Different Wheat Species Classifier Application of ANN and ELM

Muhammet Fatih Aslan, Kadir Sabancı
Department of Electrical and Electronics Engineering, Karamanoglu Mehmetbey University, Karaman, Turkey
mfatihaslan@kmu.edu.tr
kadirsabanci@kmu.edu.tr

Akif Durdu
Department of Electrical and Electronics Engineering Selcuk University
Konya, Turkey
durdu.1@selcuk.edu.tr

***Abstract*—Wheat is the most important food source around worldwide. Classification of wheat is very important in terms of quality, health and cost. In this study, classification of three different wheat species from the UCI library was carried out. There are 70 species of each of the Kama, Rosa and Canadian species and each of them has seven features. The features are area, perimeter, compactness, length of kernel, width of kernel, asymmetry coefficient and length of kernel groove. 210 data were used for classification and 70% of them were allocated for testing and the remaining 30% were for training. Seven features were used as inputs for training and testing operations. The classification process is carried out with Artificial Neural Networks (ANN) and Extreme Learning Machines (ELM). The application was implemented using the Graphical User Interface (GUI) for easy and aesthetic use. The most accurate parameter values are determined with ELM and ANN. The average accuracy and average processing times were calculated using these parameters. As a result of ANN based classification, average training accuracy rate was calculated as 92.51%, average training time was 0.81 seconds and average test accuracy rate was 87.93%. As a result of ELM based classification, the average training accuracy rate was calculated as 95.85%, the average training time was 0.0069 seconds and the average test accuracy rate was 94.44%. High accuracy values were obtained with both algorithms. However, as seen from the values, ELM provided both faster training and higher accuracy values. It is seen that the difference between training delays is too much. For this reason, the use of ELM is more advantageous for these applications than the use of ANN.**

Keywords—Wheat classification, Artificial Neural Network (ANN), Extreme Learning Machine (ELM)

I. INTRODUCTION

Wheat is the most important food source around the worldwide. It is the basic nutrient used in the production of flour and fodder. It is one of the most basic foodstuffs for people to feed. And it is the raw material of bread and macaroni. In terms of planting area and production amount in Turkey, wheat is the most prevalent feeder [1]. On average 40% of Turkey's daily energy needs are covered by wheat products [2]. Therefore, wheat is an essential food source in terms of production and consumption. Studies on wheat are related to the quality and cost.

Computer aided systems have become available in many areas of our lives. Particularly, the usage rate of these systems is increased by recent studies on artificial intelligence. ANN algorithm, a sub-science of artificial intelligence, is becoming popular in many different fields of agriculture. ANN is used to estimate such values as field crop yield, biomass production, seeding dates, amount of soil moisture and organic matter content in the soil [3]. The use of computers in the agricultural sector provides great advantages in classification, seed analysis, production and quality determination. In conventional farming, these tasks are very time consuming. In addition, each of these activities is carried out visually by experts. Computer Vision technology is also used for quality control of corn seed to achieve accurate and rapid inspection performance [4].

