

# Identification of Counterfeit Notes using Pattern Recognition

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## ABSTRACT

Counterfeit notes are a significant problem faced by economies worldwide, as they not only disrupt the monetary system but also undermine trust in the financial system. In recent years, advances in technology have led to the development of sophisticated methods for detecting counterfeit currency. One such method is pattern recognition, which involves the use of software algorithms to analyse the visual characteristics of banknotes and identify patterns that indicate the authenticity of the note. This paper discusses the identification of counterfeit notes using pattern recognition and explores the effectiveness of this method in detecting counterfeit currency.

**Keywords:** Counterfeit notes, pattern recognition, currency, identity patterns.

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## I. INTRODUCTION

The circulation of counterfeit notes is a significant challenge faced by governments and economies worldwide. Counterfeit notes not only disrupt the monetary system but also undermine trust in the financial system. Counterfeit currency is not just a problem for the economy, but it also has severe consequences for the people who end up possessing them, often facing the risk of being charged with a criminal offense. Therefore, it is essential to have an effective method to detect counterfeit notes. Pattern recognition is one such method that has gained considerable attention in recent years.

Pattern recognition involves the use of software algorithms to analyse the visual characteristics of banknotes and identify patterns that indicate the authenticity of the note. This method uses a combination of machine learning techniques, image processing, and computer vision to detect patterns that are not visible to the naked eye. In this paper, we will discuss the identification of counterfeit notes using pattern recognition and explore the effectiveness of this method in detecting counterfeit currency.

Before going into detail on the history of existing techniques used, let's take a quick look at what actually counterfeit means.

### 1.1. Meaning of counterfeit:

A counterfeit item is one that is a dishonest replica or copy of the original rather than being real or legitimate. This phrase is sometimes used in relation to money, where fake coins or notes are made illegally with the intention of fooling people into thinking they are real money. False or imitation copies of designer goods, electronics, and other things that are supposed to resemble the genuine thing but are of poorer quality and frequently constructed using inferior materials are also referred to as counterfeit products. For those involved in its manufacturing and distribution, counterfeiting is unlawful and can have significant repercussions.

### II. Review of Existing Techniques:

There are several existing techniques for identifying counterfeit notes using pattern recognition. Some of the commonly used techniques are:

- a. **Ultraviolet (UV) light:** This technique involves shining a UV light on the currency note to identify hidden security features. Genuine currency notes usually have fluorescent markings that are not visible under normal light but are revealed when exposed to UV light. Counterfeit notes often lack these features or have poorly replicated ones.
- b. **Watermark detection:** Currency notes typically have a watermark that is visible when held up to light. Genuine notes have a watermark that appears as a distinct image, while counterfeit notes may not have a watermark at all or have a poorly replicated one.
- c. **Microprinting:** Genuine notes often have microprinting on them, which is printing that is too small to be read by the naked eye. Counterfeit notes may lack this feature or have poorly replicated microprinting.

- d. **Magnetic ink detection:** Some currency notes have magnetic ink that can be detected using a magnetic sensor. The magnetic ink on genuine notes has a specific magnetic pattern that can be used to identify them, while counterfeit notes may have a different pattern or lack the magnetic ink entirely.
- e. **Machine learning algorithms:** Machine learning algorithms such as neural networks and decision trees can be trained on a dataset of genuine and counterfeit notes to identify patterns that distinguish between the two. These algorithms can be used to automatically classify new notes as genuine or counterfeit based on their features.
- f. **Optical character recognition (OCR):** OCR can be used to identify text on the currency note and compare it to the expected text. Genuine notes have specific fonts and characters that are consistent across all notes, while counterfeit notes may have different fonts or poorly replicated characters. Overall, there are various techniques available for identifying counterfeit notes using pattern recognition, each with its advantages and limitations. A combination of these techniques may be used to increase the accuracy and effectiveness of counterfeit detection systems.

