Live Capture Interface

A live-capture script displays the camera feed with a yellow guide box. The note is positioned inside the box and held steady for 2 seconds, after which the frame is captured; SPACE forces an immediate capture and Q quits. The on-screen status shows the hold progress (for example 0.0/2 s) so that the user can steady the note, as shown in Fig. 3. This guided capture reduces motion blur and keeps the note position consistent for classification.

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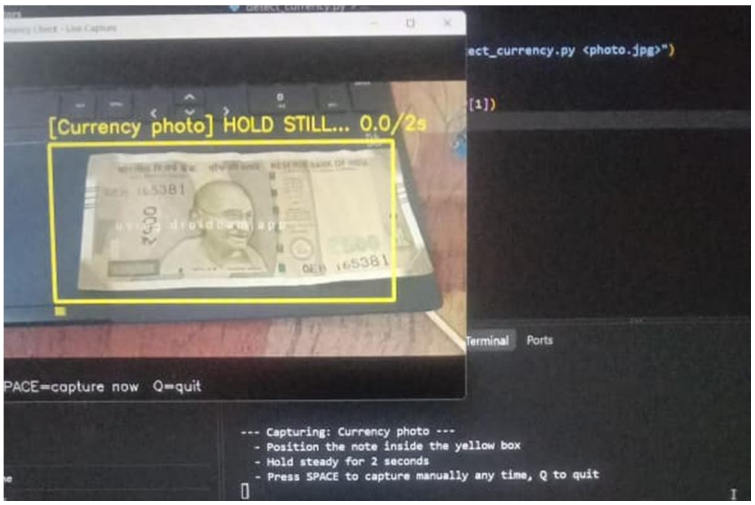


Fig. 3. Live capture window with guide box and hold-still timer.

D. Classification and Verdict

The captured image is resized and passed to the classifier, which returns a class label and a confidence score. The final decision stage then applies the system checks and prints the denomination, the verdict and the reason on the terminal. The result string is sent over the serial port (COM13 in our setup) to the Arduino, which updates the OLED display.

VI. RESULTS AND DISCUSSION

The proposed system was tested under controlled conditions with a live camera feed. The system captured and processed the currency note image and classified the note as genuine or fake. For a genuine Rs. 500 note the classifier returned the class 500_new_front_up with a confidence of 49.7%, and the system reported the final verdict GENUINE, with the reason that the note passed all system checks. The same message was transmitted to the Arduino through COM13, as shown in Fig. 4.

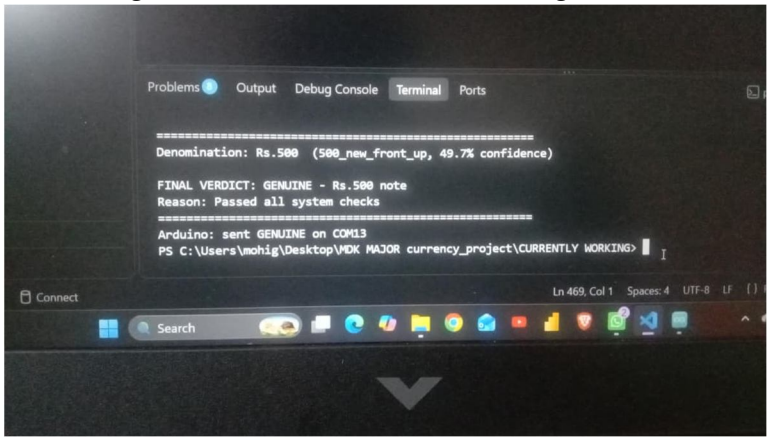


Fig. 4. Terminal output for a genuine Rs. 500 note.

When a fake Rs. 500 note was presented, the Arduino-driven OLED display showed the message CURRENCY RESULT: FAKE with the text FAKE 500, as shown in Fig. 5, confirming that the complete chain from capture to embedded display works in real time.

Overall, the experimental results demonstrate that the proposed system successfully integrates AI-based image classification with an embedded hardware interface. The successful detection of both genuine and fake Rs. 500 notes and the corresponding real-time OLED output indicate that the system can serve as a foundation for developing a more accurate, faster, and portable automated currency verification system.

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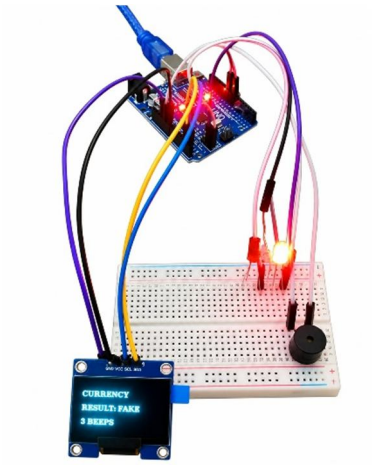


Fig. 5. OLED output for a fake Rs. 500 note.

