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Fake currency detection using image processing

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ABSTRACT

Currency duplication also is known as counterfeit currency is a vulnerable threat to Economy.it is now a common phenomenon due to advanced printing and scanning technology. Bangladesh has been facing the serious problem by increasing rate of fake note in the market.to get rid of this problem various fake not detection methods are available around the world and most of these are hardware based and costly.in the present paper an automated image-based technique is described for the detection of fake banknotes in Bangladesh. Security features of banknote such as watermark, micro-printing, and hologram etc., are extracted from the banknote images and then detection is performed using "Mathlab tools"

Keywords: *Image acquisition, Gray scale conversion, Edge detection, Image segmentation, Characteristic extraction, Comparison, Output.*

1. INTRODUCTION

Automatic recognition of fake Indian currency note is important in many applications such as automated goods seller machine and automated goods tellers machine. This system is used to detect the valid Indian currency note. The system consists of eight steps including image acquisition, grey scale conversion, edge detection, feature extraction, image segmentation, comparisons of images and output [1]. Automatic machine more helpful in banks, because banks face the problem of counterfeit currency notes or destroyed notes. Therefore involving machine makes note recognition process simpler and systematic.

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 build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems. 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 which would be impossible by analog means. Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images.

More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. Image restoration is different from image enhancement in that the latter is designed to emphasize features of the image that make the image more pleasing to the observer, but not necessarily to produce realistic data from a scientific point of view. Image enhancement techniques (like contrast stretching or de-blurring by the nearest neighbor procedure) provided by "Imaging packages" use no a priori model of the process that created the image. With image, enhancement noise can effectively be removed by sacrificing some resolution, but this is not acceptable in many applications. In a Fluorescence Microscope resolution in the z-direction is bad as it is. More advanced image processing techniques must be applied to recover the object.

2. COMMONLY USED METHODS TO DETECT FAKE NOTES

1) See-through register

The small floral design is printed in the middle of the vertical band and next to watermark. The floral design on the front is hollow and in the back is filled up. The floral design has back to back registration. The design will see as one floral design when seen against the light [1].

2) Water Marking

The mahatma Gandhi watermark is present on the bank notes. The mahatma Gandhi watermark is with a shade effect and multidirectional lines in the watermark.

3) Optically Variable Ink

Optically variable ink is used for security feature; this type of feature is in the Rs.1000 and Rs.500 bank note. Optically variable ink as a security feature for bank note is introduced in Nov.2000. The denomination value is printed with the help of optically variable ink. The colour of numerical 100 or 500 appears green when the note is flat but change the colour to blue when is held at an angle [4].

4) Fluorescence

Fluorescent ink is used to print number panels of the notes. The note also contains optical fiber. The number pannel in fluorescent ink and the optical fiber can be seen when exposed to UV light.

5) Security Thread

The security thread is in 1000 and 500 note, which appears on the left of the Mahatma Gandhi's portrait. In security thread the visible feature of "RBI" and "BHARAT". When a note is held against the light, the security thread can be seen as one continuous line

6) Latent Image

The latent image shows the respective denomination value in numerical. On the observe side of notes, the latent image is present on the right side of Mahatma Gandhi portrait on the vertical band. When the note is held horizontally at eye level then the latent image is visible.

