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BANKNOTE AUTHENTICATION USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT :*Counterfeit banknote is an imitation currency produced without the legal sanction of the state or government. This paper is focusing on how to classify the detection technique of counterfeit banknotes. The approach that will be implemented to solve this problem is by using the method of Artificial Neutral Network. In this research, the author prefers to use back-propagation training in Artificial Neural network. The instrumentation used, is the MATLAB's GUI application that will be designed and developed to examine and identify the authentication of banknotes. The sample data was provided by the Center of Machine Learning and Intelligent System database. In the process to get the result, the author decides to classify this sample of banknotes data into training, testing and validation*.

KEYWORDS: banknote, counterfeit, authentication, artificial neural network, back-propagation, Center of Machine Learning and Intelligent System database.

1.0 INTRODUCTION

Although the incidence of counterfeiting is relatively low, there are still some counterfeit banknotes in circulation and has become a serious threat to our society. With the advancement in digital image processing, it also plays a significant role in producing increasing number of fake banknotes every year [1]. But the main problem is how to identify and classify that the banknotes are real or counterfeit? In this research, the author not only focuses on detecting the real or counterfeit banknotes, but to also how classify between real or counterfeit banknotes.

Nowadays, automatic machines which accept banknotes are developed to meet various needs and functions. These machines recognize banknotes fed to them by identifying the design or value of the banknotes. It is extremely important for such machines to authenticate the banknote to distinguish it between real and counterfeit notes. In general, authentication is more difficult than recognition, since the differences in designs or values are deliberately designed to be readily distinguished, while forgeries are deliberately created for intended purposes to be indistinguishable from genuine banknotes.

According to the Emma L. Prime and David H. Solomon [2] , The perfect forgery has never been detected. The forger does not need to reproduce the actual note, but instead only produce a simulation that can be passed at least once. The forger does not need to worry about durability but must make a number of compromises dictated by the resources and skills available.

Banknotes are not designed to be used primarily with automatic identification techniques. Normally the features of the banknotes which are used for identification by such techniques have to be chosen on an empirical basis. This means, that there is generally no simple algorithm by which these features can be combined to determine whether the banknotes are valid or not.

According to the research by Chi-Yuan Yeh, Wen-Pin Su and Shie-Jue Lee [3] proposed a system based on multiple-kernel support vector machines for counterfeit banknote recognition. A support vector machine (SVM) to minimize false rates is developed. Experiments with Taiwanese banknotes show that the proposed approach outperforms single-kernel SVMs, standard SVMs with SDP, and multiple-SVM classifiers.

"Using Hidden Markov Models for Feature Extraction in Paper Currency Recognition" by H. Hassanpour and E. Hallajian [4]; This paper proposes a new feature extraction technique for paper currency recognition. In this technique, the texture characteristic is used in the recognition. 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. In these circumstances for this research, the author proposed to use neural network to classify the real or counterfeit banknotes,.

This paper is a study about the Banknote Authentication using Artificial Neutral Network (ANN). The research is to present an invention that will provide method/s, that is/are helpful for banknote authenticating or protecting physical. In this research, the data were extracted from images that were taken for the evaluation of an authentication procedure for banknotes. This data will be implemented using the Artificial Neural Network technique to classify the banknotes whether it is real or counterfeit.

The goals of this research are, first is to investigate how to classify the counterfeit banknotes and what is the current possible solution to detect it and to find the best technique to identify counterfeit banknotes detection method. Second is to develop desired model of banknote authentication to generate the optimized result of real or counterfeit notes using the Artificial Neural Network technique. This technique will use back-propagation algorithm to analyze the data that is provided by the UCI Machine Learning Repository database. Third is to test provided data proposed, by using the Artificial Neural Network technique in MATLAB's GUI application to get the optimized result. The sampling data is taken from "Banknotes Authentication Data Set" and the source is from the Center for Machine Learning and Intelligent System [6]. Then, the MATLAB's GUI application will be used to analyse the class of data that is provided from the UCI Machine Learning Repository database and it will verify whether those banknotes' data is counterfeit data or not.

The author aims is to classify the sample of banknotes data into the MATLAB's GUI application which is to examine whether the data is real or forged. The tools that will be used in this research is '*nntool*' that stands for Neural Network technique [7]. Neural network is used to simulate research, develop and apply artificial neural networks, biological neural networks and in some cases a wider array of adaptive systems.

Data were extracted from images that were taken from genuine and forged banknote-like specimens. For digitization, an industrial camera usually used for print inspection was used. The final images have 400x 400 pixels. Due to the object lens and distance to the investigated object gray-scale pictures with a resolution of about 660 dpi were gained. Wavelet Transform tool were used to extract features from images. The data attribute information: [6]

i. variance of Wavelet Transformed image (continuous)
ii. skewness of Wavelet Transformed image (continuous)
iii. curtosis of Wavelet Transformed image (continuous)
iv. entropy of image (continuous)
v. class (integer)

2.0 ARTIFICIAL NEURAL NETWORK

In this research, the author proposed to use Artificial Neural Network technique as a solution of Banknotes Authentication in detecting the real or counterfeit banknotes. An ANN is a mathematical or computational model based on biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase.

