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Classification of Wheat Kernels Types Using Different Artificial Intelligent Algorithms and Geometrical Features

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Abstract:

The aim of prepare this paper is to provide classification methods that have ability to distinguish seed types named Canadian, Rose, and Kama from each other according to their geometrical features. We implement intelligent system algorithms in order to separation wheat kernels types. Kernels dataset picked up from UCI machine learning database. The number of geometrical features is seven (area , perimeter , compactness, length of kernel, width of kernel, asymmetry coefficient , length of kernel groove). Wheat is classified by applying three algorithms firstly classified using fuzzy logic secondly using neural network with back propagation network thirdly using neuro-fuzzy network . Three different ratios of training/testing groups which are (50% to 50%, 30% to 70%, and 10%to 90%) are applied to the classifiers. The higher system's accuracy that we are get on it is 100% for training and in testing is 89.03% in fuzzy logic classifier while in neural network with resilient back-propagation(Rprop) algorithm we get on 100% in training, and 99.04% in testing, in neuro-fuzzy (NF) classifier we get on 96.19% in training and 94.28 % in testing. The system achieved using Matlab environment.

Keywords: Wheat Kernels, Geometrical features, fuzzy logic, neural network, Neuro-fuzzy.

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تصنيف بذور نبات الحنطة باستخدام انواع مختلفة من خوارزميات الذكاء الاصطناعي والخصائص الهندسية

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الخلاصة:

في هذا البحث وضفت انواع من خوارزميات الذكاء الاصطناعي من اجل بناء مصنفات ذكية لها القدرة على فصل وتصنيف ثلاثة انواع من بذور نبات الحنطة الواحدة عن الاخرى بالاعتماد على الخصائص الهندسية لتلك البذور. قاعدة البيانات التي تضمنت خصائص الانواع الثلاث اختيرت من UCI. عدد الخصائص الهندسية في قاعدة البيانات هذه هو سبع خصائص تتضمن (المساحة، الحدود الخارجية، الاكتناز، طول البذرة، عرض البذرة، معامل اللاتماثل، طول الاخدود للبذرة). بذور الحنطة صنفت بتطبيق خوارزمية المنطق المضبب اولا وبالشبكة العصبية ذات الارتداد العكسي ثانيا وبالشبكة العصبية المضببة ذات الارتداد العكسي ثالثاً. قاعدة البيانات التي تحوي الخصائص قسمت الى ثلاث مجاميع تدريب/اختبار وكانت بالنسب (٥٠%-٥٠% ، ٣٠%-٧٠%، ١٠%-٩٠%). نسب التمييز المستحصلة من تطبيق هذه المصنفات الثلاث كانت في مصنف المنطق المضبب بمقدار ٨٩,٠٣% في مجموعة الاختبار و ١٠٠% في مجموعة التدريب وبلغت نسب التمييز في مصنف الشبكة العصبية ٩٩,٠٤% في مجموعة الاختبار و ١٠٠% في مجموعة التدريب اما في المصنف الثالث (الشبكة العصبية المضببة) فقد بلغت نسب التمييز ٩٤,٢٨% في مجموعة الاختبار و ٩٦,١٦% في مجموعة التدريب لهذا المصنف. نظام التصنيف هذا انجز باستخدام بيئة ماتلاب.

1. Introduction:

Wheat is a commercial crop grown in over 120 countries worldwide and the world production accounts for 624.4 Mt (million tonnes) [1].Computer-aided quality controlling system is used in various applications on of this used to determine the excellence of wheat kernels [2].

X-ray technique is used to measure of main grain geometric features characterize all three type of wheat Kama, Rosa and Canadian[3]. The images were recorded on 13x18 cm X-ray KODAK plates. Studies were conducted using combine harvested wheat grain originating from experimental fields, explored at the Institute of Agrophysics of the Polish Academy of Sciences in Lublin[4]

In machine learning and statistics, Classification can be defined as the problem of detecting to which of a set of categories (sub-population) a new observation be appropriate, on the basis of a training set of data holding observations (or examples) whose category membership is known [5].

Classification is also defined as one of the Data Mining techniques that are mainly used to analyze a given dataset. It is used to source prototypes that accurately define important data classes within the specified dataset. There are two-step of classification procedure.

Step 1 (training): The model is generated by applying classification algorithm on training data set.
Step 2 (testing): The extracted model is tested against a predefined test dataset to measure the model trained performance and accuracy.