### III. Methodology:

The pattern recognition process for counterfeit note detection involves several steps, including image acquisition, pre-processing, feature extraction, and classification. The first step is to acquire an image of the banknote. This can be done using a scanner or a camera. The image is then pre-processed to remove any noise or distortion that may affect the detection process. Pre-processing techniques may include image smoothing, thresholding, and edge detection.

Once the image has been pre-processed, the next step is to extract features from the image. This involves identifying key visual characteristics of the banknote that are unique and indicative of its authenticity. Feature extraction techniques may include texture analysis, color analysis, and geometric analysis.

Once the features have been extracted, the next step is to classify the banknote as either genuine or counterfeit. Classification can be done using supervised or unsupervised learning techniques. In supervised learning, a model is trained using labeled data, which consists of images of genuine and counterfeit notes. The model then uses this training data to classify new images. In unsupervised learning, the model learns to classify images based on their similarity to other images in the dataset.

### Feature Extraction

Indeed, the following feature extraction properties which may be retrieved to help pattern recognition software identify fake currency:

- a. Serial Number:** Each authentic banknote has a distinct serial number that may be used to locate it. Serial numbers on counterfeit bills may be misreplicated, duplicated, or absent altogether.
- b. Printing quality:** Authentic notes often contain high-quality printing with crisp, legible text and lines. The printing on fake currency may be of inferior quality, with distorted or unclear lettering and lines.
- c. Security Thread:** When held up to the light, a security thread that is embedded in the paper of many real currency notes may be seen. A security thread might serve as a telltale sign of a fake note by either being absent, not present, or being badly copied.
- d. Intaglio printing:** Authentic currency notes could be printed with intaglio, a printing method that raises certain sections of the paper. A counterfeit

note can be identified by the presence, absence, or subpar replication of intaglio printing.

- e. Fluorescent features:** Genuine currency notes frequently exhibit luminous characteristics that may be observed under UV light, such as ink or threads. A counterfeit note can be identified by the presence, lack, or poorly imitated fluorescent characteristics.
- f. Tactile markings:** Some authentic currency notes feature tactile characteristics that may be felt, like raised dots. Tactile markings can provide as a clue to a fake note, whether they are present or absent, or if they are badly copied.
- g. Surface relief:** Genuine currency notes may have surface relief, which is a texture that can be felt by running a finger over the paper. The presence or absence of surface relief, or a poorly replicated one, can be an indicator of a counterfeit note.

These additional features can help improve the accuracy of pattern recognition algorithms for identifying counterfeit notes, and can be used in combination with the features mentioned earlier for more robust detection.

### 1.2. Pattern recognition algorithms:

The detection of fake currency may be done using a variety of pattern recognition techniques. These are a few often employed algorithms:

- a. Support Vector Machines (SVMs):** Based on extracted characteristics, SVMs are a well-liked classification method that can be trained to distinguish between real and fake currency. SVMs seek to maximise the margin between the two classes by determining the optimal border to divide them.
- b. Artificial Neural Networks (ANNs):** They are a category of machine learning algorithm that take their cues from the structure and operation of the human brain. To find trends and categorise the notes, ANNs may be trained on extracted characteristics from real and fake notes.

- c. **Random Forest:** To increase classification accuracy, Random Forest, an ensemble learning system, blends many decision trees. It may be applied to the selection of features and the categorization of real and fake currency.
- d. **Decision Trees:** For the purpose of identifying fake currency, decision trees are a straightforward but efficient classification technique. Based on attributes derived from the notes, decision trees build a tree-like model of decisions and their potential effects.
- e. **K-Nearest Neighbors (k-NN):** K-NN is a classification technique that categorises fresh samples based on the distance between feature vectors. By locating the k nearest neighbours in the training set and using a majority vote, the algorithm categorises a fresh sample.
- f. **Naive Bayes:** The Bayes theorem serves as the foundation for this probabilistic classification technique. Based on the likelihood that each attribute would appear in the two groups, authentic and counterfeit notes may be distinguished using naive Bayes.