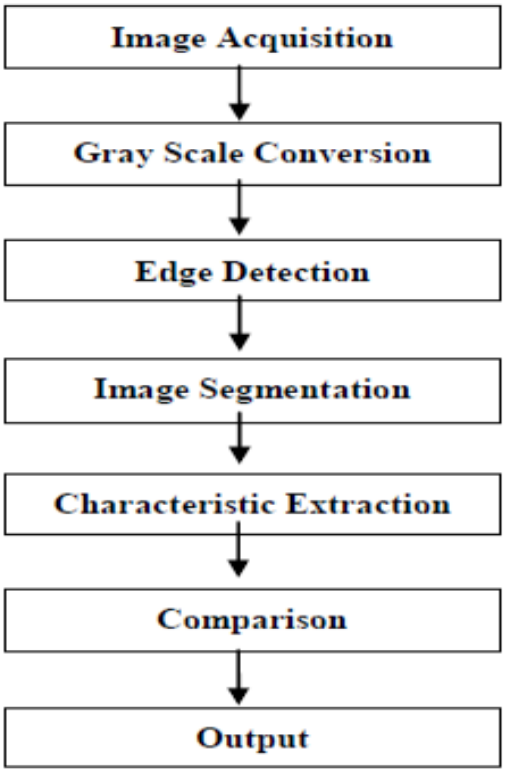
7) Micro Lettering

The micro letter's appears in between the portrait of Mahatma Gandhi and vertical band. Micro letter's contains the denomination value of bank note in micro letters. The denomination value can be seen well under magnifying glass.

8) Identification Mark

Each note has its special identification mark. There are different shapes of identification mark for the different denomination (Rs.100-
Triangle, Rs.500-circle, and Rs.1000-Diamond). The identification mark is present on the left of water mark

Architecture diagram



3. METHODOLOGY

1) Image Acquisition:

Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks. There are various ways to acquire images such as with the help of camera or scanner. The acquired image should retain all the features [7].

2) Pre-processing

The main goal of the pre-processing to enhance the visual appearance of images and improve the manipulation of data sets. Image preprocessing, also called image restoration, involves the correction of distortion, degradation, and noise introduced during the imaging process. Interpolation is the technique mostly used for tasks such as zooming, rotating, shrinking, and for geometric corrections. Removing the noise is an important step when processing is being performed. However, noise affects segmentation and pattern matching [7].

3) Gray image

In photography and computing, a gray scale or gray scale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.

Gray scale images are distinct from one-bit bi-tonal black-and-white images, which in the context of computer imaging are images with only the two colors, black, and white (also called bi-level). gray scale images have many shades of gray in between.

Gray scale images are often the result of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum (e.g. Infrared, visible light, ultraviolet, etc.), and in such cases, they are monochromatic proper when only a given frequency is captured. But also they can be synthesized from a full-color image; see the section about converting to gray scale.

4) Binarization

The image acquired is in RGB color. It is converted into gray scale because it carries only the intensity information which is easy to process instead of processing three components R (Red), G (Green), B (Blue). To take the RGB values for each pixel and make as output a single value reflecting the brightness of that pixel. One such approach is to take the average of the contribution from each channel: (R+B+C)/3. However, since the perceived brightness is often dominated by the green component, a different, more "human-oriented", a method is to take a weighted average, e.g.: 0.3R + 0.59G + 0.11B [7].

5) Edge Detection

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has these continuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision [7].

6) Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple Segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images [7]. Segmentation

4. PROPERTIES OF IMAGE INTENSITY VALUES

1) Discontinuity:

Based on abrupt changes in intensity such as edges in an image.

2) Similarity:

Based on partitioning an image into regions that are similar according to a set of predefined criteria [6].

Fuzzy clustering is a powerful unsupervised method for the analysis of data and construction of models. In many situations, fuzzy clustering is more natural than hard clustering. Objects on the boundaries between several classes are not forced to fully belong to one of the classes, but rather are assigned membership degrees between 0 and 1 indicating their partial membership. The fuzzy c-means algorithm is most widely used. The FCM employs fuzzy partitioning such that a data point can belong to all groups with different membership grades between 0 and 1.

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2 \quad , \quad 1 \le m < \infty$$

where m is any real number greater than 1, u_{ij} is the degree of membership of x_i in the

cluster j, x_i is the ith of d-dimensional measured data, c_j is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the center.

Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|} \right)^{\frac{2}{m-1}}} \quad , \quad c_j = \frac{\sum_{i=1}^{N} u_{ij}^m \cdot x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

This iteration will stop when $\max_{ij} \left\{ \left| u_{ij}^{(k+1)} - u_{ij}^{(k)} \right| \right\} < \varepsilon$, where ε is a termination criterion between 0 and 1, whereas k are the iteration steps. This procedure converges to a local minimum or a saddle point of J_m.

