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Banknote Classification Using Artificial Neural Network Approach

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Abstract: In this study, clustering process has been performed using artificial neural network (ANN) approach on the pictures belonging to our dataset to determine if the banknotes are genuine or counterfeit. Four input parameters, one hidden layer with 10 neurons and one output has been used for the ANN. All of these parameters were real-valued continuous. 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. Four input parameters are processed in the hidden layer with 10 neurons and the output realizes the clustering process. The classification process of 1372 unit data by using ANN approach is sure to be a success as much as the actual data set. The regression results of the clustering process is considerably well. It is determined that the training regression is 0,99914, testing regression is 0,99786 and the validation regression is 0,9953, respectively. Based on the results obtained, it is seen that classification process using ANN is capable of achieving outstanding success.

Keywords: *ANN, Banknote, Classification, Machine Learning Database*

1. Introduction

Image processing is changing the image and the features of a photo, which is converted form real life image to a digital image, and creating a new photo. Due to the conversion of the photo from analog media to digital media, the photo contains noise. Image processing can be used to remove the noise from the photo. In this study clustering process has been performed using ANN[1]. It is possible to detect the counterfeit money using banknote classification. For banknote classification process (BC), classification is realized according to banknote authentication data set which can be found in UCI Machine Learning Repository (center for Machine Learning and Intelligent Systems)[2]. In this study, our purpose is to perform the classification process according to the information that belongs to our data set using a data mining method, ANN.

2. Proposed Methodology

In this study, the data from banknote authentication data set is used which can be found in UCI Machine Learning Repository (center for Machine Learning and Intelligent Systems). With the given data, the variance of Wavelet Transformed image (V) {-7,04 6,82}, skewness of Wavelet Transformed image (S){-13,77 12,95}, curtosis of Wavelet Transformed image (C) {-5,28 17,92} , entropy of image (E) {-8,54 2,44}, the banknote classification has been realized using ANN.

Neural Network Toolbox of Matlab R2013b has been used for this study.

2.1. Artificial Neural Network:

ANN is a system which is modelled as an inspiration of biological neural network but with a simpler structure. The main feature of these systems is that they have fully parallel, adaptive, learning and parallel distributed memories[3][4].

ANN is composed of processor components connected with neurons. Generally, it consists of three layers, i.e. an input layer, one or more hidden layers and an output layer. Each layer has a certain number of components attached to one another called neurons or nodes. Each neuron in the input layer is connected to each neuron in the intermediate(hidden) layer. Also, each neuron in the hidden layer is connected to each neuron in the output layer. Each of the neurons is connected to the other with weights and accompanying communication networks. ANN is trained with sample data to learn the relationship between inputs and outputs. The process of learning and training is performed by varying weight values of the connections between neurons[5][6]. Signals move through neurons over weights. Each neuron receives multiple inputs from other neurons depending on their weights and generates an output signal that may also be generated by other neurons[7][8][9]. In our system, randomly chosen 206 data has been used as testing data, randomly chosen 206 data from the remaining data has been used as validation data and the remaining 960 data has been used as training data.

The ANN model which forms our system is shown below, in Fig. 1 and as it is shown in the figure, our neural network consists of total 5 inputs as of 4 + 1 inputs, one hidden layer of 10 neurons and one output.

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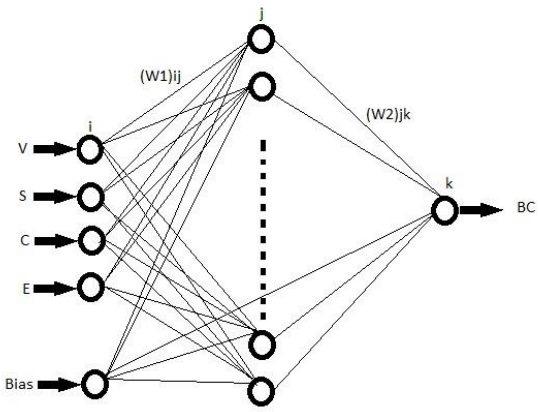

Figure 1. The structure of ANN

B. Artificial Neural Network Application For A Data Set

In this study, the following transactions are performed for determining if the banknotes are counterfeit or not using the data set of 1,372 units of banknote samples.

- As testing data, 206 units (15%) of data have been chosen randomly.
- As validation data, 206 units (15%) of data have been chosen randomly.
- As training data, the remaining 960 units (70%) of data have been chosen.