So we can say the classification is the process to allocate class label from dataset whose class label is unidentified [6].
The paper arrangement is as follows: the dataset description of the wheat kernels In section 2, briefly preliminaries is introduced for Neural Network with back propagation, fuzzy logic and neuro fuzzy network in Section 3. In section 4 the method steps of wheat classification is explained. Results and discussion in section 5, finally section 6 contain conclusions.

2. Description of the Wheat Kernels Dataset

The dataset of wheat kernels consist of 210 instances. Each instance has seven attributes plus the class attribute. All samples have seven features. These are: (areaz , perimeterz , compactnessz, kernel's length, kernel's width, asymmetryz coefficient' , kernel' groove's length).

All attributes are continuous. The inspected set included kernels fitting to three variety types of wheat: Kama', Rosa' and Canadian', for the experimentation 70 elements are randomly selected. a soft X-ray technique is used to perceived high quality imagining of the internal kernel construction. It is non- harsh and considerably inexpensive than other more advanced imaging techniques similar to scanning microscopy or laser technology. Plates with size 13x18 cm X-ray KODAK are used to recorded images on it. Studies were accompanied using association harvested wheat grain patenting from trial fields, explored at the Institute of Agrophysics of the Polish Academy of Sciences in Lublin[4].

In order to build the dataset, seven formal limitations of wheat kernels were limited:

1. The kernel's area (A).
2. The kernel's perimeter (P) .
3. The kernel's compactness C

, $$C = \frac{4 * pi * A}{P \text{ ^ } 2}$$

4. Kernel's length.
5. Kernel width .
6. Asymmetry coefficients
7. Kernel groove's length.

Wholly of these factors were real-valued continuous.

3. Preliminaries

3.1 Fuzzy logic:

Fuzzy rule-based systems (FRBSs) are well famous in soft computing techniques, which is centered on fuzzy concepts to deal with complex real-world problems. They have become a powerful system to deal with many problems for example imprecision, uncertainty, and non-linearity. They are usually used for regression tasks, classification, and identification. FRBSs also have been used in a number of science and engineering areas, e.g., in bioinformatics, control engineering, data mining, robotics, finance, and pattern recognition. Moreover, because of their effectiveness in real-world applications, their uses are growing powerfully after they were verified to be general approximators of continuous functions. FRBSs are also known as fuzzy inference systems or simply fuzzy systems. When applied to precise tasks, they also may obtain explicit names such as fuzzy associative memories or fuzzy controllers. They are based on the fuzzy set theory, proposed by Zadeh (1965), which objects at signifying the information of human experts in a set of fuzzy IF-THEN rules. Fuzzy rules use fuzzy sets, instead of using crisp sets as in classical rules. Rules were firstly derived from

human experts through knowledge engineering processes. However, this approach may not be practical when human experts are not existing or when facing complex tasks [7].

3.2 Neural Network with back propagation

In artificial intelligence any computational model that is based on it is work on way similar to Biological Neural Network such this model called Artificial Neural Network (ANN). ANN is often shortly named as Neural Network (NN). Artificial neurons which are also called nodes strongly interconnected in order to form artificial neural network. If we want to execute a specific computation we must build the construction of NN in good manner to get on correct results. A number of neurons are organized to receipts inputs from external environment. These are not the connection among neurons with each other is not required, so the organization of these neurons will be in a layer shape, known as Input layer. After perform some computation on the input data to the neurons in input layer this neuron are making some output, which is used as input data to next layer. The building of NN can be of only one (single) layer or many layer (multilayer). The construction of Neural network with single layer, there is only one layer for input and one layer for output, while in the multilayer neural network hidden layer can be one or more [8].

The most communal type of ANN used in classification is the MLP (multi-layer perceptron) networks based on the BP (back-propagation) learning algorithm .This kind of network is named BPNN (back propagation neural network)[9]. The error-correction learning rule is the principle of the back propagation algorithm which is based on using the error function in order to adjust the connection weights to progressively reduce the error. To simplify, this error is the variance between tangible network output and the wanted output. Therefore, the BP learning algorithm is committed to the supervised learning paradigms because it requires a desired output pattern [10].

