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Fake Currency Detection Using Image Processing

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Abstract- Fake currency has always been an issue that has created a lot of problems in the world. Every country has been badly affected by this which has become a major problem. Moreover, it makes the domestic currency lose out its credibility in the global market. Thereby triggering adverse socioeconomic impacts. Counterfeit currency is also usually associated with terror financing. According to an RBI report, fake notes of the new Rs 500 series saw a 37% rise in 2019-20, and there was a fall in circulation of Rs 2000 notes. The increasing technological advancements have made the possibility of creating more counterfeit currency. Fake currency has always been an issue that has created a lot of problems in the world. Every country has been badly affected by this which has become a major problem. Moreover, it makes the domestic currency lose out its credibility in the global market. Thereby triggering adverse socioeconomic impacts. Counterfeit currency is also usually associated with terror financing. According to an RBI report, fake notes of the new Rs 500 series saw a 37% rise in 2019-20, and there was a fall in circulation of Rs 2000 notes. The increasing technological advancements have made the possibility of creating more counterfeit currency.

Keywords: Red Green Blue, Region of Interest, Fake Indian Currency Note

I. Introduction:

Fake currency has always been an issue that has created a lot of problems in the world. Every country has been badly affected by this which has become a major problem. Moreover, it makes the domestic currency lose out its credibility in the global market. Thereby triggering adverse socioeconomic impacts. Counterfeit currency is also usually associated with

terror financing. According to an RBI report, fake notes of the new Rs 500 series saw a 37% rise in 2019-20, and there was a fall in circulation of Rs 2000 notes. The increasing technological advancements have made the possibility of creating more counterfeit currency.

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The project majorly deals with the field of Image processing. Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the buildup of noise and signal distortion during processing. Digital image processing allows the use of much more complex algorithms, and hence, can offer both more sophisticated performance at simple tasks, and the implementation of methods that would be impossible by analog means.

II. Literature Survey

As there are different techniques to avoid counterfeiting, such as encrypting security features in banknotes, researchers began developing various algorithms to detect counterfeiting, taking various currencies throughout the world into consideration. There are several papers available that provide information on detecting fake currency. The following are some of the papers addressed in the references.

This research article gives information on how to identify the security features of the Indian currency. It has mentioned all front side as well as reverse side features of 2000 rupees notes and 500 rupees notes. The author mentioned around twenty features like note's size, color, security threads with an inscription, number on the top left and bottom right side, emblem of Ashoka pillar on the right side, etc. [1]

This is the first book to provide a balanced explanation of image processing basics as well as the software techniques that are needed to implement them. The book integrates all fundamental concepts of DIP and Image Processing Toolbox from MathWorks, Inc. a leader in scientific computing. The Image processing toolbox provides a stable, well-supported software environment for addressing a broad range of applications in digital image processing. It includes topics such as image registration, color profiles, new image features, minimum-perimeter polygons, and local features using MATLAB covered in detail.[2]

In image processing, grayscale image plays a vital role. Color is complex. Color information doesn't help in identifying important edges or other features. Some algorithms can only be applied to grayscale images hence there is a need of converting RGB images to Grayscale images. The author has introduced various image processing techniques and software applications to convert color images to grayscale images.[3]

Understanding the content of a picture and extracting meaningful and valuable information from it is one of the most important aims of image processing. The edge detection technique helps us to do that. Edge detection decreases the quantity of data in an image while maintaining the image's structural properties. The author mentioned several algorithms to detect edges. The author also experimentally observed that the canny edge detector gives better results than other techniques such as Sobel, Prewitt, Roberts, and Laplacian of Gaussian.[4]

The research on a currency verification system based on image processing and the extraction of features was carried out. This research was performed on Indian currency. Image Acquisition, Grayscale conversion, Edge Detection, Image Segmentation Characteristic Extraction, and Comparison are the six steps of the system. To perform a comparison between the actual and counterfeit notes, edge detection and picture segmentation were applied. [5]