5. ALGORITHM

1. Initialize $U=[u_{ij}]$ matrix, $U^{(0)}$

2. At k-step: calculate the centers vectors $C^{(k)}=[c_j]$ with $U^{(k)}$

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^m \cdot x_i}{\sum_{i=1}^{N} u_{ij}^m}$$

3. Update $U^{(k)}$, $U^{(k+1)}$

$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\|x_i - c_j\|}{\|x_i - c_k\|} \right)^{\frac{2}{m-1}}}$$

4. If $\| U^{(k+1)} - U^{(k)} \| < \varepsilon$ then STOP; otherwise return to step 2.

6. FEATURE EXTRACTION

Feature extraction is a special form of dimensional reduction. When the input data to an algorithm is too large to be processed and it is suspected to be very redundant then the input data will be transformed into a reduced representation set of features. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full-size input [7]

7. FLOWCHART

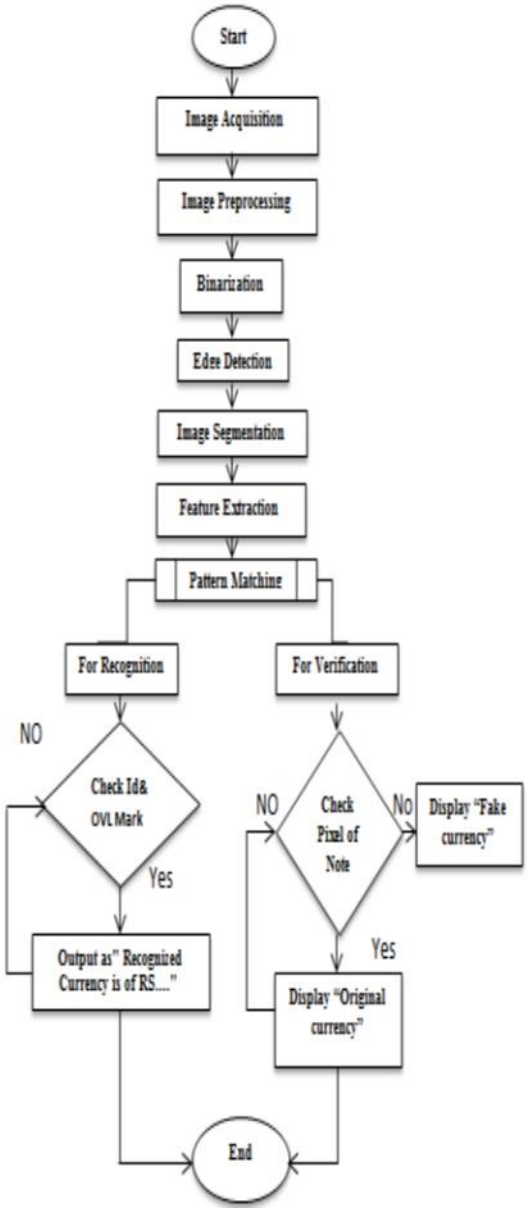
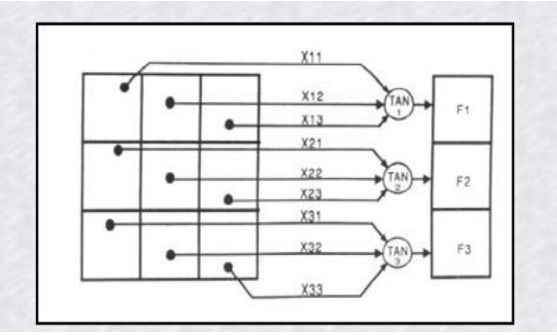


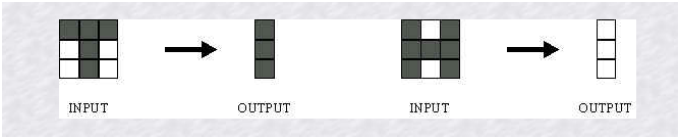
Figure: Flowchart for Currency Recognition and Verification System

8. PATTERN RECOGNITION - AN EXAMPLE

An important application of neural networks is pattern recognition. Pattern recognition can be implemented by using a feed-forward (figure 1) neural network that has been trained accordingly. During training, the network is trained to associate outputs with input patterns. When the network is used, it identifies the input pattern and tries to output the associated output pattern. The power of neural networks comes to life when a pattern that has no output associated with it, is given as an input. In this case, the network gives the output that corresponds to a taught input pattern that is least different from the given pattern.



