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Counterfeit Paper Banknote Identification Based on Color and Texture

Shaurav Lamsal[1]*, Aman Shakya[2]

[1,2] *Department of Electronics and Computer Engineering, IOE, Central Campus – Pulchowk*
***Corresponding author**: lamsalshaurav71@gmail.com

Abstract
Currency identification is the application of systematic methods to determine authenticity of questioned currency.Color and texture feature are used for the classification of an image. This paper present the techniques used for the extraction of feature, identification and classification of counterfeit and genuine bank note. It presented simple method of identification of counterfeit paper banknotes, which automatically using image processing techniques. Color and texture feature of a currency is used for identification. Color descriptor skew, mean and standard deviation is calculated from samples which are checked against the parameter that are previously defined. Texture parameter entropy and correlation are calculated from different set of database image. Matching score below the threshold, input currency image is classified as fake note. Otherwise the currency is genuine.

Keywords
Color, Texture, Template matching, Image processing, Counterfeit currency detection

1. Introduction

Currency counterfeiting is as old as the start of coinage around the world. The paper currencies are the center of target to counterfeiters. Counterfeit detection is mainly executed based on the Chemical or Physical properties of paper currencies. The counterfeiters nowadays can evade the chemical property and physical feature based counterfeit paper currency detection system due to technological advancement [1]. Beside that right now all country in the world has their own currency with different characteristics, size and totally different between each other's [2].

The counterfeiting of currency notes is one of factor which affects the economy of any country. Hence each country tries to deter such counterfeiting of one's currency notes using many methods, among which the security features in currency notes is one of the prominent and the most effective method [3]. The security features are embedded in each currency note is various ways. Some of such features are easily identifiable, some need tools to identify and some need special attention to detect. It is essential that anyone working if field of handling currency notes should have appropriate and adequate knowledge about such features so that one can differentiate the counterfeit note from genuine. Speed and accuracy of processing are two important factors in such systems. Of course, the accuracy may be more important than the speed [4].

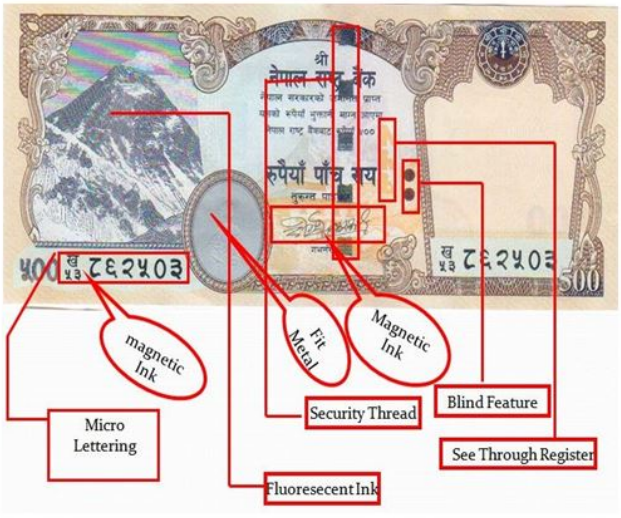

Figure 1: Different Security Feature of a Banknote

A banknote carries security features mainly on its paper, design and printing process. Examination or verifica-

tion of currency notes is mostly conducted by checking the following aspects: i) physical dimensions, ii) paper quality, iii) design, and (iv) printing technique. Physical dimension of currency note depends on its cut size of length, width, grammage and thickness of paper. The paper on which currency note is printed carries important level of security. Watermarks and security thread are other important parts of security on currency note paper [5].

2. Previous Work

The software detects fake currency by extracting existing features of banknotes such as micro-printing, optically variable ink (OVI), water-mark, iridescent ink, security thread, Contour Analysis, Face Recognition, Canny Edge and Hough transformation algorithm. This paper also focuses on the pros and cons of implementation details that may degrade the performance of image processing based paper currency authentication systems [1]. The process of identification is done by comparing the original images of money that will be tested with reference of original currency paper image that has been extracted and capture its characteristics and with the help of canny operator to make edge detection where the previously existing image has to be pre-processing, including extraction characteristic [2, 3].