3.3 Neuro-Fuzzy system

Neuro-fuzzy (NF) systems are multi-layer feedforward adaptive networks that recognize the basic elements and task of conventional fuzzy logic systems. It is a hybrid system that combine neural network with fuzzy logic. Every intelligent part has its own characteristic and also shortcomings. For instance, although fuzzy systems have a very good logic behind their decision but cannot obtain the rules they used to make those decisions automatically and its need a human knowledge to build these rules. On the other hand, neural networks are good at recognizing the patterns of signals but not good at explaining how they reach their outcome. The above reasons are the basis principle for

hybridization where the techniques are combined together to overcome the shortcomings of the individual technique. Neuro fuzzy utilize neural network's structure and learning algorithms to learn the shape of membership functions for the fuzzy system. Neuro-fuzzy systems are used for different applications such as engineering design, medical diagnosis, financial trading, classification, etc. [11,12]

4. Method Steps of Wheat Classification

We props classification method for decisive spices of a wheat seed, the data of the seed was processed by Mtalab R2017a environment with three intelligent algorithms fuzzy logic, neural network with back propagation, and nero-fuzzy network**.** The dataset of seed was received from UCI where three classes is recorded in this data set named Canadian, Rose, and Kama and 7 attributes for each class. The separation of wheat kernels is interest because the fact that wheat kernels grow intertwined with each other and they have different economic revenues. Totally 210 samples were analyzed with 70 pieces from each of the 3 types of seed which are getting randomly. Figure1 below clear the block diagram of the classification process.

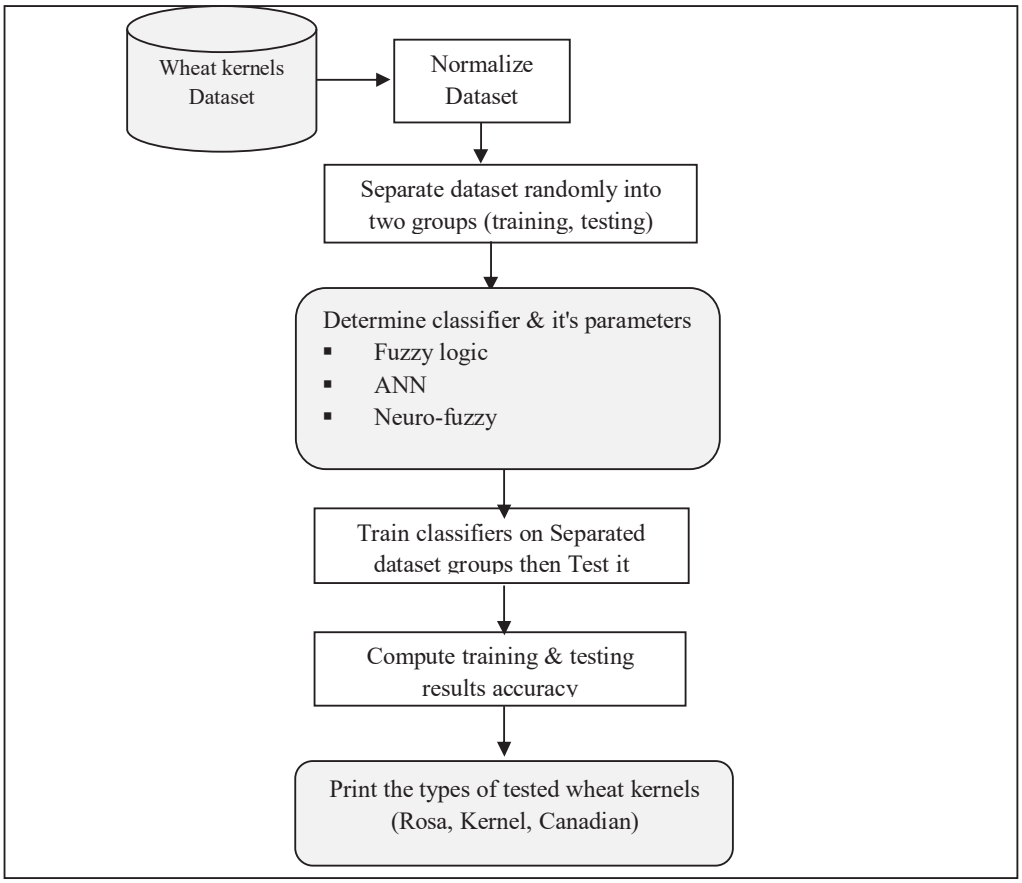

Figure1. Classification Process Diagram

4.1 Normalized dataset

Normalization is vital step in any classification processes in order to increase the training capabilities .The learning of any classifier mode will be done slowly if normalization step doesn't perform on dataset. Min-Max Normalization used in this paper normalize the Vector of features which clear in the following equation[13]:

$$y = (x_{max} - x_{min}) * (x_1 - x_{min}) / (x_{max} - x_{min}) + x_{min} \cdots\cdots (1)$$

The input features will be rescale when normalization performs on it, where this input is converting from a period of values to a new one. Frequently the period of values are commonly between [0, 1] or [-1, 1] in order to ease and increase the computations[13].