For example: The network of figure 1 is trained to recognise the patterns T and H. The associated patterns are all black and all white respectively as shown below.



If we represent black squares with 0 and white squares with 1 then the truth tables for the 3 neurons after generalization are;

X11:		0	0	0	0	1	1	1	1
X12:		0	0	1	1	0	0	1	1
X13:		0	1	0	1	0	1	0	1
OUT:		0	0	1	1	0	0	1	1

Top neuron

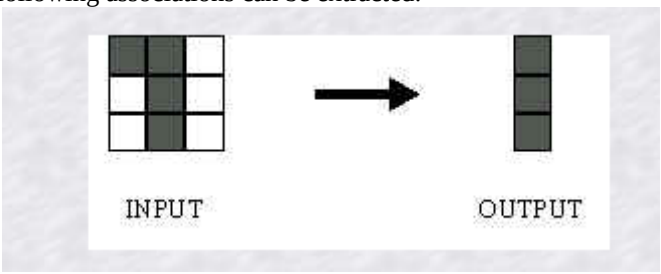
X21:		0	0	0	0	1	1	1	1
X22:		0	0	1	1	0	0	1	1
X23:		0	1	0	1	0	1	0	1
OUT:		1	0/1	1	0/1	0/1	0	0/1	0

Middle neuron

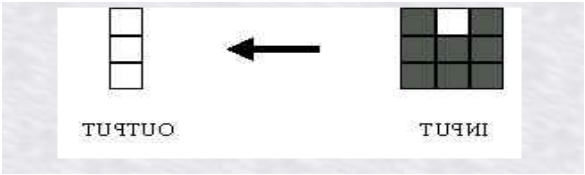
X21:		0	0	0	0	1	1	1	1
X22:		0	0	1	1	0	0	1	1
X23:		0	1	0	1	0	1	0	1
OUT:		1	0	1	1	0	0	1	0

Bottom neuron

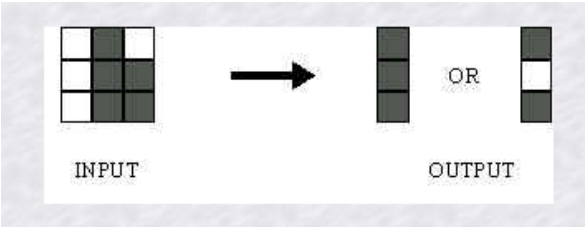
From the tables it can be seen the following associations can be extracted:



In this case, it is obvious that the output should be all blacks since the input pattern is almost the same as the 'T' pattern.



should be all whites since the input pattern is almost the same as the 'H' pattern.



Here, the top row is 2 errors away from the T and 3 from an H. So the top output is black. The middle row is 1 error away from both T and H so the output is random. The bottom row is 1 error away from T and 2 away from H. Therefore the output is black. The total output of the network is still in favour of the T shape.

9. SOFTWARE REQUIREMENTS

- Operating system: Windows XP,7,8
- Coding Language: MATLAB 2013

10. LANGUAGE DESCRIPTION

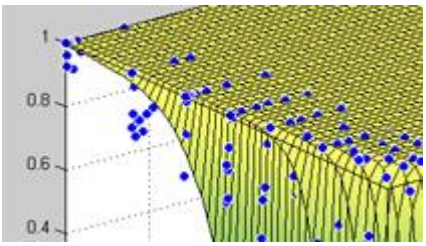
MATLAB (**mat**rix **lab**oratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, the creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, Fortran, and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

In 2004, MATLAB had around one million users across industry and academia. MATLAB users come from various backgrounds of engineering, science, and economics.