This paper has explained Indian fake currency detection using computer vision. In this paper, the researcher has extracted currency features and developed his dataset and used it for currency detection. He has used ORB and BF approaches to extract features of paper currency.[12]

GLCM is a second-order statistical texture analysis method. This research paper shows an application of the gray level co-occurrence matrix to extract second-order statistical texture

features of images. The researcher showed that texture features have high discrimination accuracy, require less computation time, and can be used for real-time pattern recognition applications efficiently. [11]

III. Theoretical Background

The project majorly deals with the field of Image processing. Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the buildup of noise and signal distortion during processing. Digital image processing allows the use of much more complex algorithms, and hence, can offer both more sophisticated performance at simple tasks, and the implementation of methods that would be impossible by analog means.

The system will extract the following features and compare them with the real note.

Fig. Features of Indian note

Fake currency detection varies depending on specific features of the banknotes of the country. For the Indian banknotes, features are considered for testing purposes Rs 2000 note. There are some important security features of the Indian currency:

- See-through register
- Bleed Line
- Watermark
- Security thread
- Latent image
- Micro lettering
- Identification mark

See-Through Register:

When the note is held up to the light, this feature will reveal the number of the note.

Bleed Line:
The bleed lines are printed on the obverse in both, the upper left and the right-hand edge of the notes to aid the visually impaired. The bleed line is printed only 2000, 500, 200, and 100 notes.
Watermark:
The Mahatma Gandhi watermark is present on the banknotes. The Mahatma Gandhi watermark is with a shaded effect.
Security thread:
To the left of the Mahatma's image, a security thread is visible. The fully embedded security thread is plain and non-readable.
Latent Image:
On the obverse side of the notes, a vertical stripe on the left side of Mahatma Gandhi's face has a latent image indicating the matching decimal number. This image is visible only when the note is held horizontally at eye level.
Micro lettering:
This feature appears between the vertical band and Mahatma Gandhi's portrait.
Identification mark:
Each note has its special identification mark. There are different shapes of an identification mark for different denominations (Rs.100-Triangle, Rs.500-Circle, Rs.2000-Rectangle).

Paper fake currency recognition is one of the applications of pattern recognition. There are some similar recognition systems, such as face recognition system, and fingerprint recognition system. Although, the theories they use are similar, but the techniques and approaches are different. These techniques involve steps like noise removal, preprocessing, etc. To make the system more comprehensive, we need to create a small database for storing the features of the currency.
The main steps in the system are:

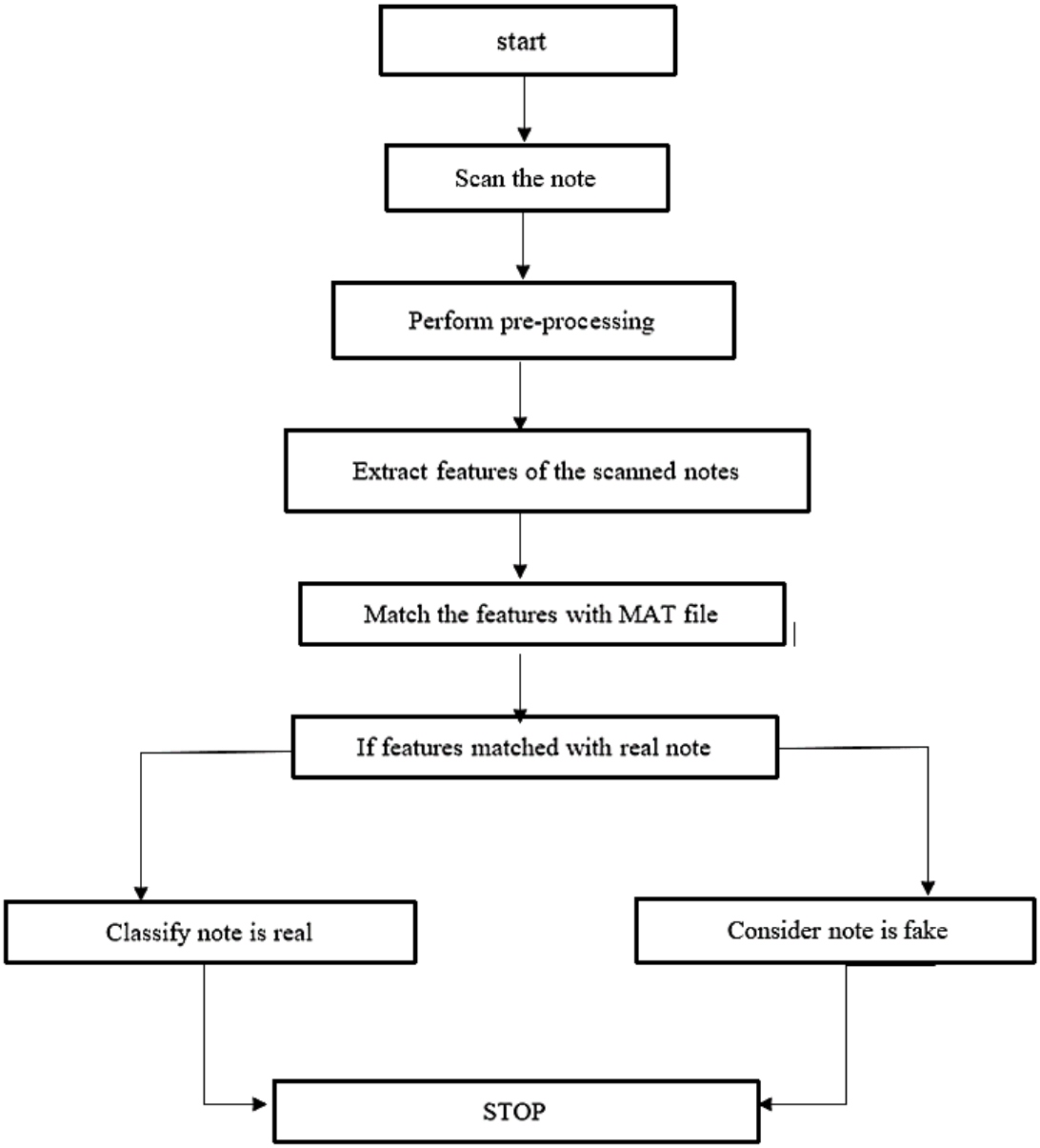
Read an image
Preprocessing, removing noise
Feature extraction
Classification
Result

The approach consists of several steps including image acquisition, grayscale conversion, edge detection, feature extraction, image segmentation, and comparison of images.

Technical Specifications:

This system will check whether the Indian currency note is fake or real. We have used the MATLAB image processing toolbox. This low-cost system using effective and efficient image processing techniques and algorithms will provide accurate and reliable results.
Software Requirement:
Operating System: Windows 7
Tools: MATLAB 2017
Hardware Requirement:
Processor: Intel Core 2 Duo
RAM: 2GB
Hard Disk:200 GB or more

IV. Methodology:
The approach consists of several steps including image acquisition, grayscale conversion, edge detection, feature extraction, image segmentation, and comparison of images.



4.1.1 Image Acquisition:

The system takes the image of the currency that we wanted to review or certify as genuine currency. Scanning an image or taking a picture with a phone and then uploading it to the system can be used to
obtain the input image.

4.1.2 Noise Removal:

Noise can occur in digital images in a variety of forms. Noise is caused by errors in the image acquisition process, which cause pixel values to differ from the true intensities of the real image In MATLAB medfilt2(I) performs median filtering of the image I in two dimensions. Each output pixel contains the median value in a 3-by-3 neighborhood around the corresponding pixel in the input image.