The Markov chain concept has been employed to model the texture of paper currencies as a random process. The method proposed in this paper can be used for recognizing paper currencies from different countries. The features employed in this paper are independent of the way that a paper currency is placed in front of the sensor. To improve the accuracy of the proposed method in recognizing dirty banknotes, it is necessary to pass the paper currency through a filter in order to reduce the effect of dirt by improving the lightness of the image. Also, to reduce the effect of dirt on the image a linear transform function could be very helpful. The performance results of applying the proposed methods on banknote denominations of 23 different countries indicate that the technique has 95 percent accuracy [4].

An image analysis based pattern classification method is proposed to authentic the printing process used in printing different texts on currency notes. Features suitable for doing this are selected and then studied to detect fraudulent samples based on the printing method. This classification is done by using Support Vector Machines and Neural Nets. The discriminatory power of the selected features in authenticating the printing process is tested using the Linear Discriminate Analysis. Experimental results show that the proposed framework provides a highly accurate framework for authenticating the printing process in bank notes [5].

This paper is focusing on an advanced mobile based application that is used to identify fake money. The application is an online application. Thus, it requires continuous Internet connection for its execution. For using this application, user need to take a photograph of the required note holding it against sufficient light. Then the software examines the note and gives the appropriate result to the user about the authenticity of the note. This application has mainly Watermark Detection, Security Thread Detection, checking currency series number, identification mark and sees through register mechanism which actually detects the trueness of the currency [6]. It has reviewed different fake currency detection systems. Commonly Used Methods to Detect Fake Currency are See through Register, Water marking, Fluorescence, Security Thread, Intaglio Printing, Latent image, Micro lettering, Identification Mark, Optically Variable Ink. Digital Image Processing method, MATLAB techniques, Counterfeit Detection Pen, Ultraviolet counterfeit detection scanner have been used for fake currency detection [7].

3. Methodology

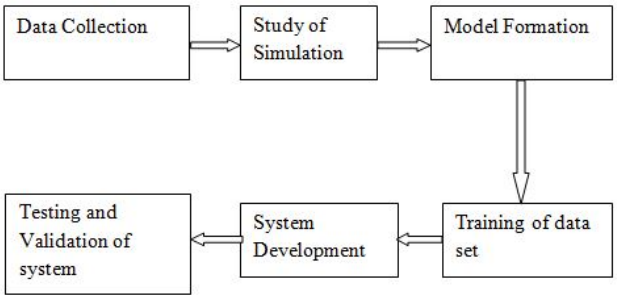

Figure 2: Block Diagram of Research Methodology

Data Collection: Real and fake note samples are acquired from bank. Samples are scanned at 400 dpi for

experimental purpose. Those samples of real and fake notes are stored in database.

Study of Simulation: Different simulation techniques are prevailing in research field. Opencv, Python, Matlab are some Simulating tools. Among those tools matlab is mostly used because it contains large sets of tool box. Image processing tool box is used in this research study.

Training of data set: Fake samples dataset and real samples dataset are tested in model that previously developed. For training purposes typical samples from datasets are taken and tested.

System Development: System development is performed by analyzing the value that is obtained while testing a datasets. Simulating parameters are changed according to final system development.

Testing and validation of system: System development is followed by testing and validation. Database that is previously formed are tested in final system. Based on testing and validation system accuracy and performance are calculated.

3.1 Proposed Work

This paper is composed of three phases. The first phase deals with image processing, the second phase deals with feature extraction and the third phase deals with classification of the detected image.

