IMAGE PROCESSING BASED ANN WITH BAYESIAN REGULARIZATION LEARNING ALGORITHM FOR CLASSIFICATION OF WHEAT GRAINS

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Abstract

In this paper, an image processing technique (IPT) based artificial neural network (ANN) model using bayesian regularization (BR) learning algorithm is presented for classifying the wheat grains into bread and durum. Images of 200 wheat grains are taken by a high resolution camera in order to generate the data set for training and testing processes of the ANN-BR model. The features of 5 dimensions which are length, width, area, perimeter and fullness are acquired through using IPT. Then ANN-BR model input with the dimension parameters are trained through 180 wheat grain data and their accuracies are tested via 20 data. The ANN-BR model numerically calculate the outputs with mean absolute error (MAE) of 0.017 and classify the grains with accuracy of 100% for the testing process. These results show that the IPT based ANN-BR model can be successfully applied to classification of wheat grains.

Keywords: Classification, wheat grains, image processing, artificial neural network, bayesian regularization learning algorithm.

1. Introduction

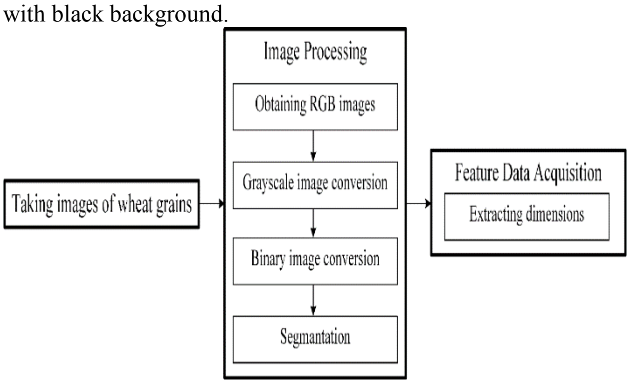
The standard of the flour used for the end-products such as bread, macaroni and cake highly depends on the quality of the wheat. The most important factor affecting the quality of the wheat is the amount of the protein in it. Durum wheat has more protein than the bread wheat. The bread wheat grains mixing into durum grains lead to a reduction in its protein content. Classification of grains is very important to increase the quality and decrease the cost. Evaluating the agricultural products in terms of visual features thanks to computer technologies has been an attractive field in recent years. Image processing techniques (IPTs) can be employed to classify the products through the visual features. In order to ensure automatic quality assessment, artificial intelligence techniques (AITs) are integrated to the IPTs [1,2]. Artificial neural network (ANN), support vector machine (SVM), adaptive neuro-fuzzy inference system (ANFIS), decision tree (DT), K-nearest neighbors (KNN), Naive Bayes (NB) and discriminant analysis (DA) are the most used AITs for classifying agricultural products [3,7]. Over a last decade ANN which is widely used AIT model adopts remarkable importance in classification of agricultural grains due to its fast and accurate modeling.

Several works for classifying of various agricultural products have been studied in the literature. Berman et al. classified wheat grains using near infrared hyperspectral image analysis [8]. The efficiencies of the cotton seeds were appointed by classifiers depending on DT and multilayer perceptron (MLP) by Jamuna et al. [9]. In classification of the wheat and barley seeds, DA and KNN were used to form a classifier [10]. Progressive analysis and meta-multiclass method were employed to classify the wheat grains by Zapotoczny [11]. A study using classifiers and ultraviolet visible spectrophotometry conducted to classify the spice through the KNN [12]. Prakash et al. studied the classification of objects for machine vision implementations with classifier algorithms of the KNN and Naive Bayes [13]. ANN and ANFIS were utilized to classify rice grains into five species with respect to the morphologic features [14]. A MLP-based ANN was modeled by Muñiz-Valencia et al. for classification of coffee grains according to their mineral content [15]. The ANN with the NB was designed by De Oliveira et al. for classification of green coffee grains into four group [16]. It is seen that those proposed classifiers varied among the used techniques, the features of products taken into account and the classification accuracy. Some of them might be difficult to implement while several took into account fewer parameters in classification. Therefore, their mean errors concerning the accuracy of the classification maintained limited.