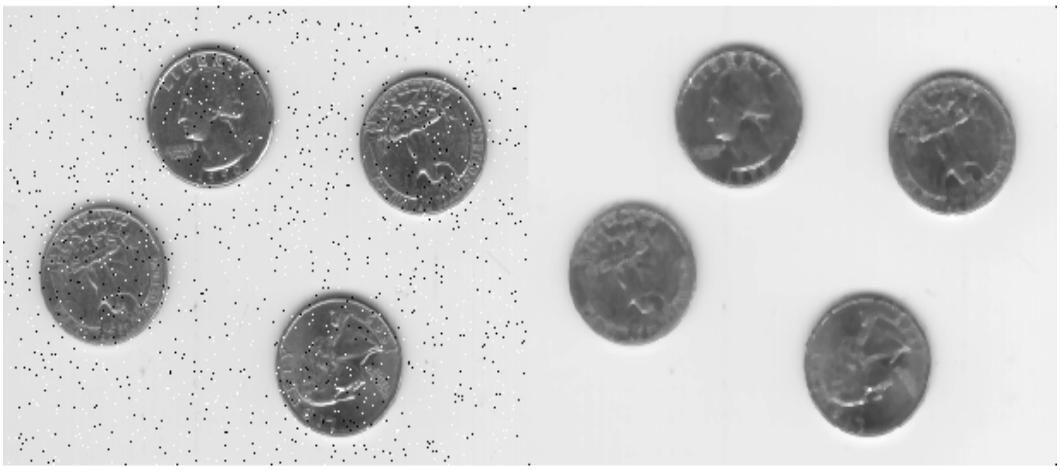


Fig. 4.1. Noise removal by using median filtering

4.1.4. Gray Scale Conversion:

Converting a color image to a grayscale image requires a greater understanding of the color image. In a picture, a pixel color is made up of three colors: red, green, and blue (RGB). The RGB color values are represented in three dimensions XYZ, illustrated by the attributes of lightness, chroma, and hue. The quality of a color image depends on the color represented by the number of bits that a digital device could support.

A Grayscale image, on the other hand, is seen as a single-layered image. Gray Scale conversion is a vital part of image processing because RGB or color information has a 3-dimensional property which makes signal processing so much bulky and heavy to remove. In the grayscale image, the darkest possible shade is black, and the lightest possible shade is white, Black means the total absence of transmitted or reflected light, and white means total transmission or reflection of light at all visible wavelengths. To convert a colored image to a grayscale image, the average method or luminance method can be used.

4.1.4. Edge Detection:

Edge detection is a fundamental tool in image processing and computer vision, particularly in the areas of feature detection and feature extraction, which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. Edge detection is one of the fundamental steps in image processing, image analysis, image pattern recognition, and computer vision techniques. There are various techniques are available for detecting the edges information such as Roberts, Prewitt, Sobel, Laplacian of Gaussian, and Canny.

Fig. 4.2 Edge detection using the canny method

4.1.5. Segmentation:

Image segmentation is the process, which is divided a digital image into multiple segments, a set of pixels. It is also called the image thresholding in which the threshold is decided and if the value of the given pixel is above the threshold, then is converted into a white pixel otherwise converted into a black pixel.

4.1.6 Feature Extraction:

Feature extraction is a sort of dimensionality reduction in which important sections of a picture are efficiently represented as a compact feature vector. When picture files are huge and a reduced feature representation is required to fulfill tasks like image matching and retrieval rapidly, this technique is effective. And then these features are retrieved and applied for comparison.

Feature extraction describes the process of converting the input images into a unique set of useful feature sets. In other words, it is a way of reducing the dimensionality of raw images into a concise set of desirable features. A good set of extracted features make the task of formal classification technique easy in classifying the images. However, the extraction of useful distinctive features is a complex and tedious task. There are several well-known techniques for feature extraction including local binary patterns, transform features, principal component analysis, decision boundary feature extraction, and statistical features.

Statistical can be thought of as a recurrent pattern of information or structure in raw data. There are different ways to extract the statistical features such as structural, statistical, and transform-based methods. In this project statistical-based feature extraction methods are used, specifically focused on first order histogram-based features and second-order co-occurrence matrix features of currency images.

