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Review Article

Paper Currency: A systematic review of design, security features, and counterfeit detection

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Abstract: *Counterfeiting of currency notes remains a persistent global challenge with extensive economic consequences. This systematic review provides a comprehensive analysis of the detection techniques employed to combat counterfeit currency, involving various countries. The aim is to synthesize and evaluate the effectiveness of these methods, highlighting on the advancements made, and classifying areas of research with respect to its security features, conventional detection techniques, fuzzy logic and image processing techniques and other methods. One of the central themes emerging from this analysis is the importance of security features in currency design. Technological advancements have catalyzed the development of advanced detection tools and automated frameworks. Researchers have explored machine learning algorithms, image processing, and data-driven approaches to detect counterfeit notes efficiently. Additionally, this systematic review identifies the significance of cross-disciplinary collaboration. It emphasizes the need for cooperation between graphic designers, printers, papermakers, and central banks to create secure currency designs and implement effective detection mechanisms. Moreover, the geographical scope of this review extends to various countries where each region faces unique challenges and employs distinct methods to detect counterfeit notes, reflecting the global diversity in counterfeit threats. As the threat of counterfeit currency continues to evolve, this case by case analysis will serve as a valuable resource for banking and financial sectors, and researchers seeking to enhance counterfeit detection strategies and safeguard economies worldwide.*

Keywords: *currency, counterfeit, security features, authentication, detection techniques*

1. Introduction

Counterfeiting currency has been an age-old malpractice that seeks to destabilize economies and erode public trust in financial systems. The battle against counterfeit money is not new, but with advancements in technology, the methods employed by counterfeiters have become increasingly sophisticated, making the distinction between genuine and fake notes extremely challenging. Counterfeit notes can lead to significant economic losses, not only for individuals who unknowingly accept them but also for businesses and governments. Consequently, the detection of counterfeit currency has evolved into a crucial area of study. In today's digital world, paper currency is facing a transformation as nations consider the introduction of virtual banknotes, potentially defining the concept of actual money. Different international, national, and local communities and organizations play fundamental roles in understanding, detecting, and preventing the circulation of counterfeit notes. Various studies have explored the economic impact of counterfeiting, the significance of security features in currency, and methodologies for detecting counterfeit banknotes, with many focusing on Indian and other regional currencies, emphasizing the need for advanced

technologies and methodologies for note authentication. Non-visual methods involve chemical analysis to verify paper quality for counterfeit detection, while conventional techniques like UV illumination, texture, pattern, color analysis, and currency localization serve distinct purposes in identifying counterfeit currency notes. Several researchers have proposed systems using digital image processing techniques for identifying and distinguishing between genuine and counterfeit banknotes, with applications ranging from histogram enhancement to texture analysis, all aiming to provide fast, efficient, and reliable counterfeit detection. Researchers have developed a range of methods using image processing, neural networks, machine learning, and other techniques to recognize, verify, and differentiate genuine and counterfeit currency notes from multiple countries, achieving high accuracy rates and adapting to advancements in counterfeit technology. Numerous institutions have extensively researched counterfeit currency detection and genuine currency identification employing different techniques like image processing, MATLAB features extraction, hyper spectral imaging, and statistical feature analysis, to ensure currency security and authenticity.

This systematic review aims to highlight on the modern detection techniques that have been developed to identify fake currency notes. From conventional detection techniques to sophisticated image processing algorithms, different kinds of authentication methods have been explored. By understanding and reviewing these techniques in depth, this paper provides a comprehensive overview that could secure the current systems and possibly innovating new, more effective detection methods in the future.