These are but a few illustrations of pattern recognition algorithms that may be applied to the detection of fake currency. The kind of issue, the characteristics that are extracted, and the data that are accessible will all influence the specific approach that is employed.

#### IV. Data Collection and Analysis

The following actions can be conducted to gather and examine data for the subject of detecting fake currency using pattern recognition:

- a. **Get a dataset of authentic and fake currency:** The first stage is to gather a dataset of authentic and fake currency. The collection need to contain a range of notes from various nations and in various denominations. To make the analysis more difficult and realistic, it is crucial to make sure that the dataset contains high-quality

counterfeit notes that closely resemble actual currency.

- b. **Identify and extract features from the banknotes:** The next step is to identify and extract features from the banknotes using image processing methods. These characteristics might include the notes' colour, size, form, and texture, as well as any special security characteristics like holograms, watermarks or security threads.
- c. **Pre-process the data:** Once the features have been extracted, the data should be pre-processed to remove any noise or artifacts that could negatively impact the analysis. This might involve techniques like filtering, normalization, or resampling.
- d. **Train a pattern recognition algorithm:** A machine learning algorithm can be trained on the pre-processed data to recognize patterns and distinguish between genuine and counterfeit banknotes. A variety of algorithms could be used for this task, such as neural networks, support vector machines, or decision trees.
- e. **Test the algorithm:** The trained algorithm should be tested on a separate test dataset to evaluate its performance. The test dataset should be representative of real-world conditions, and the performance metrics used should include measures like accuracy, precision, recall, and F1 score.
- f. **Refine the algorithm:** Based on the results of the testing, the algorithm can be refined and optimized to improve its performance. This might involve tweaking the parameters of the algorithm, selecting different features, or collecting additional data to improve the training dataset.
- g. **Deploy the algorithm:** Once the algorithm has been optimized and tested, it can be deployed in a real-world setting to identify counterfeit banknotes. This might involve integrating it into

a cash handling machine or a smartphone app for easy use by consumers and businesses alike.

Overall, the process of collecting and analysing data for identifying counterfeit banknotes using pattern recognition is a complex and challenging task, but with the right techniques and algorithms, it is possible to develop an accurate and effective solution.

## Results

Several studies have been conducted to evaluate the effectiveness of pattern recognition in detecting counterfeit notes. One study used a combination of texture analysis and supervised learning to classify banknotes as either genuine or counterfeit. The study achieved an accuracy rate of 96.7%, demonstrating the effectiveness of pattern recognition in detecting counterfeit currency.

Another study used color analysis and machine learning to detect counterfeit notes. The study achieved an accuracy rate of 98.4%, demonstrating the effectiveness of color analysis in identifying counterfeit notes.

## V. Legal and Ethical Considerations

It is crucial to think about the ethical and legal ramifications of a system for employing pattern recognition to detect counterfeit currency while creating and implementing it. Among the most important legal and moral factors are:

- a. Data privacy:** The system may gather and handle users' personal information, including pictures of their banknotes. It is crucial to make sure that the necessary data protection rules and regulations are followed while collecting, processing, and storing this data.
- b. Accuracy and impartiality:** When identifying fake currency, the system must be both accurate and impartial. False allegations or the denial of legitimate banknotes might occur from any biases or flaws in the system.

- c. Use of force:** In some circumstances, employing force to take down suspects of using fake currency may be essential. The appropriateness and legality of the use of force must be ensured.
- d. Jurisdiction:** Different countries may have different laws and rules regarding fake currency and how to spot it. Making ensuring the system conforms with the pertinent rules and regulations in the area where it is installed is crucial.
- e. Transparency:** The system must be open and honest in how it operates and must give users information that is simple to comprehend about how it functions and how choices are made.
- f. Ethics:** When developing and implementing the system, ethical issues should be taken into account. For example, it's important to make sure that the system isn't used to discriminate against people or groups based on their colour, ethnicity, gender, or other protected traits.
- g. Accountability:** Mechanisms must be in place to guarantee responsibility for the system's performance and operation, including independent authorities' supervision and evaluation.