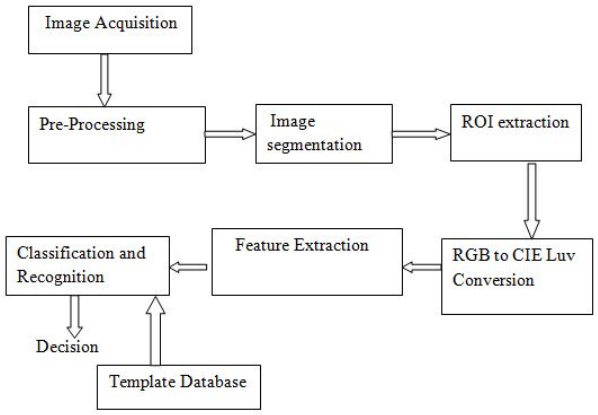

Figure 3: Block Diagram of Proposed Work

Automatic recognition of fake currency has been a challenging research area. A robust method that is more economically efficient and practically flexible for automatic fake currency inspections are required. Due to great technological advancement counterfeiting problems have become more and more serious. Therefore the issue of efficiently distinguishing counterfeit banknotes from genuine ones via automatic machines has become more and more important. The fake currency detection system is developed to detect the fake currency by applying different techniques and methods on currency note. The fake currency detection system should be able to recognize the note quickly and correctly.

- **Step 1:** Image Acquisition

The image database considered in this chapter is composed of digital images taken by digital scanner. The image we get from camera or scanner is formatted by JPEG or BMP. JPEG (Joint Photographic Experts Group) is a standard for destructive or loss compromising for digital images.

- **Step 2:** Pre-Processing

The aim of pre-processing in currency image inspection is to suppress the unwanted information from the image data and enhance the desired image features important for further processing. Pre-processing is an important step in the sense that, with an effective process, much of the subsequent analysis is simplified.

- **Step 3:** Image Segmentation

The approach is to partition an image based on abrupt changes in intensity such as edges in an image. The approach in the second category is based on partitioning an image into regions that are similar according to a set of predefined criteria. Currency note segmentation is done by applying scan line algorithm on the image after edge detection. The line that contains the number of pixels greater than the set threshold is highlighted (marked). As a final point, there is a distinct area produced by the intersection of both the scans. It is in the form of a rectangle which surrounds the currency note present in the image. This forms the localized part of the image. These features present in the currency notes have not changed over a long period of time and continues to be like this only for a foreseeable future.

- **Step 4:** Region of Interest Extraction

Image acquisition and image pre-processing techniques are employed; either the entire note or distinct Regions

of Interest (ROI) are acquired and compared independently. After segmentation of an image analysis of required region of interest is a crucial part of processing. Among different image segment part, Mount Everest template has been selected as a region of interest.

- **Step 5:** RGB to CIE Luv Conversion

A color can be described as a mixture of three other colors or "Tristimuli". Typically RGB for CRT based systems (TV, computer) or XYZ (fundamental measurements). However, it is frequently useful to separate the color definition into "luminance" and "chromaticity". It is a linear color space, but the conversions are reversible. Coloring information is centred on the color of the white point of the system, subscript n, (D65 in most TV systems).

- **Step 6:** Feature Extraction of Image

Feature extraction involves simplifying the amount of resources required to describe the large set of data.Color features mean, standard deviation, variance and skew are calculated from the input template image which is the ROI. Similarly texture features entropy, correlation of an image is calculated which are further used in classification of image. For correlation input segmented image which is in RGB form, is compared with the database images and result of maximum correlation is display based on which further analysis is obtained.

- **Step 7:** Classification of Image

Mean, standard deviation and skew which are the color feature of an input template image also entropy and correlation which are the texture feature are compared with the value of database image. It is like a key point matching since the key features of an input template image is matched with the key points of desired image. Key points from the detected image will be matched with the trained database image's keypoints, Based on the matching score of the input image keypoints and that from database template. Image thus input is classified as a fake or genuine.

