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Identification of fake currency using soft computing

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Abstract Advancements in color printing techniques have led to a surge in the creation and duplication of counterfeit currency notes, which has become prevalent in India. Although it was previously difficult to carry out this type of operation, anyone with a laser printer now has the capability to do it. This issue is considered a major problem due to the country's various problems, such as frauds, corruption and black money. It is needed to develop the system for the detection of fake currency. A system that can quickly identify counterfeit money is being developed. The proposed solution will utilize image processing to authenticate Indian currency notes. The proposed system will involve extracting different features from the notes, such as the security thread, Bleed Line, edges, shapes, textures, colors and Fluorescence. It is being developed using the software known as MATLAB. The supervised learning model of support vector machine for the extraction of the notes' features is also being used. This is utilized for analyzing the data related to classification and regression. Once the statistical features have been extracted, they were matched with the features stored in MAT file using SVM (Support Vector Machine) classifier. We have also conducted a test of other methods, such as the black box algorithm. The proposed solution is very fast and simple to implement, allowing it to identify if the notes are fake or real. The outcome of proposed system is the remarkable working of proposed system for the detection of fake currency and accuracy has been measured with the help of confusion matrix. The accuracy, precision & F- score are best by using SVM as compare to SVC (support Vector Classifier) & GBC (Genetic Bee Colony) algorithm.

Keywords: soft computing, SVM, counterfeiting, fake currency identification.

1. Introduction

Researchers have been working on developing various methods that can automate the process of banknote recognition, which has been increasing due to the demand for such systems (Shende and Patil, 2018). One of their main goals is to make sure that the recognition is fast and accurate. Vending machines and other similar applications require software that recognizes banknotes. In order to guarantee the accuracy and reliability of the system, it must be capable of extracting the required data (Santhiya 2021). This is a challenging task, and it can affect the development of systems. The proposed system is teaching you how to implement a system that can identify fake notes using the MATLAB software. This is important since the rapid advancements in the financial industry have made it necessary for cash to be identified automatically. This is especially true for vending machines and sales terminals. Researchers have been pushing for the creation of an efficient and reliable cash identification system, as vending machines that can recognize banknotes have started to appear in various goods, such as candies and soft drinks. The researchers' objective is to extract the data from the notes. Although there are numerous methods that can be used to identify notes, the best approach is to utilize the note's various characteristics. For example, the note's color and size are typically taken into account to determine if it's authentic. This method is not very effective since dirty notes can make their colors significantly different. To improve the system's accuracy, it's important to extract the relevant details from the image.

2. Methodology

The proposed system shown in Figure 1 can be used to identify fake notes by using the captured image from a digital camera. It can also perform various other functions such as detecting the features of the paper currency (Jadhav and Khanai 2016). After the image has been converted into a grayscale, the notes' features are then categorized and cropped.

2.1. Acquisition of Image as an input

Transformations of physical objects into digital images can be achieved through this process. For example, the image presented in Figure 2 shows Indian currency notes, which was captured using a digital camera. Subsequently, it was manipulated and preserved for future reference.

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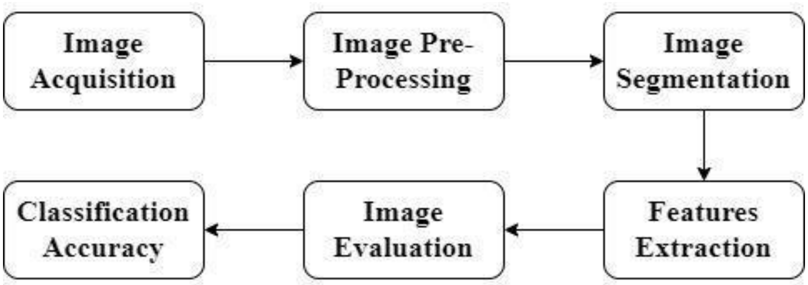

Figure 1 Systematic Block Diagram of Proposed System.

Figure 2 Acquired scanned input image.

2.2. Pre-processing

Before the extraction and analysis of data is carried out, the process of image pre-processing is performed. This involves preparing various images for scaling, color adjustments, and orientation.

The use of model pre-processing techniques can help improve the efficiency of neural networks and image analysis (Sardeshmukh et al 2023). In particular, if the input pictures are too large, the training time can be reduced.