In this study, an ANN model using bayesian regularization (BR) [17] learning algorithm based on IPT is designed to classify wheat grains into bread or durum according to their dimension features with high accuracy. The model is built on feed forward back propagation (FFBP) based on multilayer perceptron (MLP). 5 dimension features of 200 wheat grains are acquired for each grain through IPTs for input ANN-BR model. The feature data of 180 grains and 20 grains which are uniformly selected from the total number of 200 grains are respectively employed to train and test the accuracy of the model. The ANN-BR model correctly classifies the wheat grains into durum and bread with 100% for the training process.

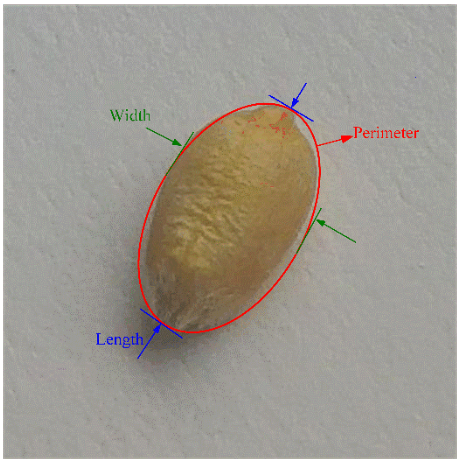
2. Image processing technique and data acquisition

In this section, images are taken and they are imposed to the IPTs to acquire data related to the visual features of the wheat grains in order to the ANN-BR model as illustrated in Figure 1. A setup including a computer, a camera and a box arranged by camera holder and a strip LED lighting is used in order to obtain the images. The camera is Logitech C920 CCD having specifications of full HD (1080p), 15 MP, H.264 encoding, Carl Zeiss optics. The photographs are taken by the camera fixed at 35 cm height from the wheat at the bottom of the box which is closed and self-illuminated. The inside of the box is covered with black background.



''Figure 1.'' Flowchart of extracting dimension features

The images of the wheat grains for bread and durum taken by the camera are illustrated in Figure 2. As can be seen, the main discrimination between the two grains is that the durum wheat grain is bigger than that of bread wheat. Therefore, dimension features of the wheat grains are considered in this study to model an IPT based ANN-BR network. As given in Figure 3, the photographs of 100 bread wheat grains and 100 durum wheat grains are taken via the high resolution camera. The wheat used for classification are cultivated in Konya, Turkey.



(a)

(b)

''Figure 2.'' The images of the grains for a) bread wheat, b) **durum wheat**

(a)

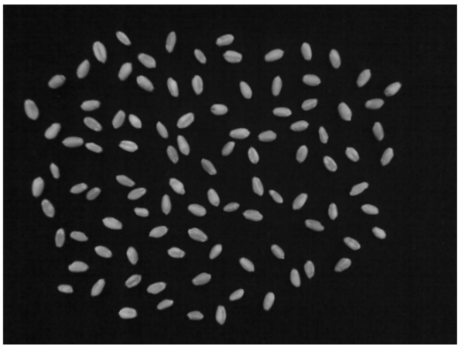
(b)

''Figure 3.'' The RGB images of 100 grains for a) bread wheat, b) durum wheat

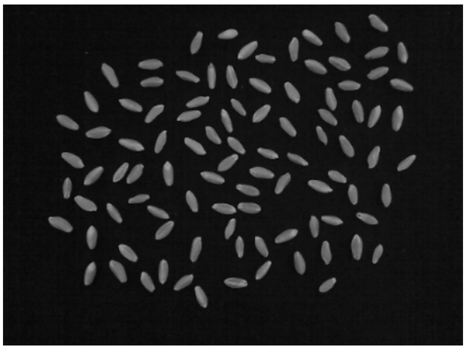
The IPTs are conducted through MATLAB® software to acquire the feature data. Firstly, the RGB level of the each pixel in the images are determined. These images are then converted to grayscale format as shown in Figure 4a and 4b. Secondly, the grayscale images seen from Figure 4c and 4d are converted to binary images (black/white) using Otsu's method [18] in accordance with threshold values of 0.30588 and 0.25882 for bread and durum grains, respectively. Thus the noise of each image is eliminated using morphological process. Thirdly, the each grain's position is fixed and they are tagged according to its position through segmentation process.

