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A Heuristic Approach for Fake Currency Identification

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Abstract: *Every economy runs on profit and losses, losses incurred can damage economy and wellbeing of the Nation. Economy in broad sense refers to prosperity of a nation in terms of production, distribution and trade, however there are certain negative events which hamper the growth of the economy, one such area is un-authorized printing and circulation of fake currency. Though every government is employing experts and utilizing the best solutions possible to curb the issue, yet estimated average damage in 2018 was about Rs 400 crore in India itself. Thus it is required to plan a framework that is useful in identification fake paper money notes with quick speed and in less time. The framework proposed is has two sections. The first is preprocessing, including identifying edges, packing information dimensionalities, and removing highlights. The second one involves a neural classifier. In this investigation we present a technique that works on features that differentiate fake and original currency. This paper proposesa technique for extracting serial quantities, color and impregnation of amount among several other distinct features for segregation of fake currency from genuine one, the technique has been implemented using MATLAB and was tested for set of 100 samples achieving an accuracy of 84%.*

I. Introduction

Economy in broad sense refers to prosperity of a nation in terms of production, distribution and trade, however there are certain negative events which hamper the growth of the economy, one such area is un-authorized printing and circulation of fake currency. , therefore identification and elimination of fake currency plays a vital role in boosting the economy of the nation. Currency is in the form of paper notes with several salient features to distinguish them from fake copies, however every time the details of which cannot be checked by naked eye . Thus an automated feature extraction technique is required, it concerns with extracting the information from the raw data which is vital for identification purpose, for minimizing the withinclass pattern diversity while improving the between-class pattern variability[1]. The process of feature extraction reduces the dimensionality of the data. Reduction helps in issues arising from computation time and available space for memory.

Over the years, in tandem with enhanced growth of world economy, the beginning of Euro area, and the rise of Asia economics, frontier trade and personal intercourse of different nations are frequently increasing. Challenge has come down to conventional paper currency identification system. Most importantly, the focus of every the conventional currency identification technology and system on identifying counterfeit currencies. In most of internationalbanks, large number of currency belong to different countries, which need to be processed, and it is quite a possibility that all of them are not realcashes but a fake reproduction.

In practice identification and segregation of fake currencies should be incorporated as process, so that filtering is achieved and losses are minimized [2]. Therefore it is important to design a currency identification technique and bank systems that can not only identify correct recognitions and classifications for known paper currencies, but also completeeffective rejections for fake paper currencies.

The identification of the serial numbers printed on the paper currency such as 100, 200 or 2000 banknotes can be segregated through various techniques. Serial numbers printed are currency issuanceserials,whichareutilized asidentifiers(IDs).Serial numbers are unique and it is not used more than once.Accurate and quick identification of these numbers is very important. The reasons can be summarized as

1. Requirement for accurate statistics by national treasuries and the banks.Afterthecurrency areprinted byan authorized printingfactory,before the national treasuries can legalize the currency, they needtohave information about theserialnumbers,sothatthenationaltreasuries canknowthetotalnumberofdifferentkindsofcurrency [3].
2. Requirement for reprinting of the destroyed currency, treasuries need to inform theprintingfactoriestoreprintthosecurrency withthesameserialnumbers.

3. Requirement for the analysis of the crimes by the trouble creators. It would be very helpful for the investigators to detect clues of the trouble creators,if the stolen or fake currency can be quickly and accurately identified. Some features about how to identify a fake Indian currency are givenbelow [3]:

i. **Optical Variable Ink:** Printing ink and color of the numerals100, 200 or 2000are distinct and distinguishable, with specific font size and design.
ii. **Latent Image:** On being held horizontally, printed image of the numerals 100, 200 or 2000 appear on the vertical band.
iii. **Security Thread:** Every paper note has a 3 mm wide thread with amount with RBI impregnated on it.
iv. **Micro lettering:** RBI and the numeral impregnated when viewed closely are located between theShri MahatmaGandhiimageandverticalthread.
v. **Watermark:**On being held against incandescent light, image ofShri MahatmaGandhiand electrolyte marking displaying the amount appears.

II. Proposed Methodology

Proposed approach for feature extraction of Indian currency can be broadly categorized into following :

i. Preprocessing of currency image.
ii. Binarisation
iii. Morphological filtering
iv. Segmentation
v. Feature Extraction
vi. Prediction as fake or genuine

Lot of algorithms have been developed for efficient feature extraction,primarily features are application specific and often determined diversified heuristic approaches and data synthesis. In any specific problem such as, e.g., character or speech recognition, there is an accumulated knowledge of the most feasible ways to extract the relevant information. Speed and accuracy of processing are two important factors for feature extraction method. The accuracy may be more important than the speed. Over the years a number of algorithms have evolved for efficient, accurate and quick identification of fake currencies, relying mostly on techniques for feature extraction.