4.2 Separating Dataset into Training & Testing group

In this step the Separating process will be done randomly three times with specific ratio at each time in order to form different training/testing groups. Table1 shows the number of data that used as training and testing sets for each group.

Table1 number of data in training and testing

Group no.	Training to testing ratio	Training data	Testing data	Total data
1	10% - 90%	21	189	210
2	30% - 70%	63	147	210
3	50% - 50%	105	105	210

4.3 Determine one classifier and it's parameters

Our classification method use three type of classifiers to distinguish wheat kernels each one of them have special parameters that must be determined carefully to get on good results in classification. We clear bellow all required parameters belong to the three classifiers that give us good classification results in this paper.

1- **Fuzzy logic**: has seven input, three output, and Mamdani model will be used as reasoning system.
2- **Back-propagation neural network**: has three level input layer with seven neuron ,hidden layer with 15 neuron and output layer with three neuron, number of epochs to train is 100 epoch, the resilient back-propagation algorithm (Rprop) used to update weights and biases values of this network. Activation functions "Tansig" and" purelin" are used in hidden, output layer respectively.

3- **Nero-Fuzzy network:** NF network structure that will be used in this work is based on Takaj fuzzy inference system. NF network is composed of three layers; an input layer, hidden layer represent fuzzification and rule layer, and an output layer. Learning algorithm for a NF network will be derived base on gradient descent technique. By practicing we find that the best values for training the network when the number of fuzzy set is 7 for each input for the NF network and this is used for all groups, while there are three nodes in output layer.

4.4 Train and Test classifiers on Separated dataset groups

The groups of dataset kernels are prepared and initiated to enter the classification process. Now we will train and test all classifiers on this groups and record it's results as it's clear in following steps.

4.4.1 Train and Test the fuzzy logic classifier

When the information is vague, ambiguous, imprecise, noisy, or missing input, then fuzzy logic offers a simple approach to reach at a certain conclusion based upon this information. Furthermore, fuzzy logic imitates how a individual creates decisions and executes reasoning; however, fuzzy logic does it much faster [14, 15].

There are many types of fuzzy, the classic ones are Mamdani, Sugeno and Tsukamoto model. Mamdani model which is consider the simple and commonly used model which is applied in this paper. For easiness, as shown in figure (2) ,(3) we assume the rules in the fuzzy reasoning system of Mamdani model to know for each type this wheat features are belong. We train and test this fuzzy system on three group of dataset that we are separated it in previously steps and we found the great rate of classification we get it in this classifier was in third group of dataset (50-50 instances) where we get on accuracy 100% in training group and 89.51% in testing group.