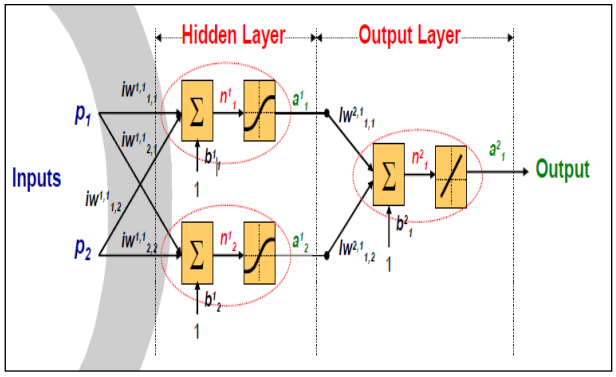

Figure 1 [8]: Architecture of Artificial Network with 2 layers

An ANN usually organizes its units into several layers shown in Fig. **1**. The first layer or input layer, the intermediate layers or hidden layers, which are not always present because they are sometimes not needed, and the last or output layer. The information to be analysed is presented (or fed) to the neurons of the first layer and then propagated to the neurons of the second layer for further processing. These results are propagated to the next layer and so on, through to the last layer, converting the information into the network output. The goal of an ANN is to discover some association between input and output patterns [9].

2.1 BACK-PROPAGATION ALGORITHM

The back-propagation algorithm is a supervised learning method, an implementation of the Delta rule. It is more useful for feed-forward networks (networks that have no feedback or simply, that have no loop connections). The term is an abbreviation for ''backwards propagation of errors". Back-propagation requires all transfer functions used by the artificial neurons (or ''nodes") to be differentiable.

Back-propagation is used to calculate the error gradient of the network with respect to its modifiable weights. This gradient is always used in a simple stochastic gradient descent algorithm to find weights that minimize the error. Back-propagation may have practical problems of getting trapped in local minima and knowing when the procedure has converged. It is important to note that back-propagation networks are necessarily multilayer perceptron's (MLP) usually with one input, one hidden, and one output layer [9].

2.2 BANKNOTE RECOGNITION

Banknote recognition is an image processing technology that is used to identify banknotes authentication of various countries. Probabilities that the notes of various countries are probably interweaved together; therefore there is an increase of counterfeit notes cases?and it has becoming a challenge for conventional banknote recognition systems. However, the focus of most of the conventional banknote recognition systems and machines is to identify counterfeit currencies. It is not enough for practical businesses. The reason is that, in most of banks, especially those internationalized banks, there are large quantities of cash belonging to too many different countries, need to be processed, and it is possible that all of them are real cash. The situation where the cash that belongs to different countries mixed together is possible and it leads to failure to process/identify it using with conventional banknote recognition systems. Banknote recognition systems should be able to recognize banknotes from each side and each direction. Since banknotes may be defaced during circulation, the designed system should have a meaningful accuracy in detecting torn or worn banknotes. The technology of banknote recognition is

used to research the visible and hidden banknote characters, identify all-around features and dispose off the process on time. The original information of the banknotes might be distorted due to age and worn out and also damaged by human being in its circulation. There are approximately 50 currencies all over the world, with each of them looking totally different. For instance the size of the notes is different, the color and the pattern. It is very difficult for people who work in foreign exchange area to distinguish banknotes of different countries. Also notes become older than coins and also possibility of joining broken notes is greater than that of coins [11].

STEPS OF BANKNOTE RECOGNITION

1. Image Acquisition

There are various ways to acquire image such as with the help of camera or scanner. Acquired image should retain all the features. For this research an industrial camera used for print inspection. The final images have 400x 400 pixels.

2. Gray Scale Conversion

Image acquired in step ***1*** is too large to process and colour information is not needed, except the colour index. First, RGB image is converted to pixel values and then to gray scale picture with a resolution of about 660 dpi were made.

3. Wavelet Transform tool

It is the fundamental tool in image processing. Wavelet Transform tool were used to extract features from images. The data attribute information:

- Variance of Wavelet Transformed image (continuous)
- Skewness of Wavelet Transformed image (continuous)
- Curtosis of Wavelet Transformed image (continuous)
- Entropy of image (continuous)
- Class (integer)

4. Image Segmentation

It subdivide the image into its constituent regions. For monochrome images, there are two basic properties of image intensity values. Similarly, in which image is partitioned into regions that are similar according to some predefined criteria. Other than that is discontinuity, in which image is partitioned based on abrupt changes in intensity for example; edges.

5. Classifier

The input of the classifier will be; the test banknote images and the three parts of output for the classifier: i) The country that is using the banknote; ii) The denomination of the input banknote image; iii) The front or back side of the banknote. Artificial Neural can be used for training classifier.