In this study, a feed forward network structure that contains an input layer, a hidden layer and an output layer (Fig. 1) was used. After the ANN structure was designed, the data obtained in the experimental study were normalized in the 0-1 value set using Eq. 1 in order to improve the characteristics of the training. The Back Propagation algorithm was used in the training procedure. Different transfer functions (Purelin, Tansig, Logsig etc.) were used and tried in the neurons in the hidden and output layers and (Tansig) was selected as the transfer function that yielded the best result.

$$x_{norm} = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \qquad (1)$$

The training data set was used to determine ANN neuron and bias weight values. Training was repeated to obtain the lowest level of error by changing the number of neurons and the epoch number. Then, the trained algorithm was applied on the test data set.

The network has been trained by giving different values trough the hidden layer and the results have been observed. It has been seen that better results were obtained using a network with a hidden layer of 10 neurons.

At the end of these procedures, the network structure that yielded the best classification is given in Table 1.

Table 1. The parameters and properties used in ANN

Parameters	Properties
Number of neurons in the input layer	4
Number of the hidden layers	1
Number of neurons in the hidden layer	10
Number of neurons in the output layer	1
Learning rate (α)	0,4
Coefficient of momentum (β)	0,3
Learning algorithm	Gradient descent (traingd)
Transfer function	Logarithmic sigmoid (logsig)

The regression graph of the training data set is shown in Figure.2.

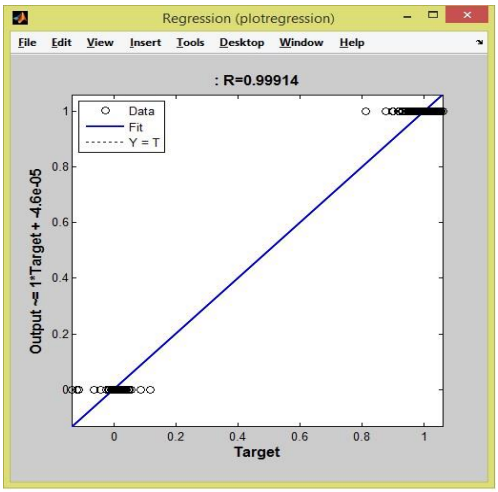

Figure 2. Regression of Training Data Set

The regression graph of the testing data set is shown in Figure.3.

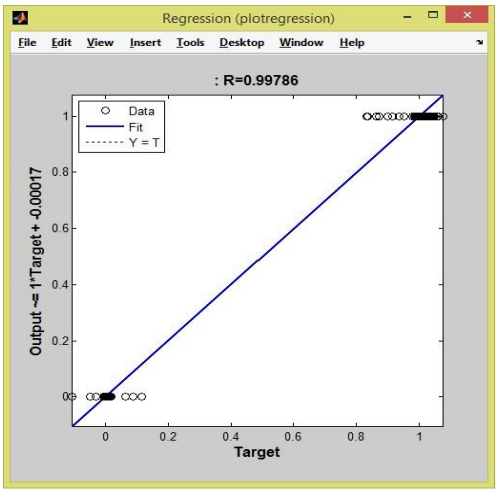

Figure 3. Regression of Training Data Set

The regression graph of the validation data set is shown in Fig. 4.

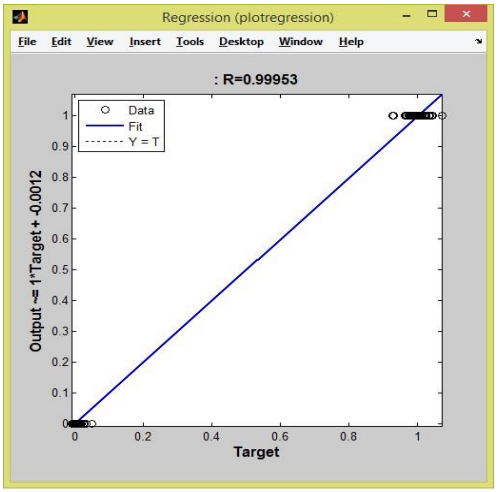

Figure 4. Regression of Training Data Set

The regression graph of the output is shown in Figure 5.

