MANTECH Publications

Journal of Computational Intelligence Theory and Its Applications
Volume 1 Issue 1

Bank Notes Authentication System based on Wavelet Features and Artificial Neural Network

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Abstract

Monetary transactions are an integral part of our day to day activities, so currency authentication has become one of the active research areas of late, and it shows a vast potential for different applications. In this paper, we introduce a system to verify the authentication of banknotes' bench mark dataset using computer vision.We considered 1372 samples of various bank notes in our work. The technology of currency authentication aims to search and extract potential features of paper currency for efficient classification. Features were extracted from images that were taken from genuine and forged banknote-like specimens. They are classified using Artificial Neural network. The variance of Wavelet Transformed image (continuous), skewness of Wavelet Transformed image (continuous), curtosis of Wavelet Transformed image (continuous), entropy of image (continuous) features are extracted from images for accurate classification. Our proposed system authenticates bank notes with zero percent misclassification.

Keywords: *Currency Recognition, Artificial Neural Network, Classification, Wavelets*

INTRODUCTION

Object recognition [1-7] and authentication is an important and highly demanded area of pattern recognition. An object can be anything in real life. It can be text in a document, a license plate of a vehicle, an iris in a person's eyes, a sign in a sign language, a face of a person, and so on. Similarly, paper currency recognition [8-15, 17-20] is as important as any other object recognition.

Some authors in the recent years have contributed to the subject of paper

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currency recognition systems. These existing paper currency recognition methods, in the literature presented here, mainly involve image processing and/or neural network techniques [11-15].

This paper deals with a simple, efficient and very accurate approach in the system design. In designing such a system, it considers different dimensions, color luminance, edge histogram using max sobel gradient, correlations as features. A different method using radial basis Function networks is utilized for developing an intelligent system which can recognize paper currency. This research is specifically designed for recognizing paper currency from United Kingdom ("Pound"), Japan ("Yen"), Europe ("euro") and India ("rupee"). The recognition technique discussed in this paper was designed in such a way that it can be used for recognizing paper currency of four different countries. To overcome the problem of recognizing dirty banknotes, the pre-processing stage is also considered.

The proposed scheme is different from various existing methods [1-21] because of its approaches in the recognition phases. Specifically, for example, sobel masks have been used in [11] for considering specific edges (images) in a paper currency. Using this method, the features are extracted and fed to a Neural Network (NN). The technique in [20] deals with Pakistani paper currency with very different feature set that is specific to regional currency marks and color of the currency. Similarly, the technique introduced in [21] is different from the proposed technique as it introduces many more features than the ones introduced in the proposed method.

The organization of the paper is as follows: Section 2 introduces the overall mechanism for PCR while in Section 3 the pre-processing steps are briefly introduced. Section 4 describes the problem formulation for four different currencies. The proposed PCR approach, together with feature extraction method as well as classification, has been completely discussed in Section 5. Section 6 describes details of experimental results for the case of multiple paper currency. Finally, Section 7 concludes the paper.

STRUCTURE OF TYPICAL CURRENCY AUTHENTICATION SYSTEM

The system presented is designed to recognize paper currency. Input to the system is an image acquired by a scanner

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or a digital camera, containing the paper currency and its outputs the features of the paper currency. This system consists of the following modules: Image acquisition, pre-processing including noise removal, feature extraction, classification and recognition. The structure of the system is shown in **Fig.1.**

PRE-PROCESSING

In the proposed system, a high resolution scanner is used to acquire the image. The acquired image of a paper currency is first converted to gray scaled image. Conversion to gray scale facilitates further pre-processing. The task of pre-processing is achieved by converting colored currency images into grayscale, then black-white images. After that, the edge of the image is filtered using Prewitt method. Then, the image edge is detected using Canny's edge detection method. Different currency images are shown in **Fig.2.**