Each grain's dimensions in terms of the length (L), width (W), area (A) and perimeter (P) are extracted from binary images. Feature of fullness (F) related to dimension is reproduced from these parameters by Eq. (1).

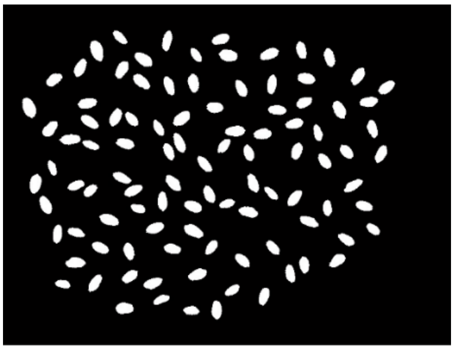
$$F = \frac{4\pi A}{P^2} \qquad (1)$$



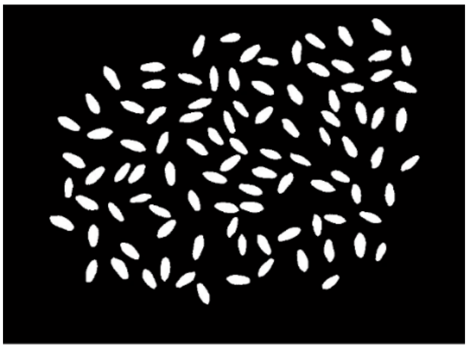
(a)



(b)



(c)



(d)

''Figure 4.'' The images of 100 grains for a) grayscale of bread wheat, b) grayscale of durum wheat a) binar images of bread wheat, b) binar images of durum wheat (originally given in Figure

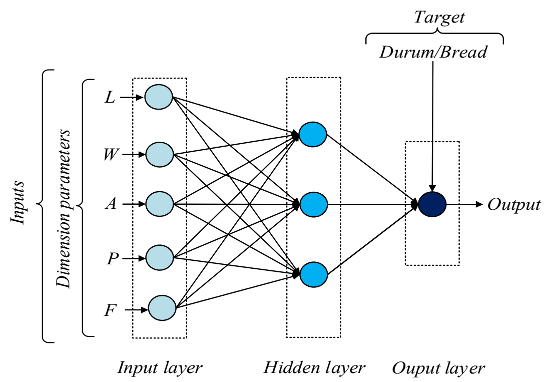
3. The ANN-BR model

An ANN consists of neurons which are organized into different layers. These neurons contain non-linear type of functional, they are mutually connected by very much similar synaptic weights. During the learning process, these synaptic weights could be weakened or strengthened and therefore helping the data to be kept in the ANN. Different learning algorithms are used for ANN networks. Some famous type of different backpropagation learning algorithms are Levenberg-Marquardt (LM), Bayesian regularization (BR), cyclical order incremental update (COIU), Powel-Beale conjugate gradient (PBCG), Fletcher-Powel conjugate gradient (FPCG), Polak-Ribiere conjugate gradient (PRCG), one step secant (OSS) and scaled conjugate gradient (SCG) [17]. In this study, the BR algorithm was used in ANN model as learning algorithm. BR learning algorithm updates the weight and bias values according to the LM optimization and minimizes a linear combination of squared errors and weights. It also modifies the linear combination so that at the end of training the resulting network has good generalization qualities.