TABLE II. Representative System Outputs

Input note	Classifier output	Verdict	Display
Genuine Rs. 500	500_new_front_up, 49.7%	GENUINE	Serial message sent (COM13)
Fake Rs. 500	Rs. 500 detected	FAKE	OLED: FAKE 500

The results show that the system can display a clear outcome within a short time after capture. The confidence of 49.7% obtained for the genuine sample indicates that the classifier can be improved by training on a larger and more varied dataset covering different lighting, note ages and orientations. The combination of vision with, so that a note that is visually similar but lacks the fluorescent security features can still be rejected. The reported performance is limited to the controlled tests described here and is not a full statistical evaluation.

VII. CONCLUSION AND FUTURE SCOPE

An AI-based multilayered currency authentication system using computer vision has been developed. The system provides real-time detection of counterfeit notes with a guided capture interface, a machine-learning classifier and an OLED output unit, while maintaining low cost and simplicity. It reduces dependency on manual verification and improves reliability. Future work includes training on a larger multi-denomination dataset, improving classifier confidence, adding the remaining denominations and note sides, adding audio indication for visually impaired users, and moving the processing to an embedded board for stand-alone ATM or shop-counter deployment.

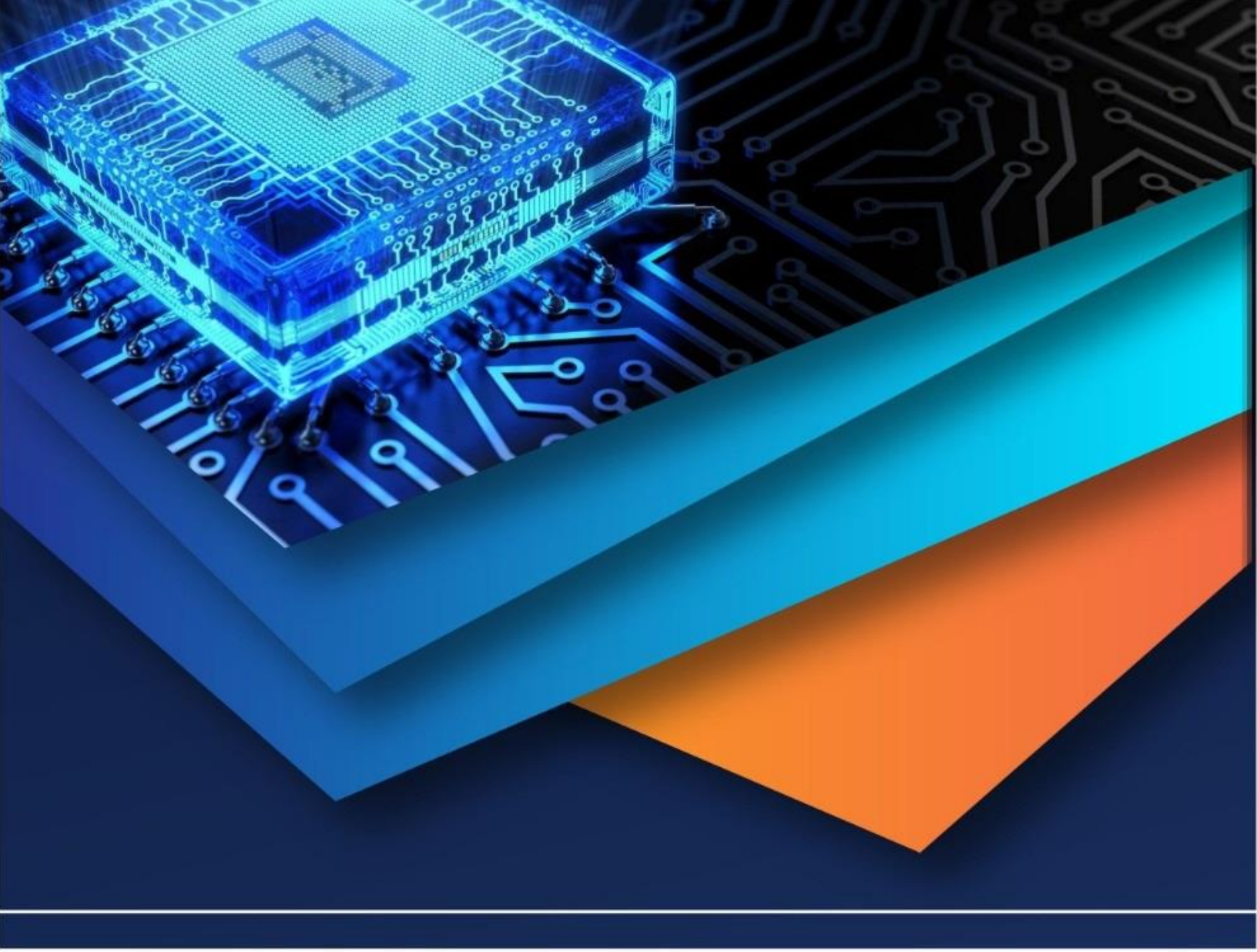
The experimental results demonstrate that the system can successfully identify genuine and fake Rs. 500 notes under controlled conditions. The integration of machine learning with an Arduino-based hardware interface makes the system simple, cost-effective, and suitable for real-time applications. The serial communication between the classification unit and Arduino enables the detected result to be displayed immediately, reducing the need for manual verification.

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