Many works have been done to classify agricultural products automatically by computer. In the study conducted by M. Punn and N. Bhalla, wheat classification was performed using two machine learning algorithms, Support Vector Machine (SVM) and Artificial Neural Network (ANN). For classification, images of wheat grains were captured using a digital camera and thresholding was performed. After this step, geometrical properties such as area, environment, volume etc. of each wheat are extracted and machine learning algorithms are applied. As a result of the application, the accuracy value of Support Vector Machine was calculated as 86.8% and the accuracy value of artificial neural network was calculated as 94.5% [5]. The proposed system in the application of N. A. Abdullah and A. M. Quteishat aims to classify three different wheat seeds into related classes. Multilayer Artificial Neural Networks was used for classification in the proposed system. Properties given as input to ANN system were area, minor axis length, main axis length, equivalent diameter, environment and entropy. Experimental results indicate that the classification system is able to classify wheat seeds with a test accuracy of approximately 95% [6]. In study by Yasar et al., the types of wheat seeds were classified by using artificial neural network (ANN). In the ANN system, 7 inputs, a hidden layer with 10 neurons and an output were used. Kama, Rosa and Canadian, which are wheat varieties characterized by geometrical properties obtained by X-ray technique, were analyzed. The obtained properties are area, environment, core length, asymmetry coefficient, compactness. Regression of 210 data with ANN was performed. As a result, the train result is calculated as 99.99% and the test result is calculated as 99.78% [7]. In Abbas M.'s master thesis, some quality criteria of CUMHURİYET-75 bread wheat variety; broken beans, weeds (wild mustard and wild oats), and other cereals (corn and barley) were determined using image processing and artificial neural network (ANN) techniques using the computer program. Grain morphology, texture and color were taken into consideration in determining the quality of wheat samples. For texture properties, contrast, homogeneity, correlation, energy and entropy were calculated. For color properties, mean values, variance, standard deviation, skewness and kurtosis values of images are extracted in RGB (Red, Green, Blue), NTSC and l * a * b * color spaces. At the end of the thesis, the overall success rate of determination of wheat quality was calculated as 97% [8]. In the study conducted by A. Khoshroo et al., the classification of four Iranian wheat species was carried out by extracting morphological features. Artificial neural networks were used in this study. From each grain image, ten morphological features were extracted using image processing methods. For the classification of wheat varieties, nine important morphological features obtained from the images were used as input for ANN. Using the values that provide the best ANN value, wheat varieties were classified and a general classification accuracy of 85.72% was obtained [9]. In a study by Maged Wafy et al., a study was conducted to automatically identify seed species by computer. In this study, SIFT (Scale-Invariant Feature Transform) algorithm was used to identify three types of grass seeds (Coronopus didymus (L.) Sm., Lolium multiflorum Lam. and Chenopodium ambrosioides L.) mixed with wheat seed samples. The accuracy rates for the detection of weed seeds were 90.5%, 89.2% and 95.3%, respectively [10]. In the practice of Arefi et al., the identification of four common weed seeds (common vetch, cleavers, cornflower and great bur-parsley) commonly found on farms in western and northern western Iran were performed using digital image analysis. The identification of the seeds was made by utilizing the characteristics such as color (RGB and HSV) and morphology. According to the results, the total classification accuracy was calculated as 98.40% [11]. Finally, Alireza Bagheri, Yaser Nikparast mentioned the significance of computer-based seed identification in the revision study and the various studies made in this subject. He described the use of morphological features such as shape, size, color, and texture in defining seeds for artificial learning, and also discussed approaches used for seed identification [12].

Classification of different seed-varieties is usually done according to morphological characteristics and colors [13]. In this study, classification of three different wheats from UCI library [14] was carried out using morphological features. Kama, Rosa and Canadian species have seven geometric features and there are 70 samples of each type of wheat. The features are area, perimeter, compactness, length of kernel, width of kernel, asymmetry coefficient and length of kernel groove. These features are given as input to ANN and ELM. The accuracy values and the processing times obtained from both algorithms are compared. According to the comparison, performance evaluations of the ANN and ELM were done.

II. Materials and Method

A. *Graphical User Interface(GUI)*

Some software development tools are designed for the analysis and solution of technical calculations and mathematical problems. GUI is an interface that allows the user to interact with the program by using visual objects (button, edit text, static text, etc.). In this study, the accuracy values of ANN and ELM were obtained using a GUI interface and graphically plotted. In Fig. 1, the prepared GUI interface is shown.

Fig. 1. *Designed GUI interface.*

B. *Artificial Neural Network(ANN)*

Artificial neural networks are a sub-science of artificial intelligence. Artificial intelligence studies are trying to imitate the brain's work. As a result, the knowledge process of the human brain is imitated and the concept of ANN is revealed. In ANN, the processing of information is carried out through neurons. The neurons are connected to each other through weighted connections. Input values given to ANN are multiplied first by weights, then summed. These values are then processed by the activation function in the hidden layers. This process continues in this way and the information is processed. The ANN performs learning by considering target values during information processing. So the network becomes trained. This trained network is then tested using different input values.