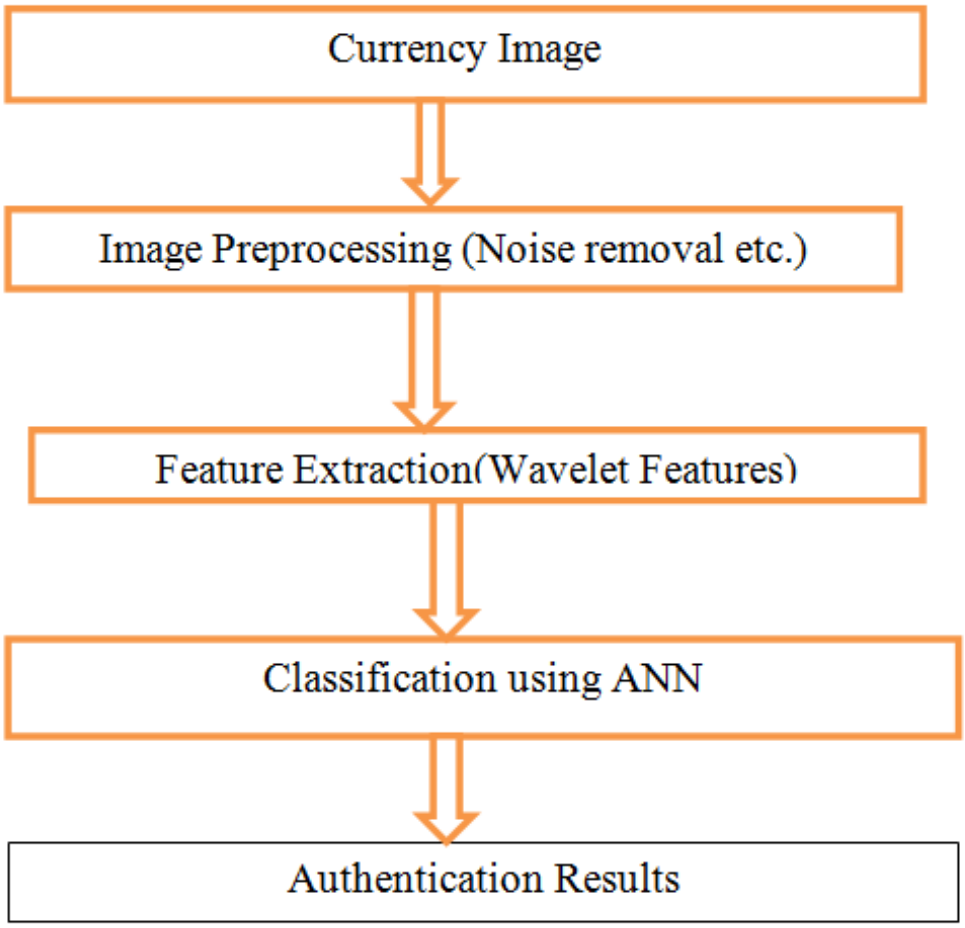


Fig.1 Flow chart of Currency authentication System

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This paper is meant for Paper Currency Authentication System. It is designed to just authenticate different currencies. This means that this system will not be concerned with other currencies. In addition, the system will focus on paper currencies, not coins. Moreover, the system is concerned with verification of the validity of the paper currencies (i.e. verifying that the paper currency is genuine and not faked). This is usually done using other methods which might involve sensing the magnetic string embedded inside the currency, or some other methods.

The goal of the paper is to present ways to achieve the best accuracy in recognizing patterns with the lowest possible errors. Given the fact that paper currencies are usually recognized by machines that have small power (such as auto-seller machines and ATM's), the cost is a limiting factor. Therefore, it is really urgent for all paper currency recognizers to minimize the power consumption, and, at the same time, achieve a high level of accuracy.

PROPOSED APPROACH

A. Image Acquisition

In this step, we scan good quality and bad quality images of four different currencies for training and testing purpose.

B. Image Pre-processing

Median filter is used for denoising the image after resizing it. A median filter considers each pixel at the same time and looks at its neighbouring pixels to decide whether it is representative of its surroundings or not. The pixel value is replaced with median of neighbouring pixel value instead of replacing with mean. Median filter is more effective when the goal is to simultaneously reduce noise and at the same time to preserve edges in the image. From the input color image, each Red, Blue and Green channels are denoised separately by using median filter.

C. Feature Extraction

In this section, we present an approach to extract the features of currency notes.The features extracted constitute input vector to the system. The potential features are extracted for efficient classification.The input vector can be written as follows:

$$F=(V,S,C,E)$$

which consists of features as its arguments, shown in Table1.