2. Review on varieties of Paper Currencies

The prominence of paper money may be diminishing as digital currencies and online transactions become more prevalent globally. The tangible nature of cash, once its defining trait, is gradually being overshadowed by an emerging digital economy where electronic transactions are widespread. Although paper currency still has its charm, there's a possibility that nations might one day release virtual banknotes, enriched with features symbolizing their cultural and national values. The fundamental distinction between different national paper currencies is their intrinsic value. Central banks set the highest denomination for circulation, with the number of zeros on a note indicating its purchasing power. Presently, in many countries, a banknote with a hundred units, such as 100 US dollars, stands as the most common highest denomination. All around the world most countries still use paper money for example, India, Russia, the United States of America, the kingdom of Saudi Arabia, Australia, China, Canada, Japan, the United Kingdom, and many more. A comprehensive study was undertaken on the paper currency features across seven continents, excluding Antarctica. Randomly selected countries from each continent were analyzed to investigate various aspects of banknotes, including design motifs, security features, and historical symbols. This research is aimed to uncover similarities and differences in currency design influenced by cultural, economic, and political factors globally. By examining these elements, the study provides valuable insights into the societal values and historical narratives embedded in banknotes worldwide. It highlights the diversity of artistic expressions and security innovations employed by different countries, offering a meticulous understanding of monetary systems on a global scale. Table-1 shows comparative analysis of different kinds of characteristics related to the security of paper money and Table-2 illustrates design chart of various kinds of paper banknotes worldwide. Related data from Table-1 and Table-2 are available in different websites for public [1], [2], [3], [4], [5], [6], [7].

Table 1 *Comparative analysis of different kinds of characteristics related to the security of paper money*

No.	Security Features	India Indian Rupee (INR) [1]	Bhutan Bhutanese Ngultrum (BTN) [2]	USA United States Dollar (USD) [3]	Switzerland Swiss Franc (CHF) [4]	Australia Australian Dollar (AUD) [5]	Brazil Brazilian Real (BRL) [6]	Nigeria Naira (NGN) [7]
1.	Watermark	Present	Present	Present	Present	Present	Present	Present
2.	Security Thread	Present	Present	Present	Present	Absent	Present	Present
3.	Intaglio Printing	Present	Present	Absent	Present	Present	Present	Present
4.	Microlettering	Present	Present	Present	Present	Present	Absent	Present
5.	Identification Mark	Present	Absent	Absent	Present	Absent	Absent	Absent
6.	Latent Image	Present	Absent	Absent	Absent	Absent	Present	Absent
7.	See-through Register	Present	Absent	Absent	Present	Present	Present	Absent
8.	Ultraviolet Fluorescence	Present	Absent	Absent	Present	Present	Present	Present
9.	Optically Variable Ink	Present	Present	Present	Present	Absent	Absent	Absent
10.	Optically Variable Fibres	Absent	Absent	Absent	Absent	Absent	Absent	Absent
11.	Tactile Feature	Present	Present	Absent	Present	Present	Present	Present

Table 2 *Design chart of various kinds of paper banknotes worldwide*

No.	Country	Length (L) in mm	Width (W) in mm	Aspect Ratio (W/L)	Color	Motif (Front)	Motif	Nigeria Naira (NGN) [7]
1.	India	129	63	0.488	Greenish Yellow	Mahatma Gandhi portrait	Ellora Caves	Present
2.	Bhutan	132	65	0.492	Yellow and Green	3rd King Jigme Dorji	Punakha Dzong	Present
3.	United States of America	156	66.3	0.425	Green and Peach	Andrew Jackson portrait	White House	Present
4.	Switzerland	130	70	0.538	Red	Light passing through prism	Butterfly	Present
5.	Australia	144	65	0.451	Red and Orange	Mary Reiby portrait	John Flynn portrait	Absent
6.	Brazil	140	65	0.464	Yellow, Orange and Brown	Effigy of the republic	Golden lion tamarin	Absent
7.	Nigeria	151	78	0.516	Green	Murtala Muhammed portrait	Lady Kwali portrait	Absent

2.1. Review on Security Features

Security features are the most important characteristics of paper currency which generally varies with the types of country. Many works and researches had been conducted till date and therefore, it is useful to bring all the works together for future development. The numbers of researches in this field are enormous, thus few of them are mentioned here which are easily available.