ANN consists of artificial neural network cells as shown in Fig 2. Each circle represents a cell. ANN basically consists of an input layer, a hidden layer, and an output layer. For each property, a cell must be placed in the input layer. The number of neurons in the input layer must be equal to the number of each different input sample available, and the input data is applied directly to the input layer. This data is then passed to the output layer through operations such as addition, multiplication and activation function. Finally, these data are given directly to the output layer.

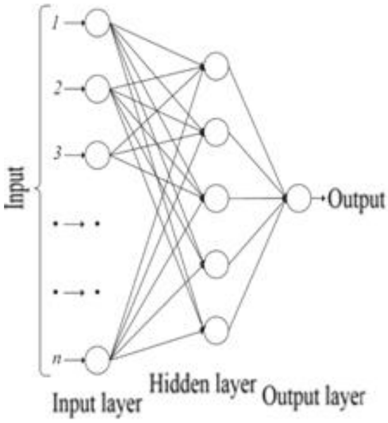

Fig. 2. *Artificial Neural Network structure.*

In this study, the properties given to the input layer were obtained from the UCI library. In this data set, there are seven geometrical features of each wheat. The features are area, perimeter, compactness, length of kernel, width of kernel, asymmetry coefficient and length of kernel groove. For training and test data, these seven features were used as input. 70% of the 210 wheat varieties were used as training and 30% as test data. The species that each wheat belongs to (Kama, Rosa and Canadian) was used as target,. More than one hidden layer can be used in ANN depending on transaction complexity. One hidden layer was used in our work. In ANN, there are parameters directly affecting the performance of the system. By changing these parameters, it is tried to create systems with least faults. These parameters are learning rate, momentum coefficient, hidden layer neuron number, epoch number. In our study, the range of these values was entered in the GUI interface and the best accuracy values were calculated. Parameter values providing the best accuracy value are recorded. Accuracy values are calculated according to these parameter values. Averages of these accuracy values were calculated and average accuracy values were obtained. The same process was repeated for the training time and the average training time was calculated.

C. Extreme Learning Machines (ELM)

In this study, Extreme Learning Machine (ELM) method which is one of the supervised learning methods was used to classify wheat. ELM method introduced by Huang et al [15].

ELM method is used in classification and regression processes. This method is offered as an alternative because of the slow performance of traditional learning methods. Training of the network is done iteratively in the traditional feed-forward ANN structure. However, this process has been converted to an analytical equation in ELM. Therefore, it provides a great advantage over other methods in terms of time in train and test operations. Moreover, it does not have limitations like learning rate, local minimum, moment coefficient, as in artificial neural networks. It has advantages over other methods in terms of fastness and high accuracy.

ELM actually has an Artificial Neural Network (ANN) network structure with a single hidden layer (see Fig. 3). Weights and thresholds are assigned randomly, as in ANN. These weights are not changed afterwards. Operations are performed according to the initial weights and threshold values. In this study, Extreme Learning Machine (ELM) method which is one of the supervised learning methods was used to classify wheat. ELM method introduced by Huang et al [15].

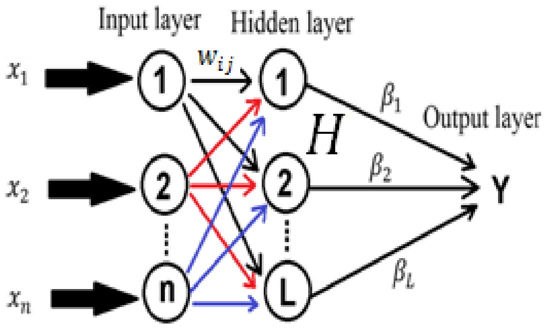

Fig. 3. *Extreme Learning Machine structure.*

In ELM, input data is directly given to the input layer. This data is then processed in neurons using algebraic operations and activation function. For the target data (Y), the target values are directly given to the output layer. Since the weights are also randomly assigned, the main purpose here is to find the Beta coefficient (see Fig. 3). Beta coefficients are generated during the train phase and then the same coefficient is used during the test phase. Moore-Penrose generalized inverse matrix [15] is used to find beta coefficients (see Equation (1)). In this case, the inverse matrix is not taken and the processing time is shortened. H, which is shown in Equation (1), is the hidden layer output matrix. As a result of obtaining the beta coefficients, the network becomes trained.