3.1. Training Process of ANN-BR Model

The dimension parameters (*L*, *W*, *A*, *P* and *F*) of the wheat grains were given as inputs and their respective classification results of IPT were given as output to the ANN-BR model. While 180 of 200 data set of wheat grains were employed for training process. After several trials, ANN-BR model based on MLP having one input layer with five neurons, one hidden layer with three neurons and one output layer with one neuron was constructed, as shown in Figure 5. "Tangent sigmoid" function is used for input and hidden layers while "purelin" function is utilized for output layer. The parameters of the ANN-BR model used in this work are listed in Table 2. The training results are checked according to the following mean absolute error (MAE),

$$MAE = \frac{\sum |\text{Target} - \text{Output}|}{\text{Number of grains}} \quad (2)$$



''Figure 5.'' The ANN model for classification of the wheat grains into bread or durum

''Table 1.'' The parameters used to set the ANN model

Parameter	**Set type/value**
Number of epochs	350
Seed value	1242375667
Minimum gradient descent	10^{-10}
Momentum parameter (μ)	0.0002
μ increment value	2
μ decrement value	0.15
Maximum μ value	10^{10}

3.2. Testing Process of ANN-BR Model

The testing data including 5 dimension features of 20 grains (10 bread wheat grains and 10 durum wheat grains) and their testing results are tabulated in Table 2 to further inspect the data and results. While the number of “2” is assigned to specify bread grains, “1” is appointed to define the durum grains as targets of the ANN-BR model. The ANN-BR model proposed in this study accurately classifies 16 grains with 0 (zero) and 4 grains with very small absolute errors. Therefore, it classifies the total grains of 20 with a negligible MAE of 1.71×10^{-2}. It demonstrates that the proposed IPT based ANN-BR model can be successfully utilized to classify the wheat grains varieties in an automatic manner.

''Table 2.'' The testing results of classifying the wheat grains with the ANN-BR model

Grain #	Dimension features					Target	Result		
	Lenght (*pxl*)	Width (*pxl*)	Area (pxl^2)	Perimeter (*pxl*)	Fullnes		$Output_{ANN}$	Absolute Error	Class.
1	69.5679	37.3539	2014	188.6518	0.7111	2	2	0	Bread
2	63.6663	35.1940	1757	166.2670	0.7987	2	2	0	Bread
3	69.3322	33.8972	1841	175.9239	0.7475	2	2	0	Bread
4	73.5171	31.9743	1835	186.1665	0.6653	2	1.7126	0.2874	Bread
5	66.2957	37.9450	1967	177.6812	0.7829	2	2	0	Bread
6	66.6693	41.0286	2140	180.8528	0.8222	2	2	0	Bread
7	65.1759	34.7517	1772	171.6812	0.7555	2	2.0002	0.0002	Bread
8	63.0120	34.5241	1702	165.2965	0.7828	2	2	0	Bread
9	68.0608	40.1471	2138	187.8234	0.7616	2	2	0	Bread
10	65.8371	35.9484	1851	176.3087	0.7483	2	2	0	Bread
11	80.5652	2.2486	0.4611	0.3755	0.3545	1	1	0	Durum
12	85.4882	2.5266	0.4267	0.3144	0.3593	1	1	0	Durum
13	87.0308	3.0332	0.4361	0.3291	0.3577	1	0.9467	0.0533	Durum
14	90.6658	3.1075	0.459	0.3878	0.3472	1	1	0	Durum
15	73.6011	2.5941	0.4613	0.3642	0.3493	1	1	0	Durum
16	76.5508	2.6234	0.4774	0.3869	0.3514	1	1.0001	0.0001	Durum
17	87.2399	2.4641	0.4851	0.4077	0.3495	1	1	0	Durum
18	81.1672	2.3156	0.4141	0.3054	0.3607	1	1	0	Durum
19	82.8189	2.5029	0.4661	0.3687	0.3579	1	1	0	Durum
20	73.6011	2.5941	0.4613	0.3642	0.3493	1	1	0	Durum
MAE								0.0171	

4. Conclusion

In this article IPT based ANN-BR model is proposed for accurate classification of the wheat grains into bread and durum. The ANN-BR model based upon the MLP with three layers is designed for this purpose. 5 features of dimensions for 100 bread and 100 durum wheat grains are acquired by using IPTs. The ANN-BR model is trained with 180 grains and its accuracy is tested through 20 grains of 200 wheat grains data. The ANN-BR model classify the wheat grains with the MAE of 1.71×10^{-2} for testing process. The proposed method can be easy integrated to the industry to automatically classify the agricultural grains.

5. References

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