Agenor [8]in the article tried to take an effort to look at the economic impact of counterfeiting culture around the world and the sectors that suffered the most. They highlighted the importance of security features and mentioned a proactive role in preventing currencies from being counterfeited. De Heij [9] suggested a structured methodology in the form of a questionnaire was created to establish a clear design policy and manage the design process effectively. This ensured smooth collaboration among the graphic designer, printer, papermaker, and central bank. It also included a Programme of Requirements (POR) that served as a detailed guideline for banknote development, involving all relevant parties. This systematic approach facilitated the objective evaluation of design proposals and the integration of security features. Sarkar et al. [10] investigated an automatic effective method for identification of fake notes. They discussed some of the important

security features of an Indian Banknote by taking some samples of currency notes and classified a methodology to correlate the real currency note with actual printing operation. Ali et al. [11] presented a paper that provided a comprehensive overview of recent technological advancements in the identification and recognition of paper currencies. It emphasized the importance of various security features on Indian banknotes and classified the detection techniques based on first and second line inspection methods. Shoeb et al. [12]presented a paper on security features of Egyptian currencies. They suggested a technique that used the color distribution in paper currency and was analyzed using image histograms and color moments. Additionally, the security features of paper currency, such as anti-scan elements, latent images, and Optically Variable Ink (OVI), were examined through feature extraction and texture analysis. Uddin et al. [13] proposed an automated image-based technique was developed to detect counterfeit banknotes from Bangladesh. Various security features, including watermarks, micro-printing, and holograms, were extracted from the banknote images. The detection process was then carried out using Support Vector Machine (SVM) technology. Sahu and Sinha, [14] and Pinki [15] suggested an approach was devised to identify genuine currency notes by focusing on the various security features of India's highest denomination notes, valued at 2000 and 500. The analysis included prominent features on both the front and reverse sides of these notes, enabling differentiation between forged and genuine currency through straightforward examinations. Kumar et al. [16] investigated a study that examined various security features of the newly introduced 500 denomination paper currency. Security features were identified by altering wavelengths using different light sources, magnification levels, and filters. Sarkar and Pal [17] conducted a comprehensive study and comparison of salient features between old and recent versions of Indian banknotes. It outlined a list of security features present in Indian currency and explored various conventional methods for note authentication and recognition, each with its specific objectives and significance. The detection process had been divided into two parts which are primarily the first-line and the second-line detection methods. Additionally, the research introduced a novel parameter, the diagonal of genuine currency notes, standardized for different denominations.

It is important to understand that relying solely on analyzing security features for detecting counterfeit currency notes has several limitations. While security features such as holograms, watermarks, micro printing, and special inks are designed to deter counterfeiters and aid detection, they are not completely reliable. Advanced printing technologies and skills possessed by counterfeiters can sometimes replicate these features with high accuracy, making it difficult for traditional methods alone to identify fake notes. Moreover, the effectiveness of security features can vary between different currencies and over time as counterfeiters adapt to new technologies and techniques. Some counterfeit notes may even pass initial visual and tactile inspections due to increasingly sophisticated replication methods. To overcome these limitations, it is crucial to employ a versatile approach to counterfeit detection. This includes using specialized detection equipment such as ultraviolet (UV) lamps, magnifiers, and counterfeit detection pens that test paper composition. UV lamps reveal hidden features like fluorescent inks, while magnifiers help inspect fine details that may be missed by the naked eye. Additionally, chemical tests from detection pens can detect counterfeit notes based on paper reactions. Furthermore, leveraging technological advancements such as machine learning algorithms and digital image processing can increase the accuracy of detection of fake notes by analyzing patterns and anomalies in banknote features that are imperceptible to human senses alone. Therefore, while security features are essential components of counterfeit prevention, their limitations necessitate complementary detection techniques. A comprehensive approach combining human expertise with technological tools ensures robust counterfeit detection, safeguarding the integrity of currency systems worldwide.

2.2. Review on Conventional Detection Techniques of Fake Currencies

Conventional detection techniques or traditional methods are designed to identify counterfeit banknotes through a combination of manual inspection, security features analysis, and specialized equipment to ensure the circulation of genuine currency.

Sarkar et al. [10] mentioned in their paper about the non-visual methods that included the use of chemical analysis to validate the paper quality and hence compared with a counterfeit currency paper to check its authenticity. Ali et al. [11] investigated various conventional detection and recognition techniques to identify a counterfeit currency note by using counterfeit detection pen, UV illumination method, and texture based technique, pattern based technique, color based technique and currency localization techniques. Each technique had its own objective and significance.