$$\beta = H^{\dagger}Y \quad (1)$$

As in ANN, the parameter value that provides the highest accuracy value for ELM is found. However, since ELM does not have learning rate, momentum coefficient, etc., only the number of neurons in the hidden layer is changed as a parameter. The number of neurons providing the highest accuracy value was determined. Using this parameter, ELM accuracy values and training times are calculated. Then, as in ANN, the average of these values was found.

III. Result and Discussion

In this study, classification of three different wheat species from the UCI library was carried out. There are 70 species of each of the Kama, Rosa and Canadian species and each has seven features. The features of seed used are area, perimeter, compactness, length of kernel, width of kernel, asymmetry coefficient and length of kernel groove. 210 data were used for classification and 70% of the data were allocated for testing and 30% were for training. Seven features were used as input for training and testing operations. The classification process is carried out with Artificial Neural Networks (ANN) and Extreme Learning Machines (ELM). The application was completed using the GUI in the computer program (see Fig 4). In ELM and ANN, parameter values providing the most accurate values are determined. For ANN, the number of hidden layer neurons was 4, the number of iterations was 1200, the learning rate was 0.4, and the momentum coefficient was 0.5. In ELM, the number of hidden layer neurons is 600. Accuracy values and training times were calculated using these parameter values (see Table 1). Subsequently, using these values, average training times and average accuracy ratios were calculated.

The prepared GUI interface and result values are shown in Fig. 4.

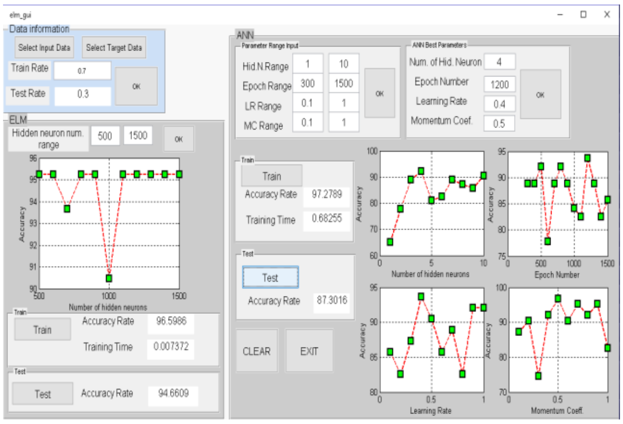

Fig. 4. *Designed GUI and accuracy values*

More than one hidden layer can be used in ANN depending on transaction complexity. However, one hidden layer was used in this study. As can be seen in Fig. 4, the graphs of the accuracy values obtained after changing the ANN parameters are given below.

Fig. 5,6,7,8 graphically show the accuracy values obtained by changing these values within a certain range for ANN.