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Table1 List of features in the input feature vector

#	Feature Notation	Feature Specification
1	V	Variance of Wavelet Transformed image
2	*S*	Skewness of Wavelet Transformed image
3	*C*	Curtosis of Wavelet Transformed image
4	*E*	Entropy of image

Features were extracted from images that were taken from genuine and forged banknote-like specimens. The attributes of the images such as the variance of Wavelet Transformed image (continuous), skewness of Wavelet Transformed image (continuous), curtosis of Wavelet Transformed image (continuous), entropy of image (continuous) features are extracted from images for accurate classification.

CLASSIFICATION ALGORITHM

Once the features are extracted, it is essential to classify the currency based on these features by using an effective currency authentication system called classifier.

One of the most common classifiers in use nowadays is Artificial Neural Network. A neural network based recognition schemes are used by many researchers in the literature [9,10,11,12].

Training Phase

Initially, the feedforward backpropagation neural network is trained with 1372 samples from genuine and forged banknote-like specimens. The performance and training stage results are shown below in fig 3 & fig4 respectively. Feedforward backpropagation neural network originates from the problem of interpolating a set of data in a hyperspace to find the best hyper-plane that interpolates that set of data. In feedforward backpropagation Neural Networks, there are three layers: input layer, hidden layer and output layer. The input layer consists of the data (or the pattern) that is to be interpolated (or classified). The hidden layer provides a nonlinear transformation from the input layer space to the hidden layer space. It usually consists of a high number of neurons. The output layer provides a linear transformation from the hidden layer space to the output layer space6. The

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network is trained with 100 images which contain normal, noisy and tilted images.

Testing Phase

Once the network has been trained on different currencies, with their corresponding feature vectors along with target class, the trained network is validated against test images to check the performance of the proposed system.