3.2 Experimental Design

Magnified scan digitized images of genuine and fake currency notes (Nepalese rupees of denomination 500) are collected. For considering study, 200 genuine samples and another 40 samples of fake currency note images are considered. Resolution is 400 dpi and Images used are of jpeg types. Bank notes used here are with no marks and writing in ROI. Banknotes of real and fake samples are scanned. ROI used for calculation are free of marks and handwriting. Effects of such marking are discussed in the report.

There are different printing techniques used in real notes. Technologies used for printing fake notes are different than that of real notes. However, the printing technique that is hard to replicate because some of its inherent characteristics. There are numerous printing processes like offset, dry offset, intaglio, letterpress, serigraphy, screen printing, inkjet, bubble-jet, digital printing, etc. that can be used for printing currency notes. Out of these many possibilities, only a few processes are normally used in practice. Database of fake notes consist of different quality. Such samples are not generated from same source. Color to print those samples are different, it indicate that sources are different.

4. Simulation results and Analysis

4.1 Histogram Analysis

Figure 4: Fake Sample filtered image with its Histogram plot

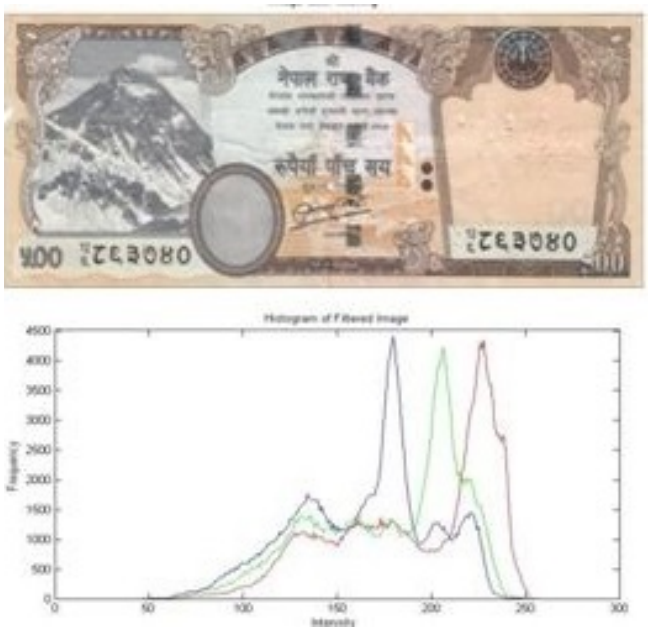

Figure 5: Real Sample filtered image with its Histogram plot

Figure 4, the first figure is Fake input sample taken and corresponding below figure is showing its RGB color histogram of a template of above sample image. A color histogram is a representation of the distribution of colors in an image. The color histogram can be built for any kind of color space, although the term is more often used for three-dimensional spaces like RGB or HSV. For monochromatic images, the term intensity histogram may be used instead. For multi-spectral images, where each pixel is represented by an arbitrary number of measurements, the color histogram is N-dimensional with N being the number of measurements taken. Each measurement has its own wavelength range of the light spectrum, some of which may be outside the visible spectrum. If the set of possible color values is sufficiently small, each of those colors may be placed on a range by itself; then the histogram is merely the count of pixels that have each possible color.

X-axis represents the intensity value whereas, Y-axis represents the frequency of intensity occurring on image. Here, the histogram analysis shows that the image print quality and also depends on intensity of light as there is a different intensity level at different time. From above histogram showing in figure 5.1, it is clear that it can go for further processing. Similarly figure 5 shows genuine sample and its corresponding histogram.

4.2 Color Features Analysis

4.2.1 Skew Calculation

Skew of a template image which is converted to CIE Luv is calculated. Skew is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point.

Figure 6: Fake sample template and it's CIE Luv color space

Figure 7: Real sample template and it's CIE Luv color space

The skew for a normal distribution is zero, and any symmetric data should have a skew near zero. Negative values for the skew indicate data that are skewed left and positive values for the skew indicate data that are skewed right. By skewed left, it means that the left tail is long relative to the right tail.