2.3. Edge detection with Gray-Scale Image

The information in the acquired image has been processed and transformed into a grayscale. As the processing of the image continues, its margins will also appear (Figure 3).

Figure 3 Grayscale image.

2.4. Image Separation

Segmentation is a process that involves breaking down the collected data into sections. This process is carried out to retrieve information that is related to objects (Figures 4 - 7).

Figure 4 Recognition mark.

Figure 5 Image Segmentation.

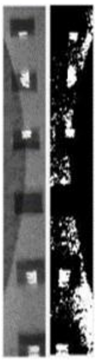

Figure 6 Segmentation of Security Thread.

Figure 7 Segmentation of serial number.

2.5. Feature extraction

A feature extraction process involves shrinking an image's dimensionality to make its appealing parts more compact. This can be useful when users are faced with matching or searching for pictures (Zhang and Yan 2018). Some examples of currency features that have been extracted are shown.

Preservation Thread

The security thread of the Rs. 2000 note is readable and features the inscriptions "RBI", "2000", and "Bharat" in Hindi. This design feature indicates that the banknote's color changes as it is tilted as shown in below Figure 8. On the other hand, the security thread of the Rs.100 and 500 notes has similar inscriptions (Kumar and Chauhan 2020).

When held up to the light, the security threads of Rs.2000, Rs.500, and Rs.100 notes can be seen as continuous lines. In addition, the embedded security threads of Rs.10, Rs.20, and Rs.50 notes feature the inscriptions "Bharat" and "RBI."

Figure 8 Color Shifting of Security Thread.

Serial Number

The bottom left and top right sides of the note have a panel that displays the serial numbers of banknotes as shown in Figure 9.

Figure 9 Prefix Letter & Serial Number.

Latent Image

The front side of a currency bill features a vertical band that contains a latent image of the denomination (Sawant and More 2016). It can be seen when the bill is held horizontal as shown in below Figure 10.

Figure 10 Invisible Image.

Mahatma Gandhi watermark

When exposed to light, the Mahatma Gandhi banknotes feature the watermark with multi-directional lines and a shade effect (Amirsab et al 2017) as shown in below Figure 11.

Identification Mark

Intaglio print can be used by blind people to identify the denomination of banknotes. For example, the denomination of the 2000 notes has seven lines long, while the 500 has five lines (Figure 12).

Figure 11 Watermark of mahatma Gandhi with multi-directional lines.

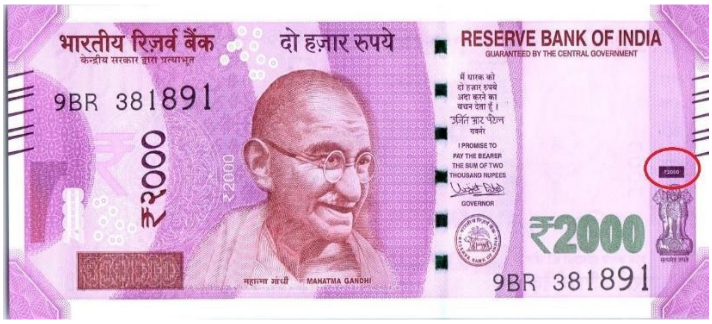

Figure 12 Horizontal lines as an identification.

2.6. Image Evaluation

An image analysis is a process that involves breaking down a picture into its basic elements. This can help retrieve information such as the type of objects in the image and their properties.

2.7. Classification Using Support Vector Machine

After collecting the various features of banknote images, it is important that the banknote pattern is identified by the extracted characteristics. This paper proposes a method that uses a classifier to identify the appropriate banknote pattern. This method is commonly used in support vector machine analysis (Kathole et al 2023). The proposed method can be used to identify counterfeit banknotes by training the classifier on images that have been pre-processed. In a working scenario, a banknote image is taken by a scanner or mobile camera. After going through the various features of the image, the classifier is able to identify the genuine notes (Figure 13).

3. Simulation Results and discussion

Figure 13 Acquired Image as an input.

A currency's image should be included in the system's input to help it verify its authenticity. This can be acquired by taking a picture with a phone or scanning it. It is needed to capture it by using good quality camera or scanner (Arya and Sasikumar 2019) (Figure 14).

