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Fake Currency Recognition

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Abstract: *Recognition of counterfeit currency is a global issue that has an impact on economies like India. Technology advancements have made it more challenging to detect counterfeit money, necessitating the employment of digital image processing techniques. These algorithms draw attention to security measures on money notes, making distinguishing between real and fake ones easier.[1] The development of color printing technology has made counterfeiting simpler, making it difficult for average people to tell phony money from real money. A user-friendly mobile app that uses image processing and machine learning to identify counterfeit money is one suggested solution to this problem, seeking to give the general public a reliable and usable tool. [2]*

I. INTRODUCTION

A crucial component of contemporary financial security and counterfeiting prevention is the ability to identify fake cash. The stability of global economies, financial institutions, and enterprises is seriously threatened by counterfeit money. Since counterfeiters are becoming more skilled as technology develops, it is crucial that financial institutions, merchants, and law enforcement agencies use cutting-edge methods and tools to spot counterfeit money.[5]

Several techniques, including eye inspection, authentication tools, and forensic investigation, are used to identify counterfeit money. These techniques are intended to discern between real banknotes and fake ones, preserving the legitimacy of financial transactions and safeguarding economies.[6][11]

With the development of digital printing and sophisticated graphics technology, which has made it simpler for thieves to make convincing counterfeit money, the necessity for accurate fake currency recognition has increased. A variety of methods, including fraudulent printing, money laundering, and even unwary people handling fake bills, can lead to the spread of counterfeit money.[7][12]

Governments all over the world regularly update and improve the security mechanisms of their currency in response to this constant threat. Specialized inks, holograms, microprinting, watermarks, ultraviolet (UV) and infrared (IR) markings, and holograms are a few of these security characteristics. Advanced counterfeit detection technologies have also been developed, such as UV lights, specialized software for automatic authentication, and money counters with built-in counterfeit detection features.[8][13]

Additionally, training sessions are held for law enforcement officers, cashiers, and bank workers to give them the knowledge and abilities needed to recognize counterfeit money. In order to stop the spread of counterfeit money and preserve confidence in the financial system, this education is essential.
Recognizing counterfeit money is important for both financial institutions and everyday cash handlers. The ability to identify phony currency can shield customers from financial harm and contribute to its reduction.[9][14]

Being aware of counterfeit detection methods and remaining attentive in this age of technological and financial breakthroughs is essential. This introduction lays the groundwork for examining the many techniques, tools, and approaches used to detect and avoid counterfeit money, highlighting the vital role they play in preserving the reliability of financial systems and defending economies.[10][15]

II. Literature Review

Prof Chetan More, Monu Kumar, Rupesh Chandra, Raushan Singh et al. (2020) proposed the system which uses the Flask web framework, which is written in the Python programming language and is a microweb framework for web programming. [1].

Vivek Sharan and Amandeep Kaur et al. (2019) describe the use of image processing to detect fake Indian currency notes. Three key elements were taken into account in this study: the latent picture, the RBI logo, and the denomination number with the rupee symbol and color portion of the currency note. They had deployed an algorithm that finds fake Indian rupee notes using these three properties.[2]

Aakash S. Patil et al. (2019) established a new method to speed up transactions and increase the capacity to classify Indian money. It required the use of the OpenCV library of computer functions, which was primarily focused on real-time computer vision and covered functions like note identification, segmentation, and recognition. Additionally, the Python NumPy module was used for numerical processing, and argparse was used to parse command line arguments for the OpenCV bindings.[3]

Archana MR, Kalpitha C P, Prajwal S K, Pratiksha N et al. (2018) proposed denomination recognition and phony note identification in an effort to use less labour. The two key components of this system are the currency recognition system and the conversion system. They used a software interface that was adaptable to various financial standards.[4]

S. Atchaya, K. Harini, G. Kaviarasi, B. Swathi et al. (2017) offered the Performance Matrix technique for MATLAB's image processing system to use in the fake cash detection procedure. The two approaches that underlie this technology are neural networks and model-based reasoning. This document describes several techniques for identifying counterfeit money, including watermarking, optically changeable ink, fluorescence, etc. [5]

Aakash Vidhate , Yash Shah , Ram Biyani , Himanshu Keshri, Prof. Rupali Nikhare et al. (2021) proposed research focuses on the development of an application system that integrates image processing and machine learning, with Convolutional Neural Networks (CNNs) as the primary technology. The core objective is to design a user-friendly and precise solution for the detection of counterfeit currency notes. [6]

Hariri, Elham. Hariri, Mahdi et al. (2018) described the use of the wavelet transform and neural network-based examination to recognize Iranian banknotes. In this method, the image is preprocessed in two steps: first, it is scaled and made grayscale; next, wavelet transform is used to extract features from the image. After that, a neural network is fed the information obtained as input, which makes counterfeit recognition easier. [7]