4.1.6.1 First Order Statistics:

A histogram provides first-order statistical information for the images. Probability density (p) can be used as a measure of the occurrence of the intensity level. This can be calculated by

$$P(i) = \frac{g(k)}{N} \ , k = 1,2,3 \ldots . M$$

Where i refers to intensity level histogram values, N refers to the total number of pixels. g(k) is the intensity level for a given grayscale level k; M is the maximum number of gray levels in an input image.

From the probability density of grayscale intensity levels (P) several useful quantitative first-order statistical features can be obtained. These features include mean*(F1*), kurtosis (*F2*), skewness(*F3*), variance(*F4*), entropy(*F5*) and energy(*F6*). The first simple feature mean represents the average of the MRI intensity, while variance measures the intensity changes around the mean. The degree of asymmetry around the mean of the histogram is measured by the skewness. The degree of outliers in the histogram is measured by the kurtosis, the uniformity of the histogram is measured by the energy, and the randomness of distribution is measured by entropy. The mathematical formulas of these first-order statistical features are given in 4.2.2

Gray Level Co-occurrence Matrix is one of the earliest techniques used for image texture analysis. Using a co-occurrence matrix, features can be defined which quantify coarseness, smoothness, and texture-related information that have high discriminatory power. Statistical features derived from the matrix are correlation (F7), and homogeneity(F8). Angular second-moment energy(F9), Entropy(F10), maximum probability (F11), and inverse difference (F12) can be calculated. Energy is a feature that measures the smoothness of the image. Homogeneity is a measure that takes high values for low-contrast images. ASM is a feature that measures

the smoothness of the image. Entropy is a measure of randomness and takes low values for smooth images. Correlation is a measure of the correlation between pixels in two different directions. The mathematical formulas of these second-order statistical features are given in 4.4.4.

4.1.7 Comparison:

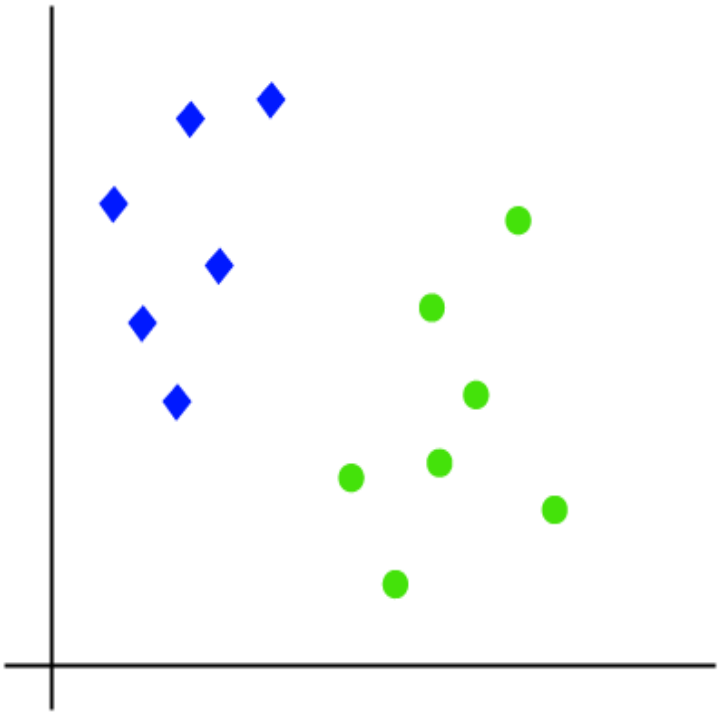
These features are compared with the stored features and the results are displayed as genuine or fake. Support vector machines are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier.

A compact set of features is identified for each category (statistical and edge). For a given fake currency image, our system computes these selected features for each category and passes them into SVM classifiers to distinguish the fake and normal notes.