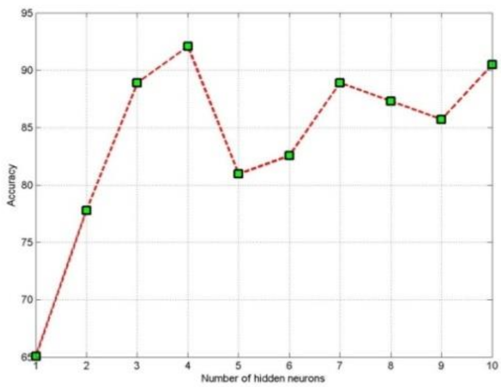

Fig. 5. *Accuracy rate according to number of hidden neurons*

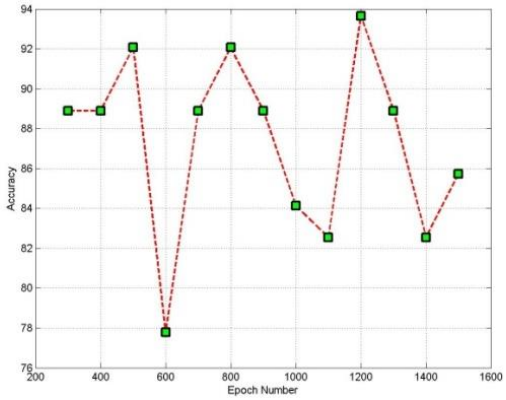

Fig. 6. *Accuracy rate according to epoch number*

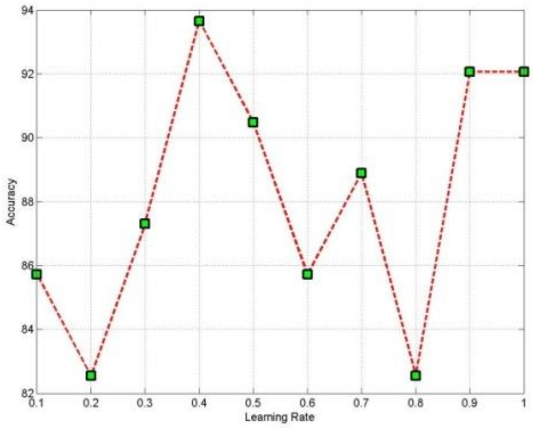

Fig. 7. *Accuracy rate according to learning rate*

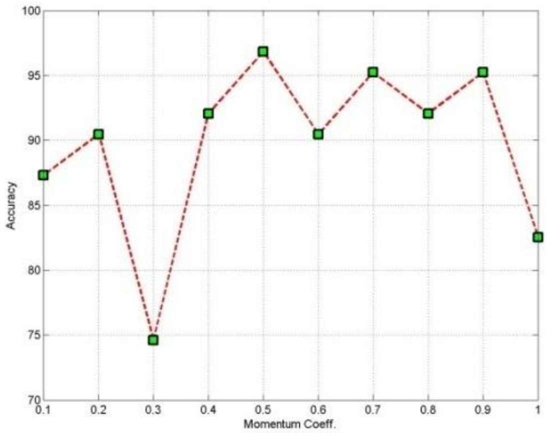

Fig. 8. *Accuracy rate according to momentum coefficient*

In the ELM method, there are no parameter limitations as in ANN. Because ELM is not a method based on iteration. Beta values are calculated directly, without iteration. The number of hidden neurons is the factor that affects performance in the ELM method. The accuracy graph obtained by changing the number of hidden neurons within a certain range is shown in Fig. 9.

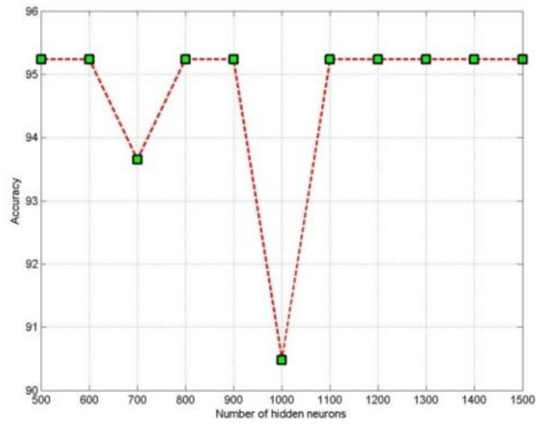

Fig. 9. *Accuracy values according to number of hidden neurons for ELM*

The average accuracy rates calculated using the specified parameter values are given in the Table 1 below.