2.3. Review on Detection Techniques by Fuzzy Logic

The idea of fuzzy logic technology has opened up a new domain in the field of counterfeit detection and a very few researches in this area are available in open literature.

Sanchez-Roger et al. [18] attempted a study to critically evaluate the effectiveness of fuzzy logic as a tool for financial research, specifically for managing banking crises. It was deemed pertinent for supervisory and regulatory bodies, banks, and academic researchers, as it introduced novel research directions on banking crises using artificial intelligence mehods. Through a comprehensive literature review, the work facilitated the integration of fuzzy logic into banking crisis analysis and identified key areas for further improvement. Sarkar and Pal [19] explored the application of fuzzy system to combat the circulation of fake currency, particularly focusing on Indian banknotes. The mapping of security features in Mamdani type interface based fuzzy logic system is illustrated in (Figure-1) by considering 3 membership function for input and output which was developed to classify banknote security features like watermarks, security threads, holograms, and others. The system used fuzzy IF-THEN rules derived from logical observations and feedback from individuals who handle currency regularly. The Surface Viewer tool visualized these interactions, generating 3D curves that distinguished between genuine, counterfeit, and worn-out notes based on their security features. This innovative approach could pave the way for a global web-based system to assess various currencies and further enhance their security features.

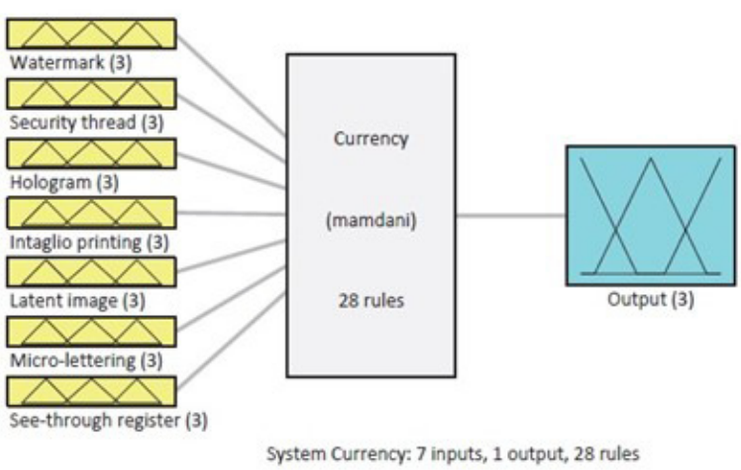

Figure 1 *Fuzzy inference system for mapping of security features to the output [19]*

2.4. Review on Detection Techniques by Image Processing

Detection techniques by image processing have emerged as innovative approach to combat the production of counterfeit currency. Ongoing researches are being conducted with advanced algorithms and digital imaging technology that offer a sophisticated means to identify fake banknotes by analyzing their visual characteristics and intricate security features with precision and speed. Some easily accessed literatures related with this area are mentioned here.