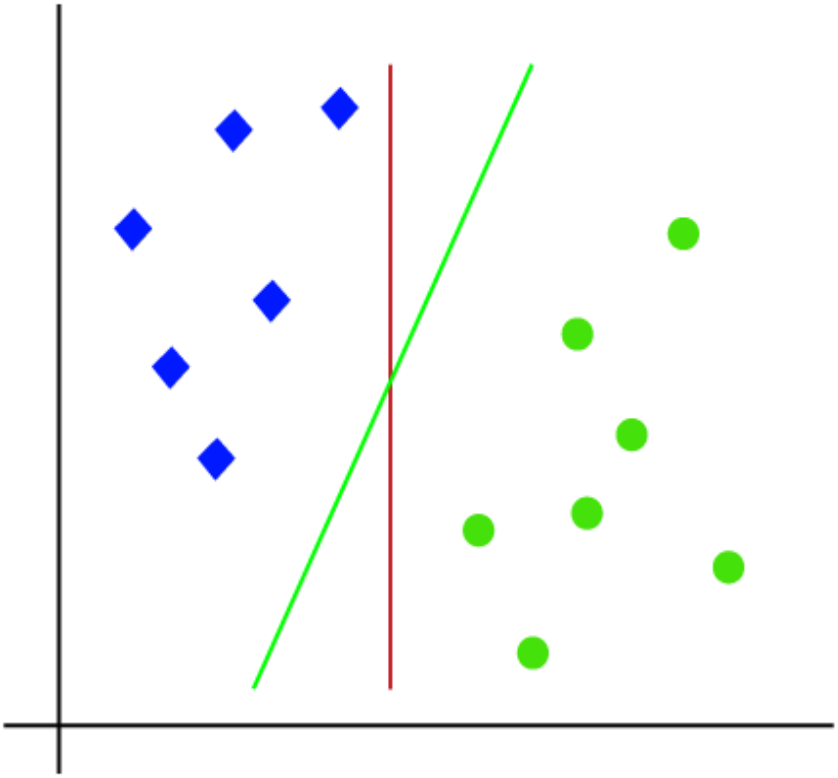
4.1.7.1 SVM:

Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane. SVM chooses the extreme points/vectors that help in creating the hyperplane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine.

The working of the SVM algorithm can be understood by using an example. Suppose we have a dataset that has two tags (green and blue), and the dataset has two features x1 and x2. We want a classifier that can classify the pair (x1, x2) of coordinates in either green or blue. Consider the below image:



So, as it is 2-d space so by just using a straight line, we can easily separate these two classes. But there can be multiple lines that can separate these classes. Consider the below image:



Hence, the SVM algorithm helps to find the best line or decision boundary.

4.2 Equations

4.2.1 Grayscale conversion:

i) Grayscale by Avg method= (R ÷3) + (G÷3) +(B÷3)
ii)Grayscale by Avg method= (R × 0.299) + (G ×0.58) + (B× 0.144)

4.2.2 First Order statistical features:

Mean $F1 = \sum_{k=1}^{M} \mathrm{kP(k)}$
Kurtosis $F2 = \sigma^{-4} \sum_{k=1}^{M} (k - F1)^4 P(k) - 3$
Skewness $F3 = \sigma^{-3} \sum_{k=1}^{n} (k - F1)^3 P(k)$
Variance $F4 = \sum_{k=1}^{n} (k - F1)^2 P(k)$
Entropy $F5 = -\sum_{k=1}^{n} P(k) \log_2 P(k)$
Energy $F6 = \sum_{k=1}^{n} P(k)^2$

4.2.3 Second-Order Statistical features:

Correlation $F7 = \sum_{K=0}^{M} \sum_{N=0}^{M} \frac{k.n.p(k,n) - u_x u_y}{\sigma_x \sigma_y}$
Homogeneity $F8 = \sum_{K=1}^{M} \sum_{N=1}^{M} (k - n)^2 P(k,n)$