TABLE I. COMPARISON OF ANN, ELM AND AVERAGE ACCURACY RATES

ANN			ELM		
Train(%)	**Time(sec)**	**Test(%)**	**Train(%)**	**Time(sec)**	**Test(%)**
97.28	0.68	87.30	95.92	0.0062	93.65
89.79	2.00	88.89	95.24	0.0089	95.24
80.27	0.25	82.54	95.92	0.0066	95.24
91.15	1.02	96.82	96.60	0.0060	92.06
95.24	0.50	74.60	96.60	0.0072	95.24
93.20	0.26	87.30	95.92	0.0075	95.24
96.60	0.32	92.06	95.24	0.0070	92.06
96.60	0.99	92.06	96.60	0.0062	95.24
87.75	1.88	87.30	95.24	0.0061	95.24
97.28	0.24	90.47	95.24	0.0069	95.24
92.51	**0.81**	**87.93**	**95.85**	**0.0069**	**94.44**

IV. CONCLUSION

As a result of classification with ANN, average training accuracy rate was calculated as 92.51%, average training time was 0.81 seconds and average test accuracy rate was 87.93%. As a result of the ELM classification, the average training accuracy rate was calculated as 95.85%, the average training time was 0.0069 seconds and the average test accuracy rate was 94.44%. High accuracy values were obtained with both algorithms. However, as seen from the values, ELM provided both faster training and higher accuracy values. It is seen that the difference between training delays is too much. For this reason, the use of ELM is more advantageous for applications with more data.

REFERENCES

[1] A. Taner, A. Tekgüler and H. Sauk, "Classification of durum wheat varieties by artificial neural networks," Anadolu Journal of Agricultural Sciences, vol. 30(1). pp. 51-59, 2015.

[2] Anonymous, [Online]. Available: http://www.fao.org, 2008.

[3] S. Ghamari, A. M. Borghei, H. Rabbani, J. Khazaei and F. Basati, "Modeling the terminal velocity of agricultural seeds with artificial neural networks," African Journal of Agricultural Research, vol. 5(5). pp. 389-398, 2010.

[4] K. Kiratiratanapruk, W. Sinthupinyo, "Color and texture for corn seed classification by machine vision," International Symposium on Intelligent Signal, Processing & Communication Systems (ISPACS), pp.1-5, 2011.

[5] M. Punn, N.Bhalla, "Classification of wheat grains using machine algorithms," International Journal of Science and Research (IJSR), vol. 2(8). pp. 363-366, 2013.

[6] N. A. Abdullah, A. M. Quteishat, "Wheat seeds classification using multi-layer perceptron artificial neural network," vol. 6(2). pp. 306-309, 2015.

[7] A. Yasar, E. Kaya and I. Saritas, "Classification of Wheat Types by Artificial Neural Network," International Journal of Intelligent Systems and Applications in Engineering, vol. 4(1). pp. 12-15, 2016.

[8] A. Masoumi, "Determination of some feautures based on quality of bread wheat with image processing technique," Ege University, Graduate Thesis, 2013.

[9] A. Khoshroo, A. Arefi, A. Masoumiasl and G.H. Jowkar, "Classification of wheat cultivars using image processing and artificial neural networks," Agricultural Communications, vol. 2(1). pp. 17-22, 2014.

[10] M. Wafy, H. Ibrahim and E. Kamel "Identification of weed seeds species in mixed sample with wheat grains using sift algorithm," 9th International Computer Engineering Conference, pp. 11-14, 2013.

[11] A. Arefi, A. M. Motlagh and A. Khoshroo "Recognition of weed seed species by image processing," Journal of Food, Agriculture and Environment, vol. 9(1). pp. 379-383, 2011.

[12] A. Bagheri, Y. Nikparast, "Seed identification by artificial vision: a review," Biological, Environmental and Agricultural Sciences, vol. 1(1). pp. 28-32, 2017.

[13] P. Zapotoczny, M. Zielinska and Z. Nita, "Application of image analysis for the varietal classification of barley:: morphological features," Journal of Cereal Science, vol. 48(1). pp. 104-110, 2008.

[14] UCI Machine Learning Repository, [Online]. Available: https://archive.ics.uci.edu/ml/datasets.html

[15] G. B. Huang, Q. Y. Zhu and C. K. Siew, Extreme Learning Machine: a new learning scheme of feedforward neural networks, IEEE International Joint Conference on Neural Networks," vol 2. pp. 985-990, 2006.