Semary et al. [20] presented a paper where a banknote detection system was implemented for Egyptian currencies by applying clear-cut digital image processing methods to guarantee a fast and robust process. The core framework of this system included digital image segmentation, histogram development, the withdrawal of Region of Interest (ROI), and relating the corresponding template through cross-correlation between the acquired image and the actual dataset. Shoeb et al. [12] suggested the techniques that utilized exploratory data analysis techniques, including histograms, defined ranges for the statistical mean and median methods, color tones, Euclidean space, and texture examination. Texture investigation involved segmentation of images to remove three security features namely the anti-scan, latent image, and optically variable ink. This method was highly effective in distinguishing between genuine and counterfeit Egyptian currency. Agasti et al. [21] proposed a system for detecting counterfeit currency notes that operates more quickly and efficiently through image processing. This system provided a method for verifying Indian banknotes by extracting various features using MATLAB software. Veiling et al. [22] proposed an approach to make a distinction between real and duplicate banknotes. They implemented the framework using hyper spectral imaging and extraction of different features. In their paper the fake note detection technique had been considered with image processing algorithms to extract the different features present on a banknote. Finally they classified Rs 100, Rs 500 and Rs 2000 notes with the help of aspect ratio calculation. Sharan and Kaur [23] investigated a system to tell apart between genuine and counterfeit notes using digital image processing techniques implemented by MATLAB programming. This process involved capturing images of the five hundred and two thousand rupee notes with a digital camera, followed by pre-processing to eliminate noise. The average intensity of the Red Green and Blue channels was considered, and another three distinctive features such as Latent image, denomination numeral, and Reserve Bank of India (RBI) Logo with Rupee symbol were processed for comparison between real and counterfeit banknotes. Madhura et al. [24] presented an automated currency detection system based on digital image processing. This system was designed in such a way so as to identify both the denomination as well as the country of origin of a currency note. The method involved first determining the country by analyzing specific predefined areas on the notes. It then extracted features such as the color, size of a note and text to determine the currencies' denomination. The results were obtained through a graphical user interface (GUI) and also provided in an audio format. Sarkar and Pal [25] investigated a method to distinguish between real and fake banknotes using digital image processing techniques. When applied on MATLAB software, the method effectively differentiated real from fake Indian banknotes. (Figure-2) illustrates the actual framework and algorithm of the methodology used for the detection of counterfeit paper currencies. The approach could process images of currency taken from any scanner or digital camera, regardless of lighting conditions or orientation. Techniques such as enhancement of images, detection of edges, and histogram analysis yielded distinct contrasts between genuine and fake notes.

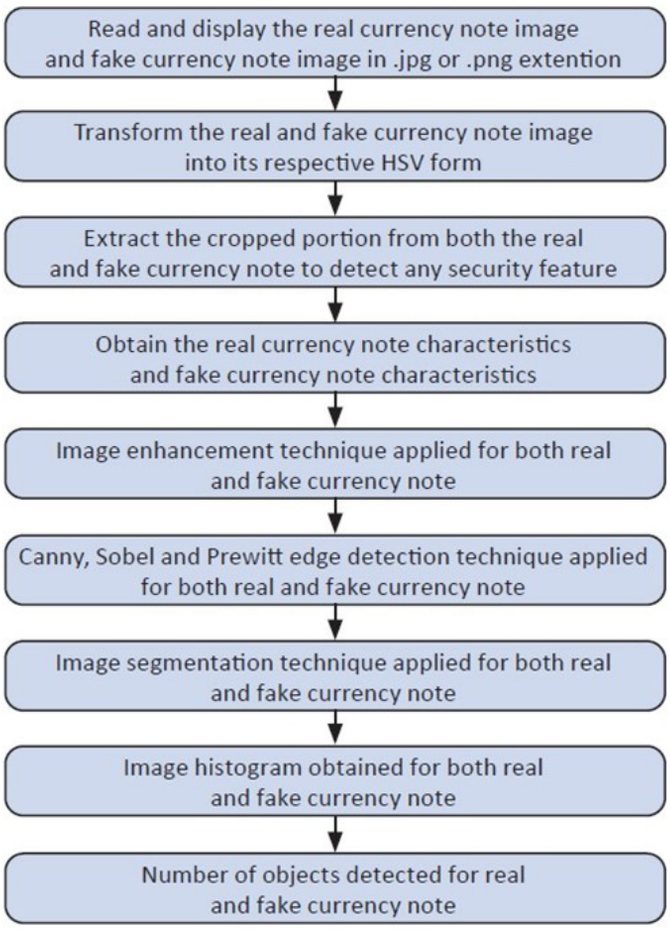

Figure 2 *Algorithm of the proposed framework using digital image processing [25]*

Fuzzy and digital image processing methods have been employed in many important applications, including the detection and prevention of currency counterfeiting. These technologies offer sophisticated tools to set apart between real and fake currency notes based on intricate patterns, color tones, security features, and more. The integration of fuzzy logic and image processing techniques can offer a robust and adaptable approach to counterfeiting detection. However, as counterfeiters also evolve their methods, it is essential for detection technologies to continually adapt and improve. Fuzzy logic has been influential in financial research for managing banking crises and detecting counterfeit currency, with applications like a fuzzy-based system for worldwide banknotes, suggesting potential for a global currency security assessment system. Also, with the application of image processing analysis it can offer a simple and cost-effective solution for counterfeit currency detection. Over time, these two techniques seem to be simpler and novel detection techniques of counterfeit paper currencies. Also, with the invention of internet of things and android based software applications these two techniques are becoming popular worldwide.