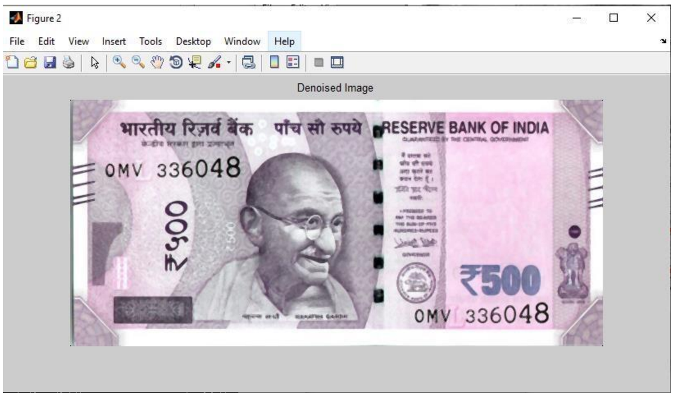

Figure 14 Noise free Image.

One of the techniques commonly utilized for reducing noise is the use of a median filter. It can effectively deal with sounds like salt and pepper, as well as outliers. It is the most important part of pre-processing to reduce the noise at great extent (Figure 15).

Figure 15 Conversion of Color image to Gray scale image.

Understanding the various factors that affect a color image's quality is very important when converting it from one to another (Ali and Manzoor 2013). For instance, the combination of blue, green, and red is usually the primary color in a pixel. There are various ways such as lightness method, average method, luminosity method etc. to convert a colored image into a grayscale one (Figure 16).

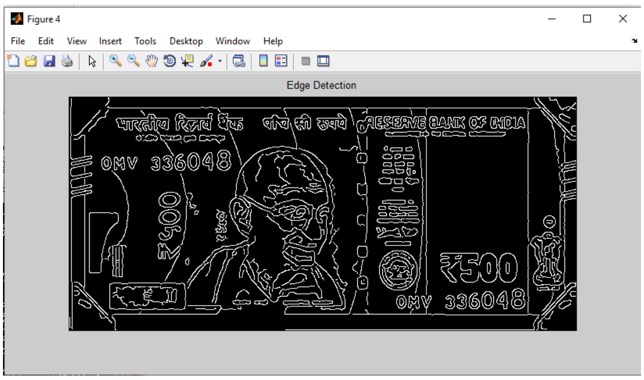

Figure 16 Boundaries of Objects within image.

Edge detection is an image processing technique that finds the edges of objects in photos. This method can also detect variations in brightness to discover the boundaries of the objects in photos. Statistical patterns or structures in a raw dataset that are recurrent are referred to as such (Wagh et al 2022). Different methods can be utilized to obtain these features, like transformations and statistical procedures (Zende et al 2017). An extraction program is utilized in the process of image processing to identify and extract details from photos, such as their edges, colors, and shapes. If the program is focused on identifying the edges, it would show these details in the extracted image.

An RoI (Region of Interest) feature extractor can be used to extract various features from a given set of photos. For instance, it can perform object detection through boundary boxes (Khoje and Shinde 2023). The texture based and edge with shape-based feature extraction to get region of interest is shown in Figure 17 and Figure 18 respectively.

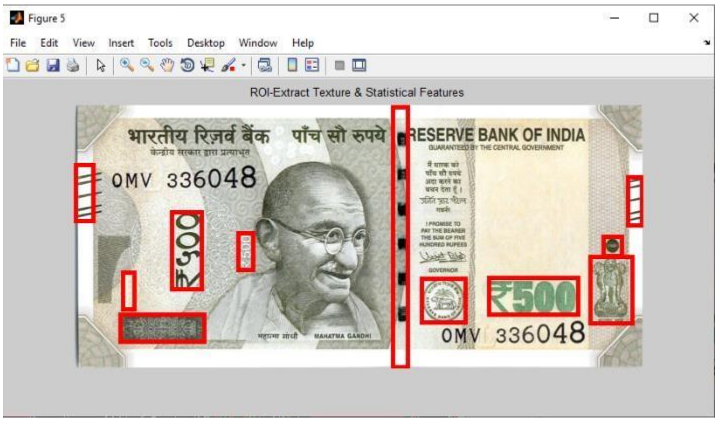

Figure 17 ROI through texture as a feature extraction.