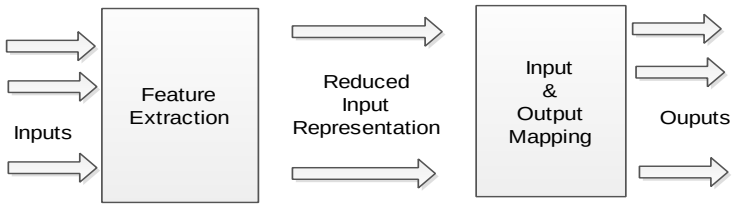

Figure 1: Generalized approach for feature extraction

III. Implementation

The proposed approach for segregation and detection of genuineness currency is achieved through following steps:

1. Image Preprocessing

For an effective identification process, it is absolutely necessary that image obtained is noise and error free, noise and error could occur due to various reasons, be it be lighting conditions, camera flap, scratches on leans, brightness and intensity levels etc [10]. This mandates the reason for an effective cleaning process before the image is taken up for feature extraction process. Thus to get the features of paper currency in most appropriate way the image of the currency is collected with appropriate spatial resolutions and brightness. Conversion of paper-printed currency to electronic data format is a vital process in computer systems for making the identification automated. After the currency is scanned , a predefined sequence of data preprocessing algorithms are applied to the images of the currency so that a cleaned image is ready for featureextraction.

Figure2: Currency Images [11]

2. **Binarization**

In this approach the image is converted into two modes of, one of zero's i.e. black color and other is One's i.e. is white color on the basis of thresholding level selected

Thresholding is the process of segregating object of interest and background and divides image in to two categories on the basis of intensity [4]. Segregation is achieved through deciding a threshold value from the intensity levels of the image. Pixel with values above threshold are assigned a single intensity usually a set of zero's or one's and pixel with values below threshold are assigned a the value opposite to that of latter. Mathematically it is expressed as

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) \leq T. \end{cases}$$

Thresholding can be processed locally or globally on an image.

Figure 3: Binarized image of currency [6]

3. MorphologyFiltering

Morphology is an operation based on set theory, it is achieved with the help of structuring element (SE), working on the principle of maximizing or minimizing the intersections and unions respectively. The technique works for reproducing missing pixels and also for removing unwanted protrusions. The two basic operations are erosion and dilation, as the name suggests erosion is employed for removing unwanted pixels and dilation for adding missing pixels. These operations are also combined to achieve desired results, two such operations are:

Openingit refers to series operation of dilation followed by erosion with same SE.Technique is employed to erase white holes on thearea of interest.
Closingit refers to series operation of erosion followed by dilation with same SE. Technique is employed to erase black holes on the area of interest.

After thresholding, the numerals on the currency may have broken or unnecessary protrusions which are smoothed by morphological techniques [5].

4. Segmentation

Segmentation is a procedure where area of interest is isolated and broken down in its constituent entities, the numerals are segregated for identification of serial number with the help of this technique , edge identification followed by segregation and identification of numerals are done for extracting the serial number of the currency. Figure 4 depicts the segmented serial digits.

Figure 4: Segmented Serial Number Digits [10]

5. Heuristic analysis of characters

The segmentation technique described often identifies objects that are redundant and have no relevance in identification of fake currency.These objects are inherent and often pose problem in serial numerals identification, even though they are of different length and breadth, contrast, brightness or hue. Proposed technique of feature extraction do not take into considerations these objects, therefore there is a need to utilize additional heuristic analysis to eliminate objects that are not relevant [6]. The technique expects all objects to possess similar characteristics. Objects with considerably diversified characteristics are eliminated and removed from identification. The technique employs with statistics of intensity of numerals and contrast ratio of segregated characters. Further font type and size of relevant numerals are same. Steps to be followed can be summarized as:

i. Segregate the serial numeral
ii. Extract and compare the intensity and contrast ratio and eliminate those who are not relevant.
iii. Extract and compare HSV values and eliminate those who are not relevant.