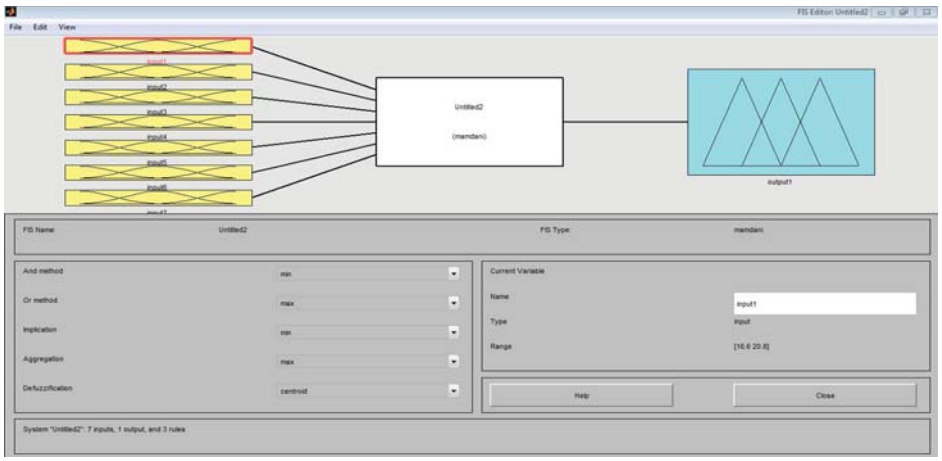

Figure2. Architecture of the fuzzy logic classifier

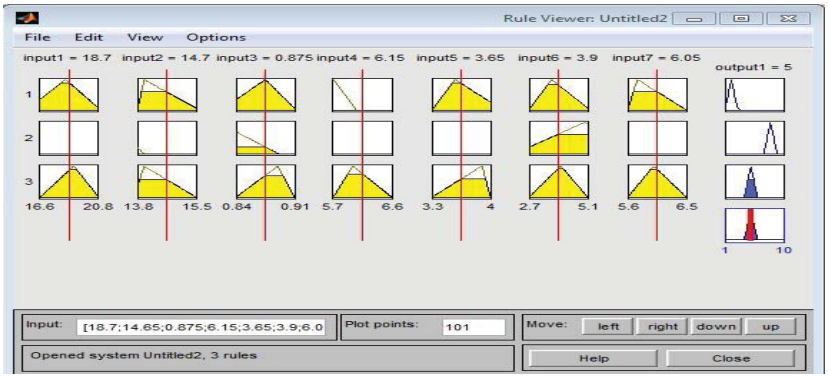

Figure3. fuzzy rule of classifier

4.4.2 Train and Test the (ANN with Rprop) classifier

We are use Resilient back-propagation (Rprop) is the finest algorithm in terms of merging speed, correctness as well as strength with respect to the training factors. The Rprop is a local adaptive learning algorithm, the simple notion is to reduce the risky effect due to the weight step size of the partial derivative. Relating to the back-propagation algorithm, the Rprop come together faster and requests a lesser amount of training [16].

The architecture of ANN with Rprop algorithm is one hidden layer are suggested in this paper to solve classification of wheat kernels as clear in figure(4) where we put 7 neurons in input layer one for each input features in the data set vector and 15 neurons in hidden layer and three neuron in output layer one for each class of wheat kernels. The network is trained with target matrix has Rows equivalent to number of information vectors of wheat kernels and columns equivalent to class number equivalent to that input vector. Each rows in this matrix contains on zeros value with a 1 value in element with position i, where i is the class number that we need to treat it. The highest classification rate in this classifier was 100% in training group and 99.04% in testing group.

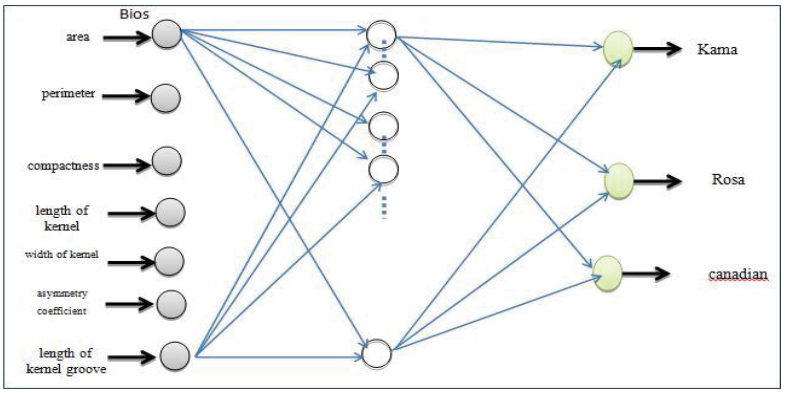

Figure 4. Architecture of ANN used for wheat kernels classification

4.4.3 Train and Test the Neuro-Fuzzy classifier

The structure of neuro-fuzzy will be based on Takaj fuzzy inference system. Learning algorithm for a neuro-fuzzy network will be derived base on gradient descent technique which used BP algorithm and in order to derive the learning algorithm, a membership function of differentiable type must use in inference rule; so a Gaussian membership function will be used in this work the. Depending on if part and then part of the fuzzy rules the parameters that will be updated in the neuro-fuzzy can be divide into two groups. For example in the (if part), because we use Gaussian membership function so the mean and variance of Gaussian function will be fine-tuned, whereas in the (then part), consequence weights will be the parameters that need to fine-tune [17]. To update the parameters of neuro-fuzzy the gradient descent based on BP algorithm use training patterns. To initialize network's weights of Neuro-Fuzzy we use some pattern that chose from training data set. Three groups of training/testing dataset will be applied to neuro-fuzzy as explain in table1. After the neuro-fuzzy network trained and tested carefully the higher classification result we get was on third group of dataset with values equal to 96.19 in training group and 94.28 in testing group. Figure (5) bellow show the structure of neuro-fuzzy network that are used as classifier in this paper.