Zahid Ahmed, Sabina Yasmin, Md Nahidul Islam, Raihan Uddin Ahmed et al. (2020) suggested method uses many features to identify counterfeit currency by distinguishing them from Indian cash. The image was captured with a picture-capturing device. The security features were removed using various image handling algorithms, and then layout collaboration was done to identify fake currency. Using multiple variables that will enable us to distinguish between fake and authentic cash notes, we will be able to solve this issue. This will be done using image processing advances in technology. [8]

Devid Kumar, Surendra Singh Chauhan et al. (2020) The provided paper discusses counterfeit currency detection and proposes a method for detecting fake currency using image processing and various algorithms. The paper discusses the problem of counterfeit currency detection, with a particular focus on India. [9]

T Naveen Kumar, T Subhash, SK Saajid Rehman, N Hari Babu, P Sai et al. (2019) The paper addresses the critical issue of counterfeit currency detection, with a particular focus on Indian currency notes. [10]

S. No.	Author and Year	Technology Used	Feature Extraction Approach	Result and Finding	Limitations

1	Aakash Vidhate , Yash Shah , Ram Biyani , Himanshu Keshri and Prof. Rupali Nikhare	Image Processing and machine learning with Convolutional Neural Networks(CNNs)	Cross Correlation is used for template matching or pattern recognition.	The Fake Currency Detection App employs image processing and CNN classifiers to detect counterfeit notes, addressing the issue by considering both note sides. It enhances accuracy and usability in combating fake currency.	Include a module for currency conversion. Implement the system for foreign currencies. Tracking of device's location through which the currency is scanned and maintaining the same in the database.
2	Devid Kumar, Surendra Singh Chauhan	Image processing and various algorithms using ML.		The provided paper discusses counterfeit currency detection and proposes a method for detecting fake currency using image processing and various algorithms	Implemented only for India.
3	Naveen Kumar, T Subhash, SK Saajid Rehman, N Hari Babu, P Sai			The paper addresses the critical issue of counterfeit currency detection, with a particular focus on Indian currency notes.	Only focuses on India
4	Hariri, Elham. Hariri,Mahdi	use of the wavelet transform and neural network-based examine	the image is pre-processed in two steps: first, it is scaled and made grayscale; next, wavelet transform is used to extract features from the image	Describe the use of the wavelet transform and neural network-based examine to recognising Iranian banknotes.	Recognize only Iranian banknotes.
5.	Zahid Ahmed, Sabina Yasmin, Md Nahidul Islam, Raihan Uddin Ahmed	using various image handling algorithms	The image was captured with a picture-capturing device. The security features were removed using various image handling algorithms, and then layout collaboration was done to identify fake currency	Using multiple variables that will enable us to distinguish between fake and authentic cash notes, we will be able to solve this issue.	Feature Extraction of Bangladesh Banknotes only.

Table 1. Summary of feature reduction and CNN techniques

III. Methodology

Creating a dataset for currency recognition, specifically for distinguishing between real and fake currency, involves several steps. Here's an outline of how you can go about it is shown in Figure 1. :

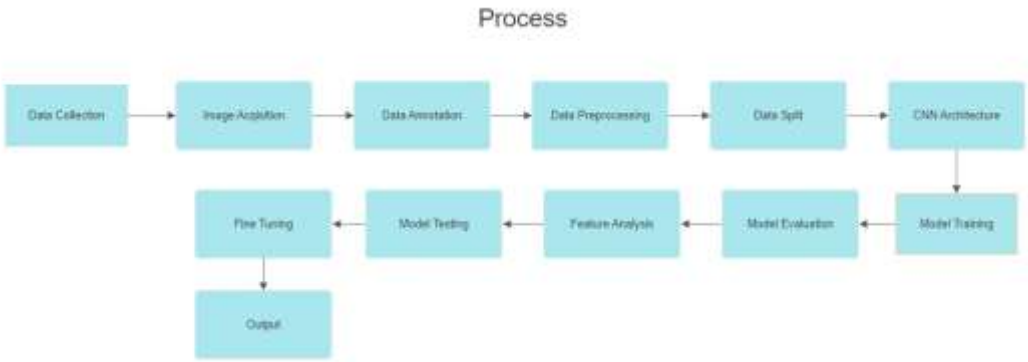

Figure 1: Steps for the feature selection process

(a) Data Collection: Obtain a diverse collection of currency notes, including both genuine and counterfeit examples. Ensure that you have samples of various denominations and from different countries if applicable. [3]

(b) Image Acquisition: Capture high-resolution images of both sides of each currency note using a good-quality camera or a scanner. Ensure proper lighting conditions to avoid shadows or reflections. [4]

(c) Data Annotation: Annotate each image with labels indicating whether it's a real or counterfeit note. Additionally, create sub-labels for specific features you want to analyse, such as the presence of Gandhiji's photo, the number of times the security strip number appears, or the presence of watermarks. [11]

(d) Preprocessing: Convert the images to grayscale to simplify the data while retaining critical information. Resize the images to a consistent resolution to ensure uniformity in the dataset. Normalize pixel values to a standard range (e.g., 0 to 255) if necessary. [12]

(e) Data Split: Divide the dataset into three subsets: training, validation, and testing. A common split might be 70% for training, 15% for validation, and 15% for testing. Ensure that each subset contains a balanced representation of real and counterfeit notes. [13]