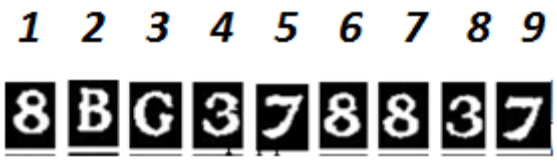

Figure 5: Serial Number segregated through heuristic analysis [10]

Image is represented by a function expressed as f (x, y) but additional heuristic processes for identification and elimination of unwanted objects is employed for matching of genuine serial numbers. Technique separates numerals and noise or unwanted elements on intensity level basis. If the obtained image is given by HSV model, saturation and hue value of the segregated numeral can be evaluated as:

$$p_h^{(i)} = \sum_{x=0}^{w_i} \sum_{y=0}^{h_i} h(x,y) \;;\; p_s^{(i)} = \sum_{x=0}^{w_i} \sum_{y=0}^{h_i} s(x,y)$$

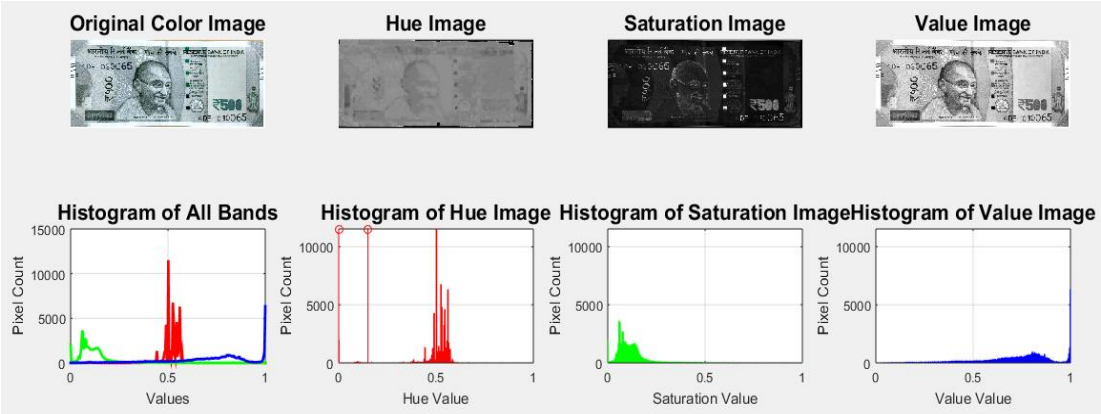

Figure 6: Segregated HSV value

6. FeatureExtraction

Finalization of feature is a pivotal process for classification of currency as genuine or fake;this has implications on design and efficiency of the classifier [7]. Diversity should be large enough for the classification to be accurate however classification becomes difficult with contrary situation. Feature types are categorized as follows:

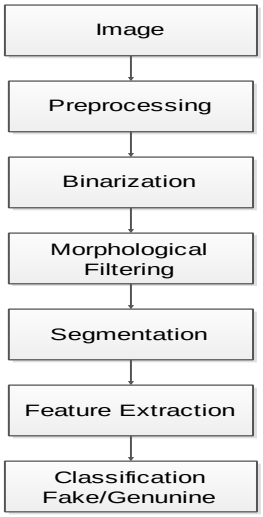

Figure 7: Feature extraction Approach

i. **Structural features:**it represents geometrical and topological features in a specific pattern in global and local characteristics.

ii. **Statistical features:** Statistical features are evaluated from value of pixels over the entire space under consideration, which is symbolically the represented by distribution.

iii. **Global transformation:** Global transformation transforms the pixel distribution in more compact form, thereby reducing the dimensionality feature and provides feature invariants to global deformation like translation, dilation and rotation.

Approaches earlier used worked on specific features by evaluating certain image characteristics [8]. The primary target is to evaluate curvature of the objects segregated: peaks generally involved curvature i.e. corners, and processing an image by corners was absolutely necessary when identifying numerals. Figure 8 depicts the extracted skeleton of a number utilized for numeral identification By applying the feature extraction we get the following extracted feature of a digit.

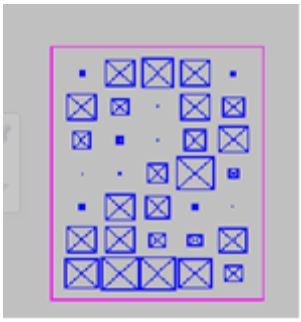

Figure 8: Extracted Numeric Digit

Base on the gray level and digits segregated the currency was compared with standard values and were labeled as genuine or fake. Approximately 100 Indian Currency notes of value 100 were analyzed in this work. The experimental results of the work was implemented using MATLAB and achieved an accuracy of 84%.

IV. Conclusion

Proposed work is an effort for efficient feature extraction and identification of fake currency notes, approach relies on the fact that HSV value and serial number on every note is distinct. Work utilizes thresholding, morphological filtering and word segmentation for segregating the features, which are mapped on standard values for classification as fake or genuine. To achieve a high recognition performance one of the best approach is Selection of feature extraction method.In future, an inclusion of consistent pattern design of the note can help extraction using Neural Network methods with them trained on feature vectors obtained from above system. The experimental results of the work carried on a sample set of 100 using MATLAB and achieved an accuracy of 84%.

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