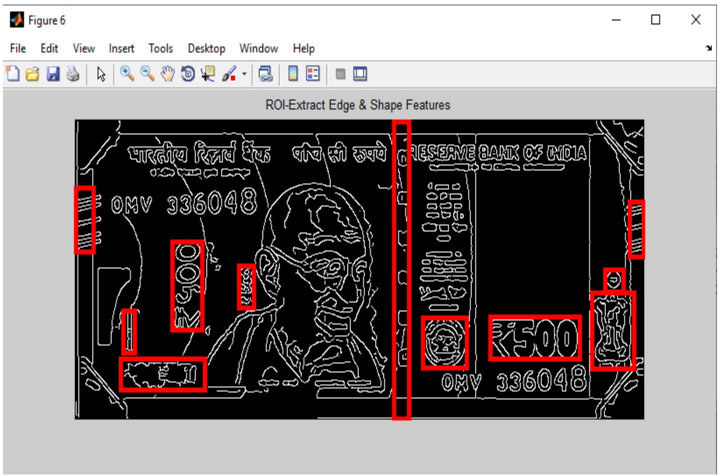

Figure 18 ROI through edge and shapes as feature extraction.

The flow of results of proposed system has been shown in Figure 19 through experimental demonstration whether the currency we've analyzed is real or fake. For instance, if we have acquired a real 500 Rs. note and checked the details of the currency through the proposed system, it shows that it is a real currency. On the other hand, if we have acquired a fake 2000 Rs. note and checked the details of the currency through the system, it shows that the note is a fake as shown in Figure 19.

Figure 20 and Table 1 show the various parameters (accuracy, precision & F-score) of the proposed system that are measured using algorithms, such as the support vector machine, the GBC, and the support vector classifier. It has been concluded that the best result is obtained with the SVM as a classifier. An algorithm accuracy comparison is a process that involves comparing the performance of various algorithms when it comes to identifying and predicting outcomes for a given dataset. The objective is to find the one that performs well on the given task, taking into account the various factors that affect its accuracy, such as the complexity, training data, and requirements for the application (Shinde et al 2023).

Table 1 Performance measurement of various algorithms.

Algorithm	Accuracy	Precision	F-Score
Proposed(SVM)	99.9	99.9	99.9
SVC	97.5	99.7	98.6
GBC	99.4	99.9	99.7

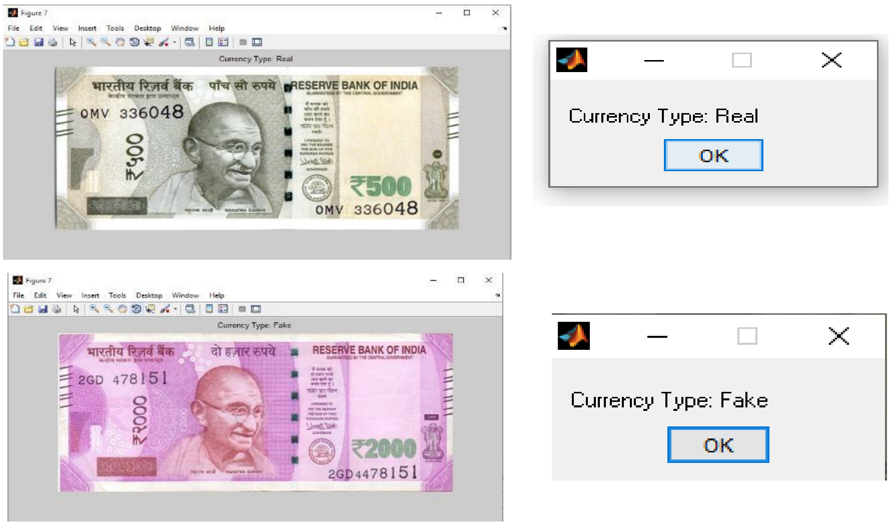

Figure 19 Recognition through Simulation.

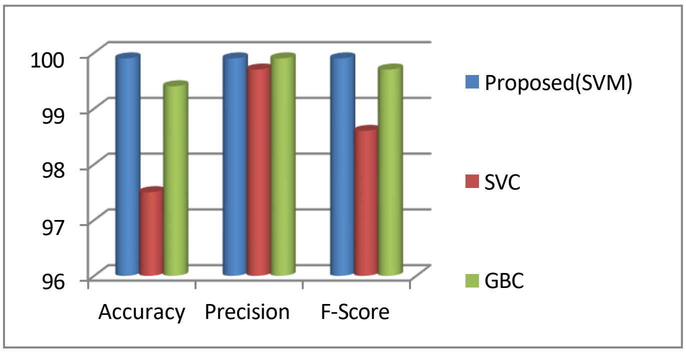

Figure 20 Performance of algorithms through Graphical representation.