6. Output

Output should be analyzed for possibilities of false rejection and false classification. By minimizing these two, it provides efficiency to the system. Output can be processed usingGUI (Graphical user interface) of MATLAB application.

2.3 FLOW OF TRAINING ALGORITHM FOR MLPNETWOR ARCHITECTURE

3.0 Summarizing the procedure of training algorithms for multilayer perceptron networks process [12]. The practical work to calculate the algorithm can be done using *nntool* toolbox. *Nntool is* used to open Network or Data Manager which allow the researcher to import, create, use and export neural network and data. Below is the flow of using *nntool* toolbox:

4.0 ***1. Collect data***

5.0 The data were extracted from images that were taken from genuine and forged banknote-like specimens. For digitization, an industrial camera was used for print inspection. The final images have 400x 400 pixels. Due to the object lens and distance to the investigated object gray-scale pictures with a resolution of about 660 dpi were gained. Wavelet Transform tool were used to extract features from images. The data attributes information is variance, skewness, curtosis, entropy and class. The source of data for the research study is from the UCI Machine Learning Repository database which the Center of Machine Learning and Intelligent System [6].

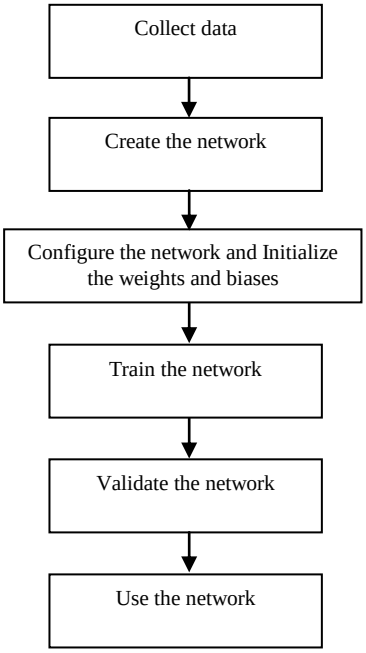

Figure 2: Flow diagram of training algorithms for MLP network architecture

2. Create the network

Open neural network toolbox by typing *nntool* to open up Neural Network/Data Manager GUI. There are two ways of accessing input/target data using *nntool* which is via Import and via New Data.

3. Configure the network and Initialize the weights and biases

The structure of the network is first defined. In the network, activation functions are chosen and the network parameters, weights and biases, are initialized. Assign all the parameters of network name, input data, target data, training function, properties, transfer functions and etc. to create appropriate Neural Network 'net'.

The default algorithm of command is Levenberg-Marquardt, *trainlm.* Default parameter values for the algorithms are assumed and are hidden from the user. They were not adjusted in the first trials. Initial values of the parameters were automatically generated by the command. It has been observed that their generation was in random and therefore the answer might be different if the algorithm is repeated.

4. Train the network

Parameters associated with the training algorithm like error goal, maximum number of epochs (iterations), etc, are defined. Then, the training algorithm is called. In this process, the author decided to use 90% data for training, 5% for testing and 5% for validation.

5. Validate the network

Neural network Training GUI will appear. The performance, Training set and Regression at plots panel can be generated.

6. Use the network

After the neural network has been determined, the result is first tested by simulating the output of the neural network with the measured input data. This is compared with the measured outputs. Final validation must be carried out with independent data.

6.0 CONCLUSION

The author described the background of the project which is about "Banknote Authentication using Artificial Neural

Training Algorithms		Comments
traingd	Gradient Descent (GD)	Original but slowest
traingdm	GD with momentum	Faster than traingd
traingda	GD with adaptive α	Faster than traingd, but can use for batch mode only.
traingdx	GD with adaptive α and with momentum	
trainrp	Resilient Backpropagation	Fast convergence
traincgf	Fletcher-Reeves Update	Conjugate Gradient Algorithms with fast convergence
traincgp	Polak-Ribiére Update	
traincgb	Powell-Beale Restarts	
trainscg	Scaled Conjugate Gradient	
trainbfg	BFGS algorithm	Quasi-Newton Algorithms with fast convergence
trainoss	One Step Secant algorithm	
trainlm	Levenberg-Marquardt	Fastest training. Memory reduction features
trainbr	Bayesian regularization	Improve generalization capability

Figure 3 [8]: Comparison of Training Algorithm

Network". The main problem of this research is to know how to identify and classify that the banknotes are real or counterfeit. The author proposed the technique of Artificial Neural Network using back-propagation algorithm. The data were extracted from images that were taken from genuine and forged banknote-like specimens. These specimens' data was provided from the UCI Machine Learning Repository database. Data analysed has been divided into three categories; training, testing, and validation. This data will be tested using '*nntool*' in MATLAB's GUI application to get the optimized result. The flow process of banknote recognition and flow process of back-propagation training algorithm also has been discussed in this research.

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