Skew of real notes on average are higher than that of fake note. Skew can play an important role in classification of currency. Threshold value is defined for classification

of an image using skew. Figure 6 and figure 7 show the conversion of RGB images to Luv color space. Figure 8 and figure 9 show the graph of skew value calculated of fake and real samples respectively.

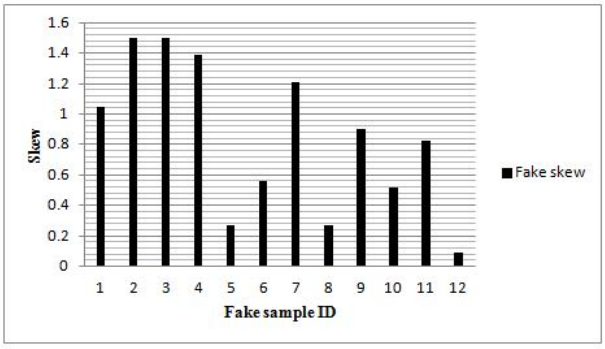

Figure 8: Graph of Skew of different fake samples

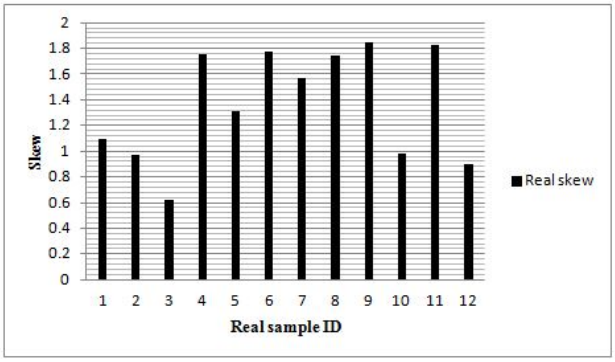

Figure 9: Graph of Skew of different real samples

4.2.2 Standard deviation Calculation

Image is converted to CIE Luv plane and Mean and Standard Deviation of Luv plane is calculated. Fake banknotes may sometime appear same as genuine notes in color but by computing the average color from the image, we may be able to decide whether they are actually printed by using the same technique.

Figure 10 and 11 show standard deviation of fake and real samples respectively. Root mean square Contrast which is also called standard deviation is greater in value of real notes than fake notes samples. It is because amount of a particular color used for printing is different for different printing processes. Combinations of color in printing real notes are defined and don't vary from one note to next for particular denomination.