2.5. Review on Detection Techniques by Other Methods

Counterfeiting currency note has evolved significantly in the modern age. While traditional instrumental techniques exist, such as Raman Spectrometer, Infra-Red (IR) detection, Ultraviolet (UV) light, magnetic detection, X-ray fluorescence (XRF) etc. they are no longer as prevalent as

they once were. Nowadays, counterfeiters rely heavily on advanced digital tools, such as high-resolution scanners, colour printers, and graphic design software, to produce convincing fake notes. These techniques allow for intricate detail replication, making detection more challenging. In response, central banks and law enforcement agencies have adapted by implementing advanced security features in modern banknotes. Therefore, in today's scenario there is a serious need of digital methodologies for newer and more sophisticated means of detecting forged currencies. Beyond image processing and fuzzy logic, various other digital methods have been developed to detect counterfeit currency. These alternative techniques offer diverse ways to recognize genuine banknotes from the fake ones, ensuring the security of financial transactions.
Table-3 provides a literature survey of currency detection techniques mainly from the year 1996 using different digital methods apart from conventional procedure, fuzzy logic and image processing approach.

Table 3 *Literature review on currency authentication all across the globe using different strategies*

Author(s)	Year	Techniques Used	Results Obtained
Frosiniet al. [26]	1996	Neural based recognition and verification techniques based on optoelectronic devices	Forged banknotes were detected with neural method and low cost sensors
Tanaka et al. [27]	1998	The probability density curve created by a multivariable Gaussian function and because of the structure of the model, it is referred as hybrid neural network.	Identified four types of currencies into the correct classes by multilayer perceptron (MLP)
De Heij [9]	2000	Methodology for Dutch banknotes in questionnaire pattern that provided for a design policy for banknotes	This approach enabled an objective selection of design proposals, including security features
Takeda and Nishikage [28]	2000	Neuro-recognition system using axis-symmetrical mask and dual image sensors for recognition of Euro currency note	Reported enhanced neuro-system by recognizing patterns of genuine and dummy currencies
Ahmadi et al. [29]	2003	Novel technique for recovering the reliability by considering the local principal component analysis approach	By using 1200 sample of US dollar bills the reliability went up to 100 percent
Choi et al. [30]	2006	Bank note classification using feature extraction by wavelet transform	Euclidean minimum distance classification rate came up to be 99%
Debnath et al. [31]	2009	Ensemble Neural Network (ENN) approach used for detection of genuine banknotes	Identification of old images of Bangladeshi banknotes

Author(s)	Year	Techniques Used	Results Obtained
Hasanuzzaman et al. [32]	2011	Currency identification approach using the Speeded up Robust Features (SURF) method that deals with image rotation, illumination changes and background noise	Applied to a large dataset of banknotes and thus achieved the recognition rate of 100%
Sarkar et al. [10]	2013	Classification methodology for connecting authentic notes to their foundation printing presses	Resulted in linking forged Indian notes to their unlawful sources
Sarfraz M. [33]	2015	Automatic Saudi Arabian paper currency recognition system on correlation between currency images using Radial Basis Function Network	Overall average recognition rate for 110 images was computed as 91.51%.
Uddin et al. [13]	2016	Automated image-based for security features like watermarks, micro-printing, and holograms, separated from the currency images and detected by using Support Vector Machine (SVM)	Considered two types of banknotes i.e., 500 BDT and 1000 BDT and achieved 100% recognition accuracy
Lee et al. [34]	2017	The study focused primarily on four key research domains which are banknote identification, counterfeit exposure, serial numeral recognition, and fitness categorization.	Described a variety of sensors in computerized and automated machines, and described the pros and cons of the techniques.
Ali et al. [35]	2019	Machine learning's state-of-the-art models called the Generative Adversarial Networks (GANs) that are used to train a model by applying unsupervised learning to perform supervised predictions	80 percent precision was resulted from this experiment by the GANs methodology for fake cash recognition
Kumar et al. [16]	2020	Explored the security features on banknotes with diverse lights, range of magnification, and various filters analyzing through Docucenter Nirvis Instrument	Denomination 500 was difficult to counterfeit due to difficult to duplicate security characteristics implanted, which made denominations more secure