A representation of the accuracy of an algorithm for detecting 100 rupee notes shows the predicted false negatives, true positives, true positive, and false negative rates. The true positive indicates that the prediction accurately identified the notes, the percentage of non-100-rupee notes that the algorithm incorrectly identified as 100-rupee notes.

A confusion matrix, such as the one shown in Figure 21, is a matrix of size n x n that shows the predicted and actual classification with n being the number of different classes.

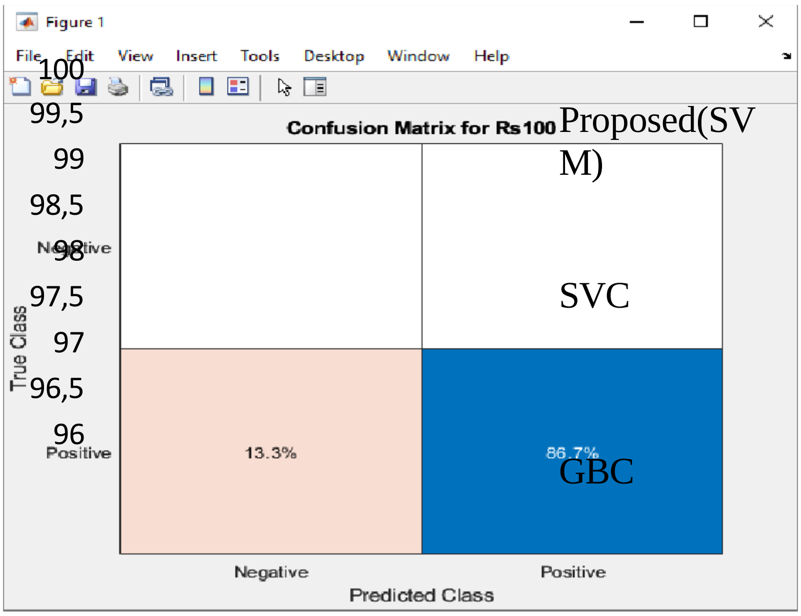

Figure 21 Confusion matrix for Rs. 100.

Table 2 shows a confusion matrix for n = 2, whose entries have the following meanings:

- a is the percentage of correct negative predictions;
- b is the percentage of incorrect positive predictions;
- c is the percentage of incorrect negative predictions;
- d is the percentage of correct positive predictions.

Using this matrix, the predicted accuracy and the classification error can be calculated as follows:

$$Accuracy = \frac{a+d}{a+b+c+d} \quad (1)$$

$$Error = \frac{b+c}{a+b+c+d} \quad (2)$$

Table 2 Confusion matrix for two-class classification.

	Predicted Negative	Predicted Positive
Actual Negative	a	b
Actual Positive	c	d

A confusion matrix graph for the accuracy of a 200 rupee note detection algorithm would display the true positive, false positive, true negative, and false negative rates for the algorithm's predictions. The true positive rate represents the percentage of actual 200-rupee notes that the algorithm correctly identified as such, while the false positive rate represents the percentage of non-200-rupee notes that the algorithm incorrectly identified as 200-rupee notes (Figure 22).