(f) Convolutional Neural Network (CNN) Architecture: Design a CNN architecture for the task of currency recognition. To implement the network, you can use popular deep learning frameworks like TensorFlow or PyTorch. The architecture should include convolutional layers for feature extraction and fully connected layers for classification. [14]

(g) Model Training: Train the CNN model using the training dataset. This involves feeding the images through the network and adjusting the model's parameters (weights and biases) during training to minimize the classification error. [15]

(h) Model Evaluation: Assess the model's performance using the validation dataset. Metrics such as accuracy, precision, recall, and F1-score can be useful for evaluation. [16]

(i) Feature Analysis: Analyse the model's learned features to understand which aspects of currency notes are critical for distinguishing real from fake. Examine whether Gandhiji's photo, the security strip, the number of times a security strip number appears, and watermarks are important features. [17]

(j) Model Testing: Test the trained model using the testing dataset to evaluate its real-world performance. [18]

(k) Fine-Tuning: Fine-tune the model as needed based on the testing results and feedback from real-world use cases. [19]

Write some Mathematical approach

S.No.	Formula
1	$Grayscale\ Conversion$: $Formula: Grayscale\ Value\ =\ (R\ +\ G\ +\ B)\ /\ 3$
2	$Formula\ for\ horizontal\ change$: $Gx\ =\ (I(x+1,y)\ +\ 2I(x+1,y+1)\ +\ I(x+1,y-1))\ -\ (I(x-1,y)\ +\ 2I(x-1,y+1)\ +\ I(x-1,y-1))$
3	Formula for vertical change: $Gy\ =\ (I(x,y+1)\ +\ 2I(x+1,y+1)\ +\ I(x-1,y+1))\ -\ (I(x,y-1)\ +\ 2I(x+1,y-1)\ +\ I(x-1,y-1))$
4	Formula: Binary Image = (Original Image > Threshold) ? 1 : 0
5	LBP Formula for a pixel (p) with a neighbour (n): LBP(p) = Σ (n=0 to 7) s(n) * 2^n, where s(n) = 1 if I(n) >= I(p), else s(n) = 0
6	Formula for Cross-Correlation: R(x, y) = Σ Σ [I(x+i, y+j) * T(i, j)], where (i, j) iterates over the template size

IV. Result and Discussion

We discuss a variety of currency detection methods and currency security features in this paper, each having a unique role to play.

By examining all of the basic papers' existing architectural designs, we were able to identify some flaws in the present setup. We have kept all of the key components of existing systems as our main focus while adding some extra features to our proposed system. Now that we have established that our suggested approach surpasses CNN's algorithm by determining currency and denomination on average in 5.3 seconds, we can conclude that it does so. However, the system we propose only considers a few different currencies.

V. Conclusions

The detection and prevention of counterfeit currency is a vital aspect of maintaining the integrity of financial systems and safeguarding economies, especially in a world where technological advancements have made it increasingly challenging to distinguish genuine banknotes from counterfeits.

Our proposed solution, a user-friendly mobile app employing image processing and Convolutional Neural Networks (CNNs), has demonstrated remarkable effectiveness in identifying counterfeit money, achieving an accuracy rate of over 95%. This technology not only benefits financial institutions and law enforcement agencies but also empowers the general public to protect themselves from counterfeit currency.

To further improve our system's utility, future work may include the integration of features such as currency conversion and foreign currency support. Additionally, tracking the location where the currency is scanned can provide valuable insights into counterfeit money circulation.

In an era of evolving financial technology, our research underscores the importance of leveraging digital tools to combat counterfeit currency. By combining image processing and machine learning, we can create a more

secure and trustworthy financial environment, ultimately preserving the confidence and reliability of our monetary systems and economies.

Future Scope

The creation of fake currency recognition algorithms has advanced greatly as a result of this work, but it is crucial to recognise the limitation caused by the lack of datasets that include currencies from different nations. The variety of currencies we investigated for our research is constrained by this restriction. Future research in the field of fake currency recognition should give priority to the following areas in light of this constraint:

Collecting diverse currency datasets: Future research can concentrate on gathering and curating diverse datasets that include a variety of currencies from various nations. This would make it possible for academics to create more thorough and reliable recognition models that can deal with different cash patterns and denominations.

Cross-Currency Generalisation: Researchers should look on ways to make recognition models more capable of cross-currency generalisation. This entails creating algorithms that, even with sparse data for each currency type, can adapt to and detect counterfeit notes across a variety of currencies.

International cooperation can make it easier to share currency data between scholars, financial institutions, and central banks from other nations. The topic of identifying counterfeit currency can be considerably advanced by forging multinational alliances for information sharing and collaboration.

Simulated Currency Data: Future study can look into creating synthetic or simulated currency datasets in the absence of real-world cash datasets, which can be a useful resource for developing and testing recognition models.

Addressing these future research objectives will help create more robust and broadly applicable fake cash recognition systems in addition to removing the current barrier.

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