11. DATA ANALYSIS AND VISUALIZATION

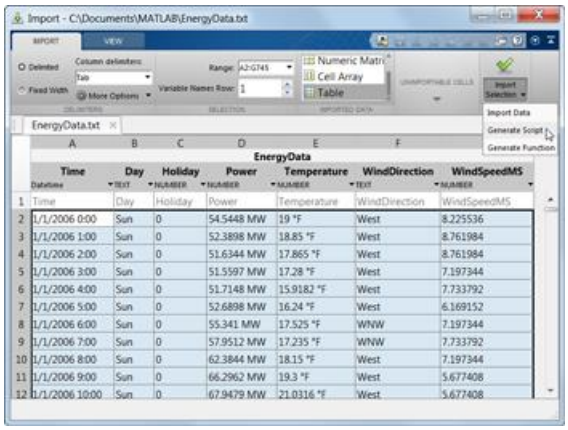
MATLAB provides tools to acquire, analyze, and visualize data, enabling you to gain insight into your data in a fraction of the time it would take using spreadsheets or traditional programming languages. You can also document and share your results through plots and reports or as published MATLAB code.



ACQUIRING DATA

MATLAB lets you access data from files, other applications, databases, and external devices. You can read data from popular file formats such as Microsoft Excel; text or binary files; image, sound, and video files; and scientific files such as net CDF and HDF. The file I/O functions let you work with data files in any format.

Using MATLAB with add-on products, you can acquire data from hardware devices, such as your computer's serial port or sound card, as well as stream live, measured data directly into MATLAB for analysis and visualization. You can also communicate with instruments such as oscilloscopes, function generators, and signal analyzers.



A mixed numeric and text file for import into MATLAB using the Import Tool. MATLAB automatically generates a script or function to import the file programmatically.

ANALYZING DATA

MATLAB lets you manage, filter, and preprocess your data. You can perform exploratory data analysis to uncover trends, test assumptions, and build descriptive models. MATLAB provides functions for filtering and smoothing, interpolation, convolution, and fast Fourier transforms (FFTs). Add-on products provide capabilities for curve and surface fitting, multivariate statistics, spectral analysis, image analysis, system identification, and other analysis tasks.

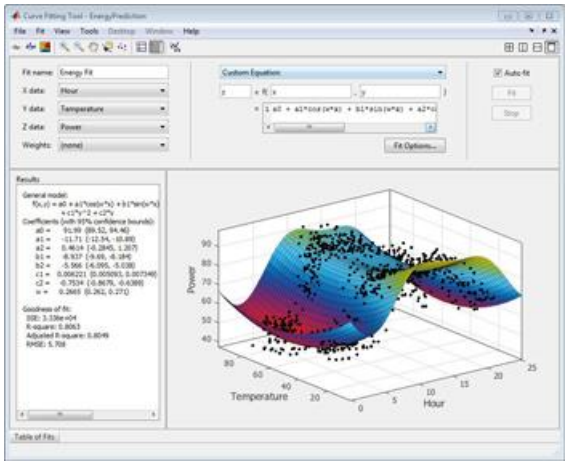


Fig: A surface to data with a custom model using MATLAB and Curve Fitting Toolbox

VISUALIZING DATA

MATLAB provides built-in 2-D and 3-D plotting functions, as well as volume visualization functions. You can use these functions to visualize and understand data and communicate results. Plots can be customized either interactively or programmatically.

The MATLAB plot gallery provides examples of many ways to display data graphically in MATLAB. For each example, you can view and download source code to use in your MATLAB application.

12. CONCLUSION

This project proposed fake currency detection using image processing. In image pre-processing the image was cropped, adjusted and smoothed. Then the image converted into gray scale. After conversion the edges are detected. In edge detection used the sobel operator. Next the image segmentation is applied. After segmentation the features are extracted. Finally compared and find the currency original or fake.
In future this work will be extended as to apply the classification to compare the original or forgery currency.

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