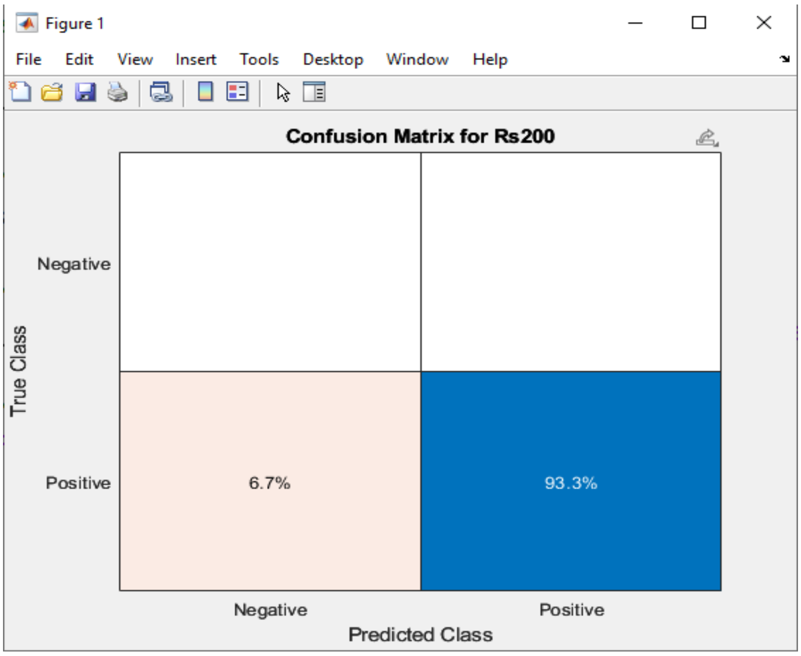

Figure 22 Confusion matrix for Rs. 200.

Table 3 shows that the maximum accuracy is obtained in the recognition of 200 & 2000 rupees note. The average accuracy obtained is 88.32 % and it is remarkable outcome.

Table 3 Currency Recognition Rate.

Note Type	Detection Rate
100	86.7
200	93.3
500	80
2000	93.3
AVG 88.32 %	

The accuracy of an algorithm that detects the value of 500 rupee notes is depicted in a matrix with the predicted false negatives, true negatives, false positives, and true positive rates. The false positive indicates that the prediction is able to identify the notes accurately, while the true positive shows that the algorithm is able to identify the non-500 rupee notes incorrectly (Figure 23).

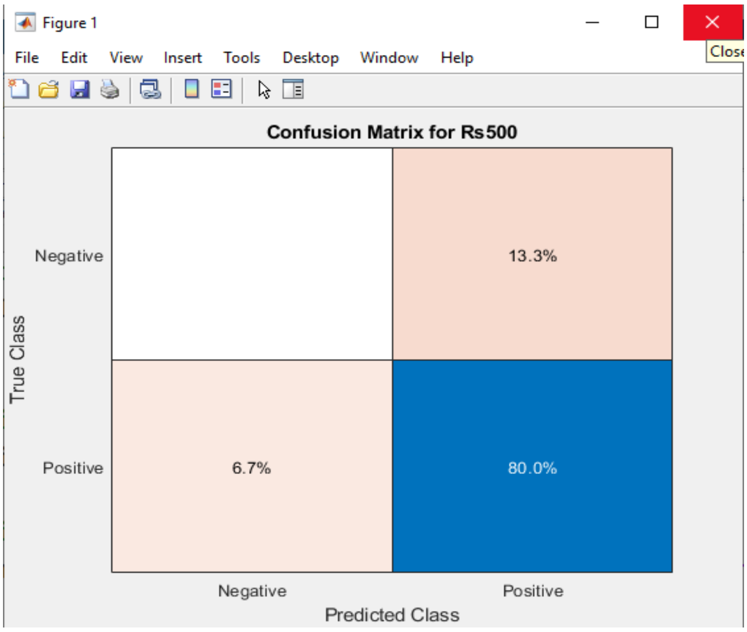

Figure 23 Confusion matrix for Rs. 500.

A representation of the accuracy of a currency detection algorithm that predicts the value of 2000 rupee notes shows the true, false, true negative, and false positive rates. The true positive indicates that the algorithm has correctly identified the actual notes, while the false positive shows that it has mistakenly identified the non-2000-rupee notes. According to the features mentioned above, got 88.32 % average correct output as an accuracy (Figure 24).