Ultimately, it is crucial to take into account the moral and legal ramifications of building and implementing a system for employing pattern recognition to detect fake currency and to take precautions to make sure it runs in a just, open, and responsible manner.

## VI. Public Survey

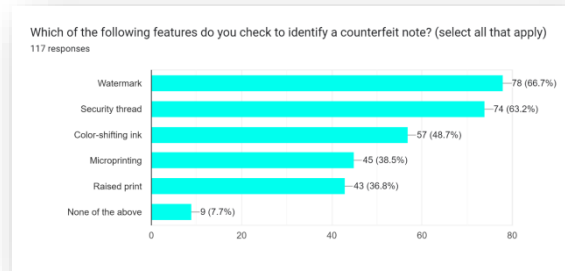
We first conducted a poll of people through Google form creator and data collection service to acquire information regarding people's awareness.

### Questionnaire:

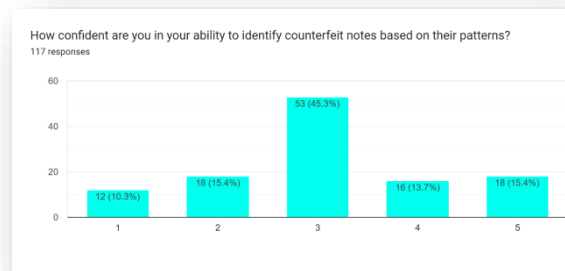
- Have you ever received a counterfeit note?
- How often do you encounter counterfeit notes?

- Which of the following features do you check to identify a counterfeit note? (Select all that apply)
- How confident are you in your ability to identify counterfeit notes based on their patterns?
- Which of the following factors do you think contribute to the prevalence of counterfeit notes? (Select all that apply)
- Do you think that the use of pattern recognition technology can help reduce the prevalence of counterfeit notes?
- How willing are you to use pattern recognition technology to identify counterfeit notes?
- Which of the following types of technology do you think are most effective in detecting counterfeit notes? (Select all that apply)
- Have you ever used a mobile application or online tool to check if a banknote is genuine?
- How satisfied are you with the current methods of detecting counterfeit notes?

3. Which of the following features do you check to identify a counterfeit note? (Select all that apply)



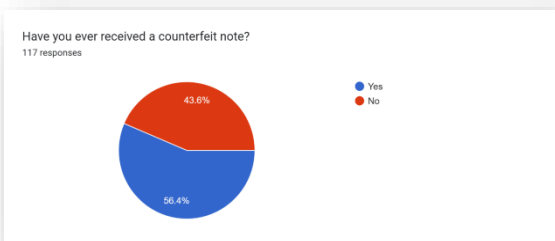
4. How confident are you in your ability to identify counterfeit notes based on their patterns?



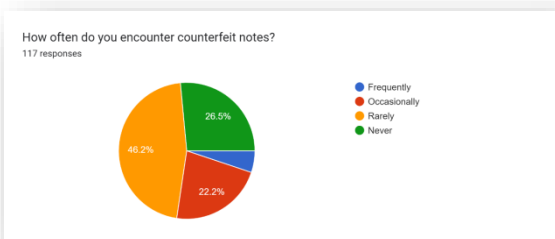
### VII. Results

Following are the results of poll conducted online through Google form.

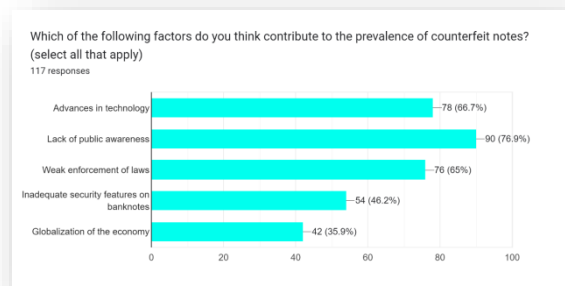
1. Have you ever received a counterfeit note?