ASM $F9 = \sum_{K=0}^{M} \sum_{N=0}^{M} [P(k,n)]^2$

Entropy $F10 = -\sum_{K=1}^{M} \sum_{N=1}^{M} P(k,n) \log_2 P(k)$

Maximum Probability $F11 = max_{k,n}(P(k,n))$

Inverse Difference $F12 = \sum_{K=1}^{M} \sum_{N=1}^{M} \frac{P(k,n)}{1+(k-n)^2}$

V. Result

Fig.5.1 Input Image

Fig.5.2 Gray Scale Image

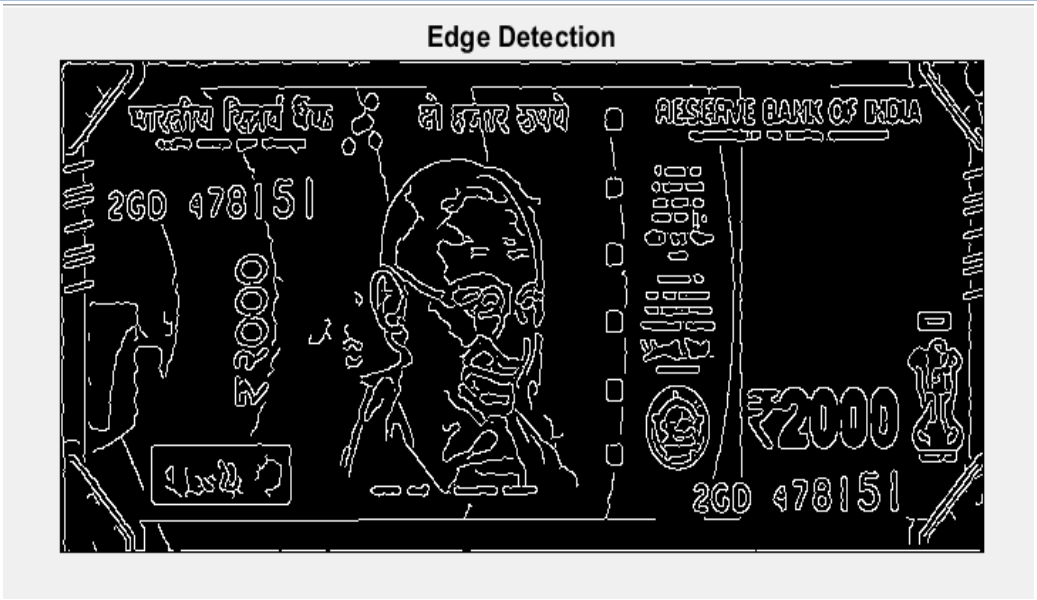


Fig 5.3 Edge Detection

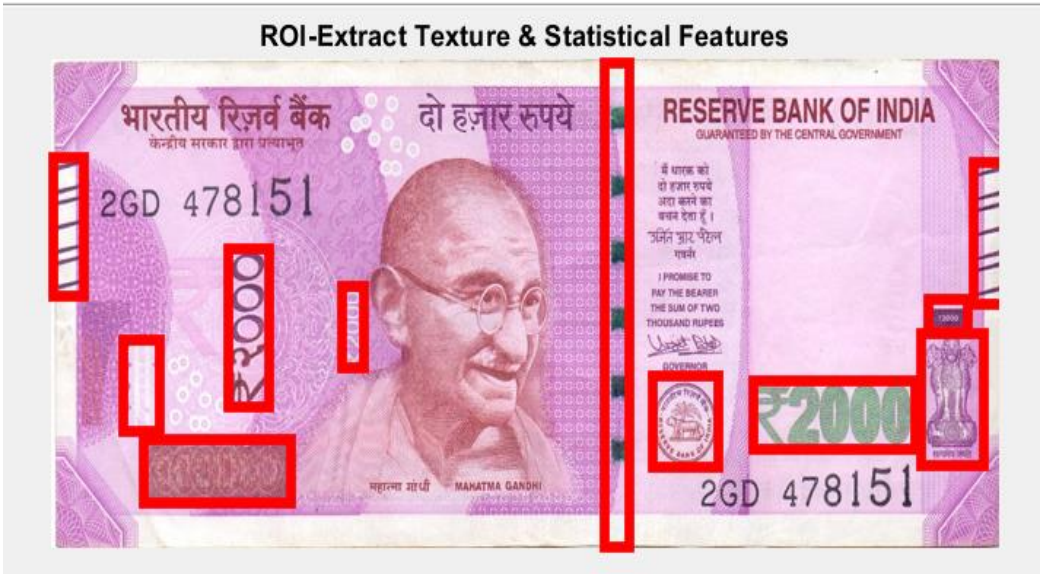


Fig 5.4. Feature Extraction

Fig 5.5 Output

VI. Conclusion

Currency use is a necessity for survival and hence it is always necessary to keep track of its originality. Paper currencies are used much more in India and hence a system to detect fake currency is needed. As the new currencies are used in the market, the proposed system seems to be useful to detect whether the currency is genuine or not.

The results of this project have shown that bleed lines, security thread, and micro lettering are the main security features, and these features need to be calculated perfectly.

Features	Comparison		
	Total Images	Correctly Detected	Detection rate
Color	20	20	100%
Denomination	20	18	90%
Bleed lines	20	15	75%
Latent Image	20	19	95%
Identity mark	20	18	90%
Security Thread	20	16	80%
Ashok Stambh	20	19	95%
RBI Logo	20	19	95%
Micro Lettering	20	18	90%
Avg			90%

In this project, we tried five images of each note with a slight change in features. According to the features mentioned above, we got 80% correct output.

Note Type	Comparison		
	Total Images	Correctly Detected	Detection rate
100	5	4	80%
200	5	3	60%
500	5	4	80%
2000	5	5	100%
Avg			80%

References

[1] “New identifying security features of Indian currency”, International journal on advanced research January 2017 by Moumita Sinha.