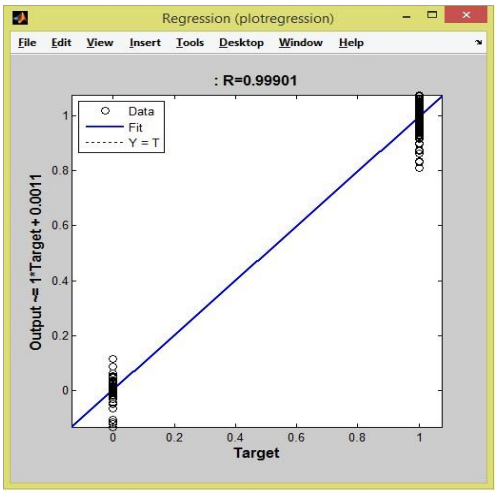

Figure 5. Regression of Output Set

3. Result and Discussion

The comparison of experimental measurement values for BC test data set and ANN estimation values are shown in Figure.6. All the randomly selected data used for test is different than the data used for training process.

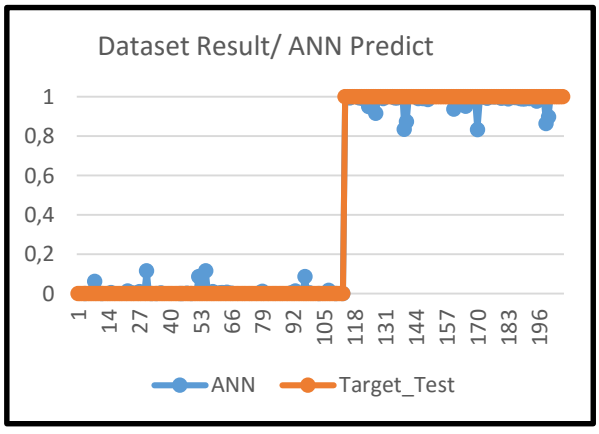

Figure 6. Data Set Result / ANN Predict

The comparison of experimental measurement values for BC validation data set and ANN estimation values are shown in Figure.7. All the randomly selected data used for validation is different than the data used for training process.

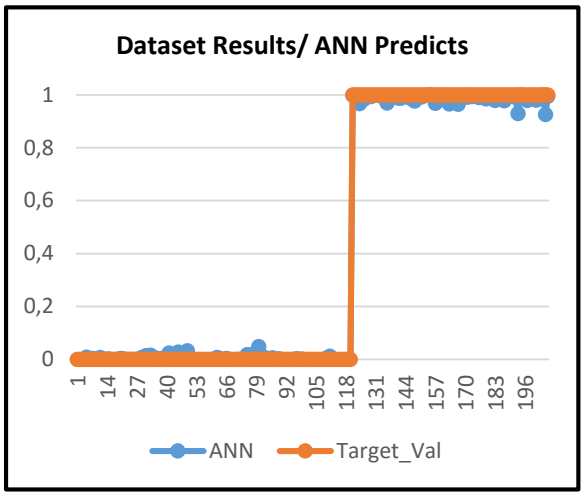

Figure 7. Validation Result / ANN Predict

Finally, the graph of the values obtained from the remaining data which is the estimation of ANN is shown in Figure.8.

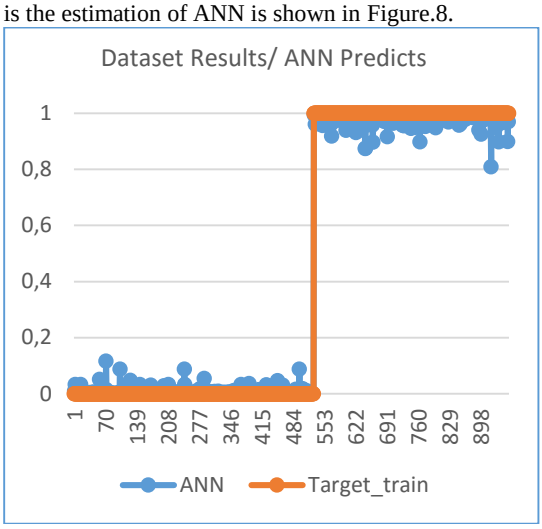

Figure 8. Train Result / ANN Predict

As seen in the figures, the estimation results and dataset results are almost overlapping. The deviation between experimental and estimated results is very small and negligible for any BC performance.

4. Conclusions

In this study, it has been concluded that ANN can be used in the clustering procedure and better results can be achieved. According to the results, it has been observed that 99% and above classification accuracy can be achieved

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