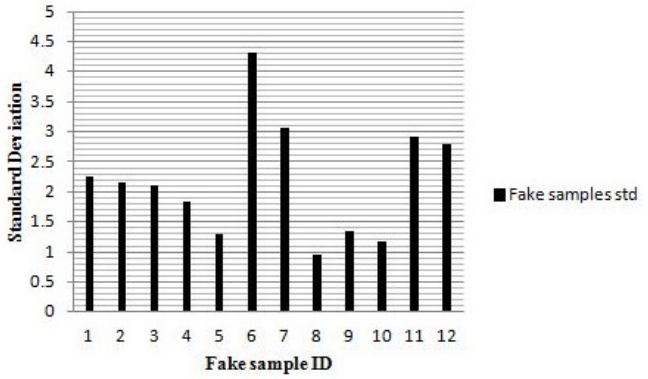

Figure 10: Graph of standard deviation of different fake samples

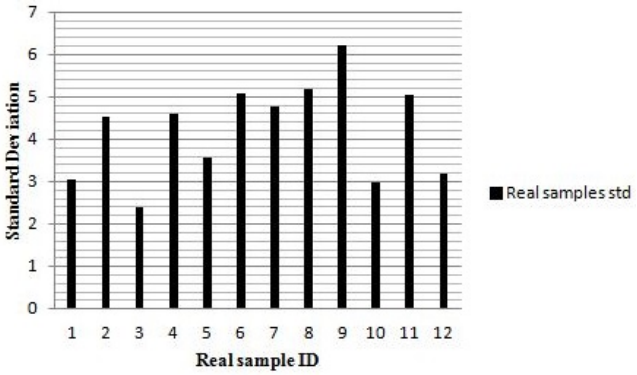

Figure 11: Graph of standard deviation of different real samples

4.3 Texture Features Analysis

Texture is a very useful feature for Currency recognition. Textural features corresponding to human visual perception are very useful for optimum feature selection and texture analyzer design.Entropy and correlation are used in this thesis for analysis of texture features of an image.

4.3.1 Entropy Calculation

Entropy of a template image of different samples of real and fake are calculateshown in graph. Entropy of different color channel red, green, blue of a template image is presented in graph.

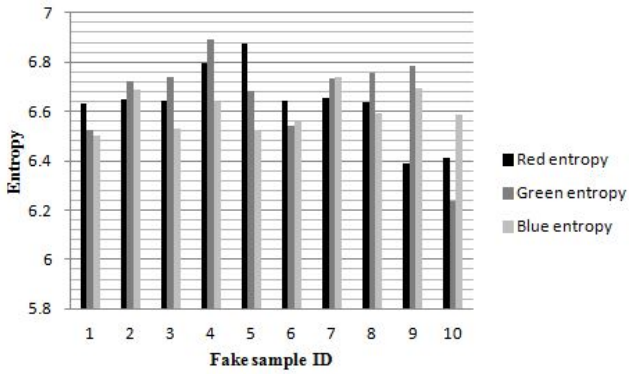

Figure 12: Graph of entropy of fake note samples

Figure 12 and 13 show entropy of fake and real note samples respectively. It gives the amount of information contained by red channel is highest, green are in middle and average amount of information carried by blue channel is least in real note. Whereas in fake note amount of information carried by different channel are random which don't follow any significant pattern. In the above run six fake and five real samples are used in an experiment.

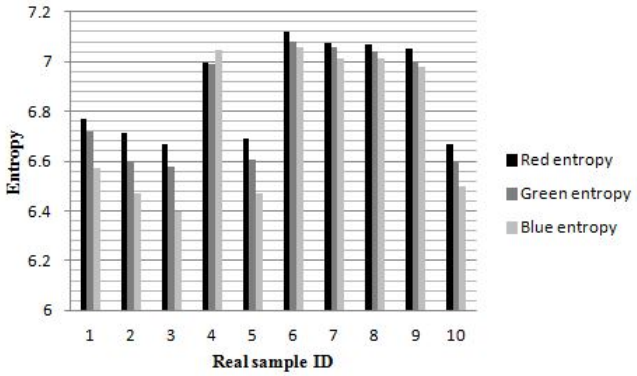

Figure 13: Graph of entropy of real note samples

4.3.2 Correlation Calculation

Correlation matches the input template image with the database image. Three different database images which are typical are taken. Different correlation value of fake note samples and real notes sample are calculated. Correlation value thus calculated is normalized correlation value. Input filter image is used for correlation purpose. Template of filter image is extracted from an image using image segmentation. Segmented image is correlated with the database image.

Figure 14 show filter image whose template has been extracted. Normalized cross correlation image that is found by moving a template of fake sample to the database image. The Brightness part of image shows that there occurs maximum correlation. Similarly it shows filter real note sample, its template and normalized cross correlation. For classification of an image, whether it matches the database image or not, there need numerical value. Numerical value is calculated and that value is analyzed whether it satisfies the predefined value or not.