2. How often do you encounter counterfeit notes?

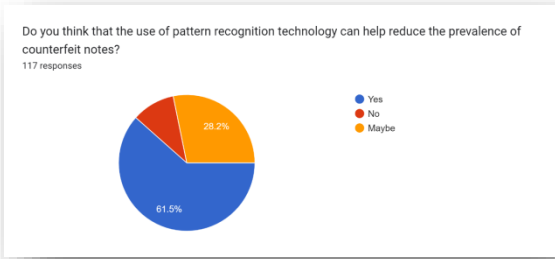


5. Which of the following factors do you think contribute to the prevalence of counterfeit notes? (Select all that apply)

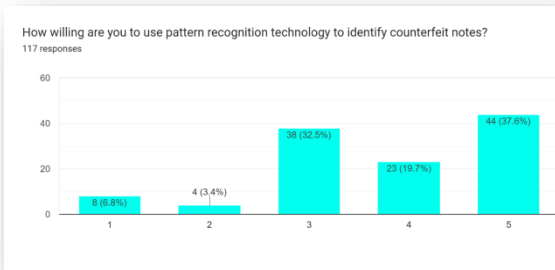


6. Do you think that the use of pattern recognition technology can help reduce the prevalence of counterfeit notes?

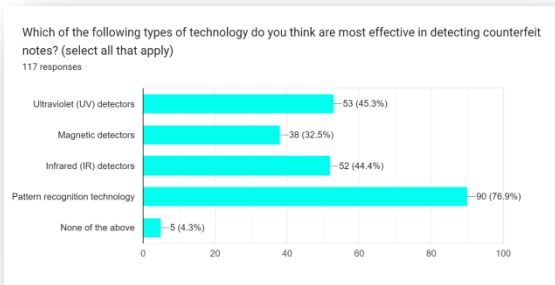




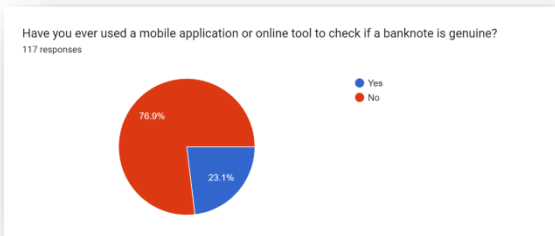
7. How willing are you to use pattern recognition technology to identify counterfeit notes?



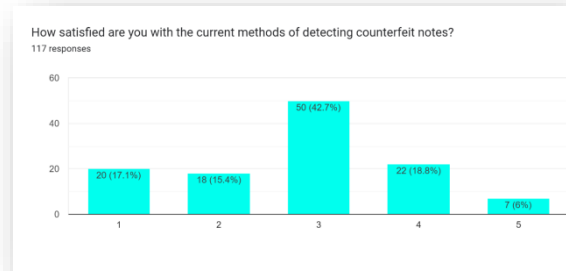
8. Which of the following types of technology do you think are most effective in detecting counterfeit notes? (Select all that apply)



9. Have you ever used a mobile application or online tool to check if a banknote is genuine?



10. How satisfied are you with the current methods of detecting counterfeit notes?



### 1.3. Descriptive Statistics:

Descriptive statistics is means of describing features of a data set by generating summaries about data samples. Here are some results which will helps us in

Have you ever used a mobile application or online tool to check if a banknote is genuine?	
Mean	0.232758621
Standard Error	0.039406692
Median	0
Mode	0
Standard Deviation	0.424423058
Sample Variance	0.180134933
Kurtosis	-
	0.364576883
Skewness	1.281409288
Range	1
Minimum	0
Maximum	1
Sum	27
Count	116
Largest (1)	1
Smallest (1)	0
Confidence Level (95.0%)	0.078057072