[2] “Digital Image Processing using Matlab®”, Rafael C.Gonzalez, Richard E. Woods, Steven E. Eddim .Publisher: McGraw Hill Education India.

[3] C.Saravanan, “Color image to grayscale image conversion”, IEEE Conference March 2010.

[4] “A comprehensive Analysis of Image Edge detection techniques”, Mohd. Aquib Ansari, Diksha Kurchaniya and Manish Dixit, researchgate publication, International Journal of Multimedia, November 2017.

[5] “Paper Currency Recognition System Using Image Processing”, International Journal Of Computational Engineering Research, Vol 3 by R.Mirza and V.Nanda.

[6] “A Novel Method for Counterfeit Banknote detection”, R. Bhavani and A. Karthikeyan, JCSE research paper, March 2014

[7] "An automatic recognition of fake Indian paper currency note using MATLAB", Binod Prasad Yadav, C.S.Patil, R.R.Karhe, P.H.Patil , IJESIT volume 3, 4 July 2014.

[8] "Fake Currency Detection Using Image Processing", Vidhi Roy, Gangey Mishra, Rahul Mannadiar, Sushant Patil, IJCSMC, vol 8, Issue 4, April 2019.

[9] "Indian Currency Detection using Image Recognition Technique", Kalpana Gautam.

[10] "Yemini Paper Currency detection system", Ghazi Alnowaini, Aisha Alabsi, Heba Ali, 2019 First ICOICE.

[11] "Image Texture Feature Extraction Using GLCD Approach", P Mohanaiah, P.Sathyanarayana, L GuruKumar , IJSRP volume 3, 5 May 2013.

[12] "Indian Fake Currency Detection Using Computer Vision", Devid Kumar, Surendra Chouhan. IRJET volume 7, 5 May 2020.

[13] "A Comparative study of Converting Colored Image to Gray Scale Image Using Different Technologies", Kavita Khobragade , March 2012.