EXPERIMENTAL RESULTS

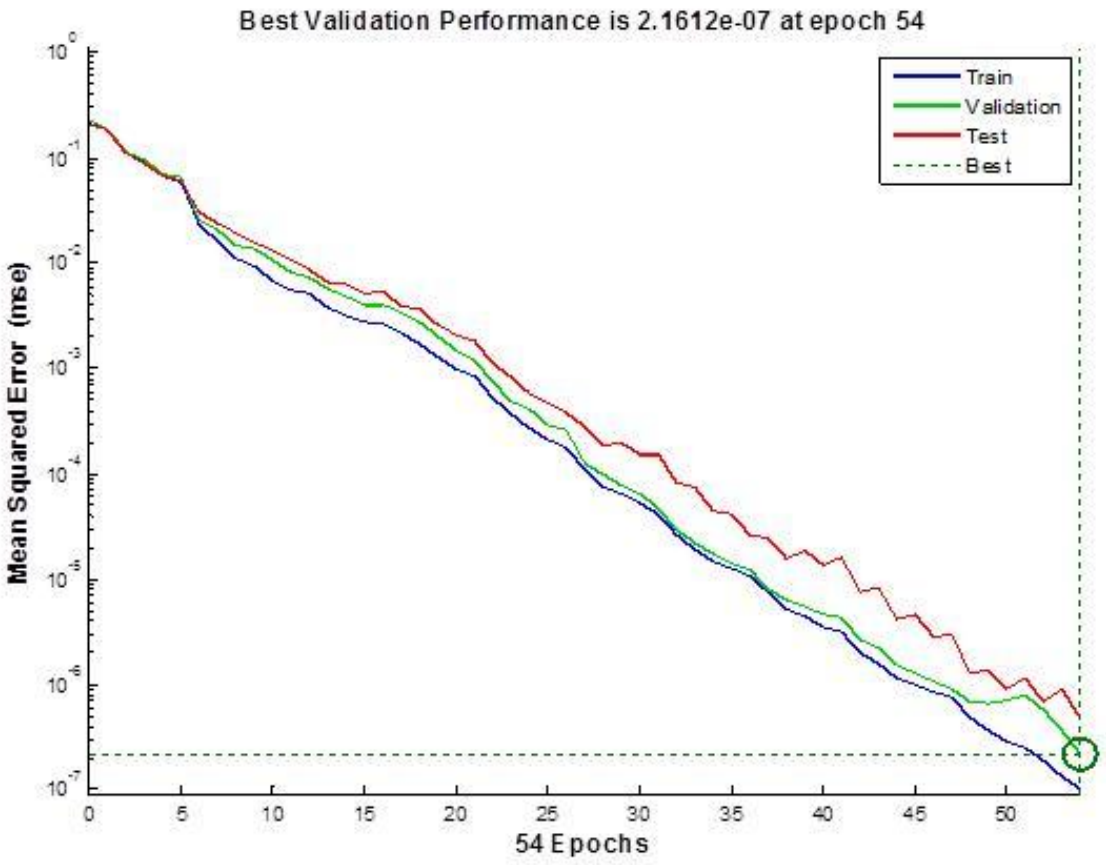


Fig 2: Performance of network classifier

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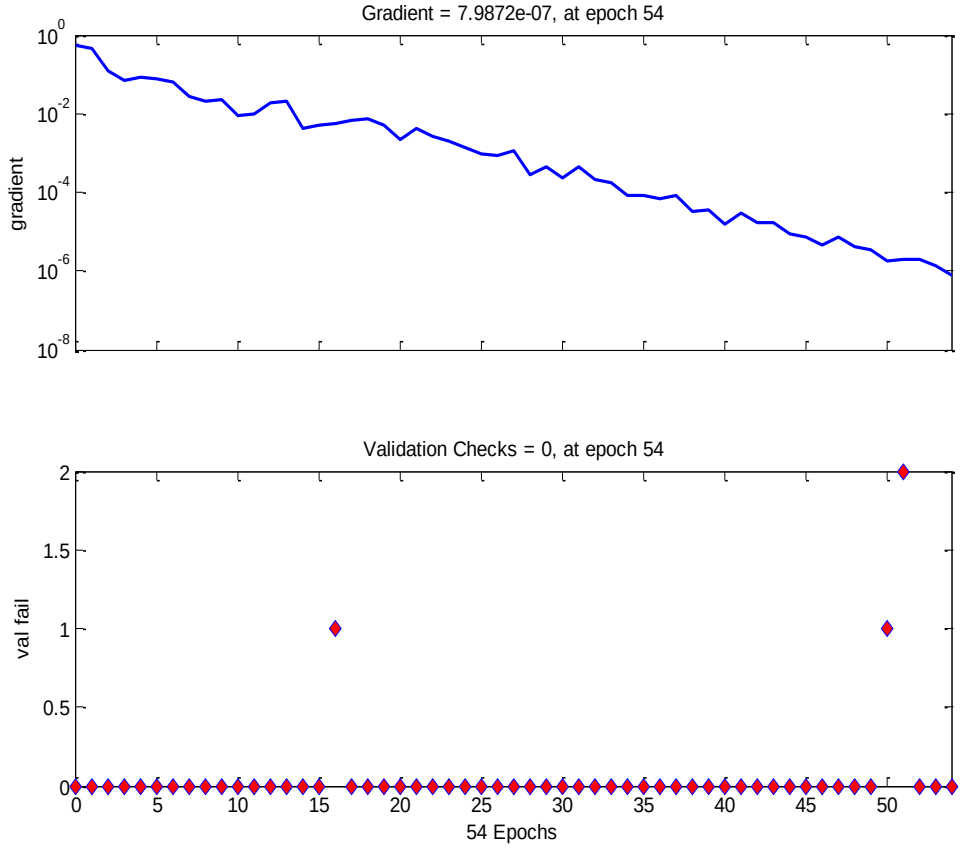


Fig 3 Training state of the network classifier

Table 3 Experimental Results of Feedforward Back Propagation Network Classifier

	Samples	**MSE(Mean SqureError)**	**%Error**
Training	960	1.03E-07	0
Validation	206	2.16E-07	0
Testing	206	4.79E-07	0

The recognition results are shown in Table 3. From the table, it can observed that our system achieved zero percent error means zero miscalssifications.

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CONCLUSION AND FUTURE WORK

Paper Currency Recognition is an important application of Pattern Recognition. Many studies have been undertaken to recognize paper currencies using Neural Networks. In this paper, another method of recognizing currencies has been introduced, which is based on wavelet features of the images. The method uses feed forward backpropagation neural network. The method is quite reasonable in terms of accuracy. However, the processing time still need to be improved. The proposed algorithm is fully automatic and requires no human intervention. The proposed feature methodology can be applied to other models of classification to improve the accuracy and efficiency of the process.

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