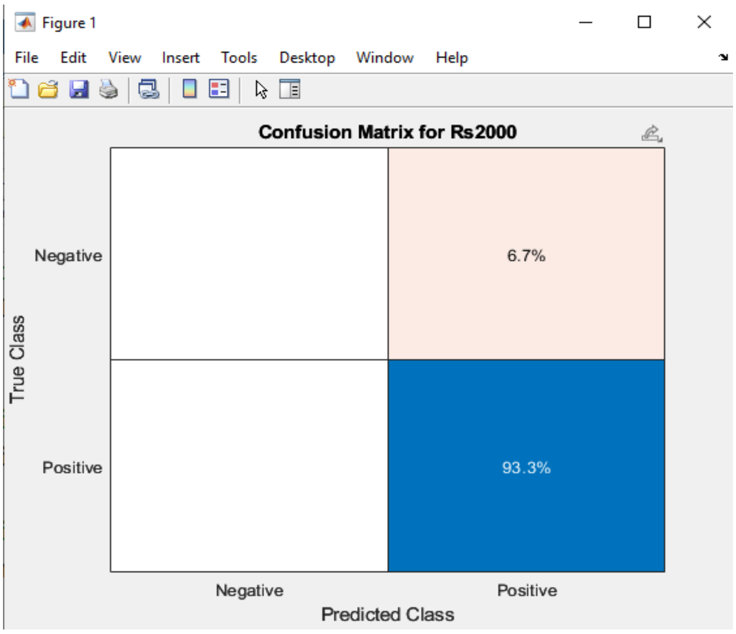

Figure 24 Confusion matrix for Rs. 2000.

4. Conclusions

The support vector machine has been used as a classifier and extracted strong features of currency such as the security thread, serial number, and the Mahatma Gandhi portrait etc. The proposed system has provided remarkable outcome in terms of accuracy, precision & F-score. The confusion matrix has played an important role in recognition of fake currency. The android app can be developed for the detection of fake Indian currency as well as foreign currency.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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References

Ali A, Manzoor M (2013) Recognition system for Pakistani paper currency. Res J Appl Sci Eng Technol. 6:3078–3085. DOI: 10.19026/rjaset.6.3698.

Amirsab SA, Mudassir M, Ismail M (2017) An automated recognition of fake or destroyed Indian currency notes. International journal of advance scientific research and engineering trends.

Arya, Sasikumar DM (2019) Fake currency detection. In: 2019 International Conference on Recent Advances in Energy-efficient Computing and Communication (ICRAECC). DOI: 10.1109/ICRAECC43874.2019.8994968.

Jadhav S, Khanai R (2016) Authentication And Counterfeit Detection Of Currency Using Image Processing. In: International Conference on Recent Innovations in Engineering and Management (ICRIEM-16), pp 709–715.

Kathole A, Shinde S, Wadhwa L (2023) Integrating MLOps and EEG Techniques for Enhanced Crime Detection and Prevention. Multidisciplinary Science Journal 6:2024009. DOI: 10.31893/multiscience.2024009

Khoje S, Shinde S (2023) Evaluation of ripplet transform as a texture characterization for Iris recognition. J Inst Eng (India) Ser B 104:369–380. DOI: 10.1007/s40031-023-00863-6

Kumar D, Chauhan S (2020) Indian fake Currency Detection using computer vision. International Research Journal of Engineering and Technology 7:2870–2874.

Santhiya I (2021) Research on Fake Indian Currency Note Detectionusing Image Processing. International Journal of Scientific Development and Research 6:196-199.

Sardeshmukh M, Chakkaravarthy M, Shinde S, Chakkaravarthy D (2023). Crop image classification using convolutional neural network. Multidisciplinary Science Journal 5:2023039. DOI: 10.31893/multiscience.2023039

Sawant K, More C (2016) Currency recognition using image processing and minimum distance classifier technique. Int J Adv Eng Res Sci 3:1–8. DOI:10.22161/ijaers/3.9.1

Shende MN, Patil PP (2018) A Review on Fake Currency Detection using Image Processing. Int J Futur Revolut Comput Sci Commun Eng 4:391–393.

Shinde S, Khoje S, Raj A, Wadhwa L, Shaikha AS (2023) Artificial intelligence approach for terror attacks prediction through machine learning. Multidisciplinary Science Journal 6:2024011. DOI: 10.31893/multiscience.2024011

Wagh KP, Vasanth K, Shinde S (2022) Emotion recognition based on EEG features with various brain regions. Indian Journal of Computer Science and Engineering 13:108–115. DOI: 10.21817/indjcse/2022/v13i1/221301095

Zende KB, Kokare B, Pise S, Togrikar PS (2017) Fake Note Detection System. IJIRT 4:46-49.

Zhang Q, Yan WQ (2018) Currency detection and recognition based on deep learning. In: 2018 15th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS). DOI: 10.1109/AVSS.2018.8639124.