In figure 5 which clear below the symbols [x1..xn] in input layer represent [x1..x7] where each one input map on features in input vector , in the hidden layer used 7 fuzzy set rule foe each input in features vector and three node in the output layer where they represent on network by symbols (y1,y2,y3) which map the three class of wheat kernels (Kama, Rosa, Canadian) respectively.

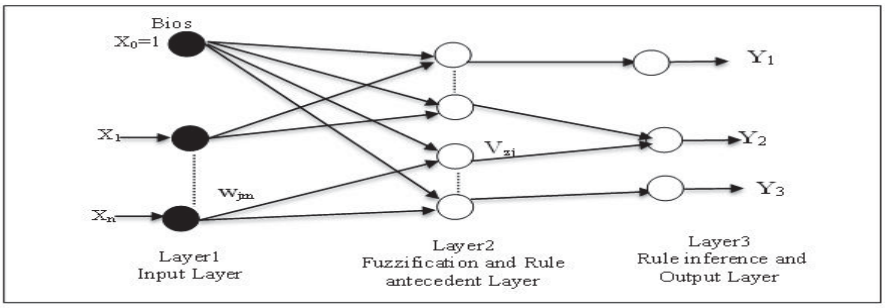

Figure (5) The architecture of neuro-fuzzy network

5. Results of Training and Testing Accuracy

To differentiate the wheat of Rose, Canadian and Kama from each other, it was processed with MATLAB R2017a program on computer have processor Intel(R) Core(Tm)i7 CPU @ 2.10 GH with RAM capacity is 8GB. Train and test accuracy success of wheat kernels was obtained for fuzzy logic, ANN and NF classifiers on three groups of dataset clear in tables 2,3,4 respectively. The

number marked in bold font in all tables (2,3,4) represent the correct classification of each type in data set to corresponding class.

Tr_acc=Training accuracy.

Tst_acc=Testing accuracy.

Class1=Kama, Class2=Rosa, Class3=Canadian.

Table (2) classification success of fuzzy logic

Train to test ratio		50/50			30/70			10/90		
Class Name		Target class			Target class			Target class		
		Class1	Class2	Class3	Class1	Class2	Class3	Class1	Class2	Class3
Output class	Class1	**32**	3	0	**41**	1	7	**44**	10	9
	Class2	4	**30**	1	**5**	**42**	2	6	**50**	7
	Class3	2	1	**32**	0	9	**40**	5	2	**56**
Tr_acc		100%			100%			100%		
Tst_acc		89.51%			83.67%			79.36%		

Table (3) success results of ANN with Rprop algorithm

Train to test ratio		50/50			30/70			10/90		
Class Name		Target class			Target class			Target class		
		Class1	Class2	Class3	Class1	Class2	Class3	Class1	Class2	Class3
Output class	Class1	**35**	0	0	**47**	0	3	**60**	2	7
	Class2	0	**38**	0	0	**53**	0	1	**62**	0
	Class3	1	0	**31**	1	0	**43**	1	0	**56**
Tr_acc		100%			100%			100%		
Tst_acc		99.04			97.27%			94.17%		

Table (4) success results of NF network

Train to test ratio		50/50			30/70			10/90		
Class Name		Target class			Target class			Target class		
		Class1	Class2	Class3	Class1	Class2	Class3	Class1	Class2	Class3
Output class	Class1	**31**	0	0	**51**	1	1	**55**	6	0
	Class2	4	**31**	0	2	**46**	0	2	**61**	0
	Class3	2	0	**37**	6	0	**40**	24	0	**41**
Tr_acc		96.19			95.23			90.47		
Tst_acc		94.28			93.19			83.06		

6. Conclusion

In this paper, by using classifiers of the fuzzy logic, ANN with Rprop algorithm and Nero-fuzzy network in the data set including 7 geometrical features of Rose, Canadian and Kama wheat, Three different ratios of training/testing groups which are (50% to 50%, 30% to 70%, and 10%to 90%) are applied to the classifiers. classified and success rates were found. The success rate was found higher than when the classification was made by ANN with Rprop algorithm with test accuracy 99.04% and training accuracy 100%for the first group (50% to 50%) and also gave a good result for other groups .While other classifier presented in this paper fuzzy logic, NF network also gave promise success rate this mean we can use this approaches to classify wheat kernels types sufficiently, and from the results we find that Neural network with BP algorithm and neuro fuzzy also with BP algorithm is less sensitive for training data size where it gave the best results even when the training data are few comparing with the fuzzy logic.

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