Author(s)	Year	Techniques Used	Results Obtained
Andrushiaet al. [36]	2020	The approach involved extracting first and second order features that are statistical in nature, which were then provided as efficient characteristic vectors to the SVM classifier	Methodologies and experimental results formed classification exactness of 95.8 percent.
Pachón et al. [37]	2021	Approach based on the strategy called transfer learning, and freezing points in convolutional neural network (CNN) Frameworks and a conventional representation on sequential CNN type AlexNet.	Results stated that ResNet18 achieved the best accuracy with 100%

3. Discussion

Paper currency notes possess a range of features that make them indispensable in modern economies. Firstly, their portability and lightweight nature enable easy transportation and storage, facilitating convenient transactions in everyday life. Despite their frequent circulation, paper notes are designed to be durable, ensuring they maintain their integrity and usability over extended periods. Anonymity in transactions is another significant benefit of paper currency. Unlike digital transactions that may leave a trace, cash transactions offer a level of privacy and discretion which are valued by many individuals and businesses. This characteristic supports financial freedom and personal security. Internationally, paper currency notes play a pivotal role in facilitating global trade and travel. They are universally recognized and accepted, providing a common medium of exchange that transcends borders and languages. This widespread acceptance contributes to economic stability and international cooperation. Beyond their practical utility, currency notes often showcase intricate designs, cultural symbols, and representations of national heritage. These artistic elements not only enhance the aesthetic appeal of banknotes but also serve as tangible expressions of a nation's identity and history. Moreover, the tactile nature of paper currency allows for straightforward verification by touch, aiding accessibility for the visually impaired and ensuring inclusivity in financial transactions. Hence, paper currency notes combine practicality, anonymity, cultural expression, and accessibility, making them essential components of global economies. Their enduring relevance underscores their role in fostering economic efficiency, preserving cultural heritage, and enhancing financial accessibility.

Instrumental detection methods historically were associated with high costs and required specialized equipment, making them less accessible to the general population. However, the rise of digital techniques, for example fuzzy logic, neural networks, digital image processing and machine learning offer a promising shift. These modern methods are not only potentially more accurate but are also cost-effective. The reason for their economic feasibility is that they can be software-based which allows for seamless integration into platforms like android and therefore, do not always rely on expensive hardware. Moreover, sophisticated detection tools

can be transformed into user-friendly mobile applications. These transitions to mobile platforms highlight the importance of comprehensive research reviews in this domain. Analyzing the advancements and effectiveness of these digital techniques can pinpoint areas for improvement and set the direction for future innovations. As a result, exploring the potential of digital detection methods, especially in the area of android applications, it is crucial for the evolution of accessible and affordable detection techniques.

4. Conclusion

The comprehensive exploration of the detection techniques for counterfeit currency presented in this investigation shows that the challenge is multi-faceted, requiring a combination of traditional methods and modern technological advancements. The literature survey for the last 30 years may be fruitful for studying the important research works in this field that have been performed by various researchers to minimize the extent of banknote forgery. In addition, the review on previous investigations has been categorized on the basis of security features, conventional detection methods, detection techniques using Fuzzy Logic, detection techniques using Image Processing and detection techniques using other methods.

While traditional methods, such as watermark and security thread verification, continue to be foundational, they alone are no longer sufficient to combat today's sophisticated counterfeits. Recent developments in digital image processing, machine learning, and fuzzy logic analysis have guided a new era of detection mechanisms. When applied accordingly, these techniques can greatly increase the accuracy and speed of counterfeit detection, ensuring economic stability and preserving public trust. Collaboration between financial institutions, governments, technologists, and researchers is vital to staying ahead of counterfeiters. Moreover, the future may also see an escalation in the integration of automated detection systems into everyday transactions, reducing human error. Furthermore, while significant progress has been made in counterfeit currency detection, the research is ongoing, demanding attention, innovation, and collaboration to safeguard our economies.

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Conflicts of interest

No conflicts of interest from the authors' side.

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