Figure 14: Normalized cross correlation of real sample

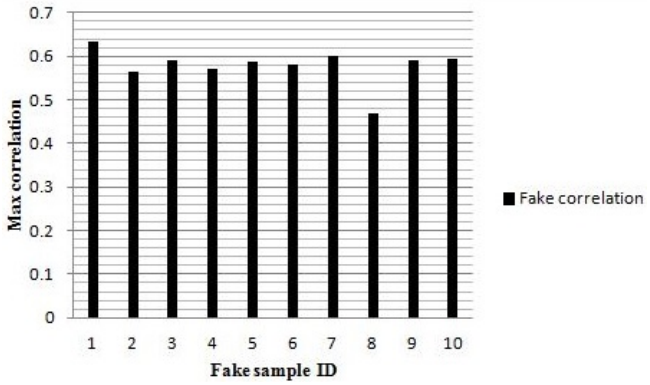

Figure 15: Graph of correlation of fake note samples with database sample

Figure 15 and 16 show the plot of normalized correlation value of fake samples with the database image sample.

Based on the threshold value classification is done.

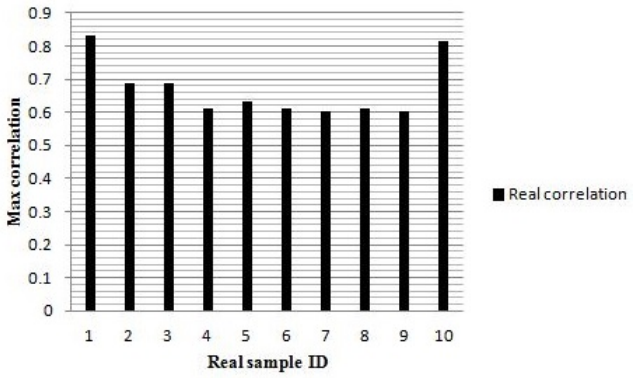

Figure 16: Graph of correlation of real note samples with database sample

Table 1: Classification Analysis

Banknote	Tested no.	Correctness	Accuracy
Rs. 500 (fake)	40	38	95%
Rs. 500 (real)	70	67	95.71%

Skew and Standard Deviation as color parameter along with combination of entropy and correlation as texture parameter contribute to classification of counterfeit paper banknote.

Process used to print banknotes provides important checkup for authentication of the notes. In many cases counterfeiting have been reported even on the paper identical to one as used for genuine notes leaving a very narrow gap to identify the original from the fake. However, the printing technique that is hard to replicate because some of its inherent characteristics. There are numerous printing processes like offset, dry offset, intaglio, letterpress, serigraphy, screen printing, inkjet, bubble-jet, digital printing, etc. that can be used for printing currency notes. Out of these many possibilities, only a few processes are normally used in practice.

Handwriting and other marking decreases the value thus calculated. It has no effect in classification of fake samples. It plays vital role in classification genuine samples. Color parameter value and texture parameter decrease with marking then without marking

5. Conclusion

Software based approach that is able to identify fake currencies from images is presented. An empirical approach for automated digital currency identification is formulated based on image processing technique. A two parts feature values is formulated consisting of color features and texture features. A technique used for the extraction of feature, identification and classification of counterfeit and genuine bank note is presented. It presents automatic identification of counterfeit paper banknotes, which automatically using image processing techniques. Color and texture feature of a currency is used for identification.

- Color descriptor skew, mean and standard deviation is calculated from samples which are checked against the parameter that are previously defined.
- Texture parameter entropy and correlation are calculated from different set of database image.
- Matching score below the threshold, input currency image is classified as fake note. Otherwise the currency is genuine.

6. Limitation

This thesis is based on some assumption so there is limitation. Banknotes in the context of Nepal contain different writing and marking by user.

- Marking decreases the overall contrast and correlation of note.
- Classification of counterfeit notes not affected by simple marking in ROI but it affects in real notes. If the marking are more and drastic than classification might not be possible.
- Color like red, and yellow are normally laid in notes while handing notes in cultural rituals. Such color that might present in notes with affects overall classification.

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