Have you ever received a counterfeit note?	
Mean	0.568966
Standard Error	0.04618
Median	1
Mode	1
Standard Deviation	0.497369
Sample Variance	0.247376
Kurtosis	-1.95437
Skewness	-0.28219
Range	1
Minimum	0
Maximum	1
Sum	66
Count	116
Largest (1)	1
Smallest (1)	0
Confidence Level (95.0%)	0.091473

Skewness	-	0.098649399
Range		4
Minimum		1
Maximum		5
Sum		325
Count		116
Largest (1)		5
Smallest (1)		1
Confidence Level (95.0%)		0.204682081

How satisfied are you with the current methods of detecting counterfeit notes?	
Mean	2.801724138
Standard Error	0.103332644
Median	3
Mode	3
Standard Deviation	1.112926636
Sample Variance	1.238605697
Kurtosis	-
	0.541717287

How confident are you in your ability to identify counterfeit notes based on their patterns?	
Mean	3.784483
Standard Error	0.110746
Median	4
Mode	5
Standard Deviation	1.192776
Sample Variance	1.422714
Kurtosis	-0.22122
Skewness	-0.69898
Range	4
Minimum	1
Maximum	5
Sum	439
Count	116
Largest (1)	5
Smallest (1)	1
Confidence Level (95.0%)	0.219367



## VIII. Findings

A survey was conducted to know the view of the people about what they think regarding the technology of counterfeit notes and the solution they have for current pattern recognition technology. So, people gave their opinions on different threats. So, this is what the stats say:

1. Out of all respondents, 56.4% received counterfeit notes and 43.6% have not received yet.
2. Out of all respondents, 46.2% of people rarely encountered counterfeit notes. 26.5% and 22.2% of people never and occasionally encountered counterfeit notes respectively.
3. Out of all respondents, 66.7%, 63.2%, 48.7%, 38.5%, 36.8% and 7.7% of people are agreed to use respective features to identify counterfeit notes i.e., watermark, security mark, colour-shifting ink, micro-printing, raised printing and none of above.
4. Out of all respondents, 45.3% of people are only confident to identify counterfeit notes based on their patterns.
5. Out of all respondents, the reason for the increase in the number of counterfeit notes are as follows: 76.9%: Lack of public awareness, 66.7%: advances in technology, 65%: Weak enforcement of laws, 46.2%: Inadequate security and 35.9%: Globalization of the economy.
6. Out of all respondents, 61.5% of respondents have agreed that pattern recognition technique is useful for reduction of prevalence of counterfeit notes.
7. Out of all respondents, as more people are receiving counterfeit notes, 37.6% of people are willing to use pattern recognition technology to identify the counterfeit notes.
8. Out of the total responses 76.9% of the people are considering pattern recognition as

the best technology for the detection of counterfeit notes. Rest think that other options also are worthy but not as much as pattern recognition.

9. Out of all respondents, 76.9% of respondents never used any application or any online tool to check even if banknote is genuine.
10. Out of all respondents, 17.1% and 15.4% of respondents are in range of not at all satisfied with current technology of counterfeit notes. 18.8% and 6% of respondents are in range of satisfied with current technology of counterfeit notes. Rest of respondents are still confused i.e. 42.7%.

From these responses, I've concluded that the new techniques such as pattern recognition for counterfeit notes are most required.

## IX. Conclusion

Counterfeit notes are a significant problem faced by economies worldwide, and it is essential to have an effective method to detect them. Pattern recognition has shown great promise in identifying counterfeit notes, and several studies have demonstrated its effectiveness in detecting counterfeit currency. The use of pattern recognition techniques, such as texture analysis, colour analysis, and geometric analysis, can significantly improve the accuracy of counterfeit note detection. Therefore, the adoption of pattern recognition methods in counterfeit note detection can help reduce the circulation of counterfeit notes and restore trust in the financial system.

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