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Prediction of lateral surface, volume and sphericity of pomegranate using MLP artificial neural network

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Introduction: Fast and accurate determination of geometrical properties of agricultural products has many applications in agricultural operations like planting, cultivating, harvesting and post-harvesting. Calculations related to storing, shipping and storage-coating materials as well as peeling time and surface-microbial concentrations are some applications of estimating product volume and surface area. Sphericity is also a parameter by which the shape differences between fruits, vegetables, grains and seeds can be quantified. This parameter is important in grading systems and inspecting rolling capability of agricultural products. Bayram presented a new dimensional method and equation to calculate the sphericity of certain shapesand some granular food materials (Bayram, 2005). Kumar and Mathew proposed atheoretically soundmethod for estimating the surface area of ellipsoidal food materials (Kumar and Mathew, 2003). Clayton *et al.* used non-linear regression models for calculation of apple surface area using the fruit mass or volume (Clayton *et al.*, 1995). Humeida and Hobani predicted surface area and volume of pomegranates based on the weight and geometrical diametermean (Humeida and Hobani, 1993). Wang and Nguang designeda low cost sensor system to automatically compute the volume and surface area of axi-symmetricagricultural products such as eggs, lemons, limes and tamarillos (Wang and Nguang, 2007). The main objective of this study was to investigate the potential of Artificial Neural Network (ANN) technique as an alternative method to predict the volume, surface area and sphericity of pomegranates.

Materials and methods: The water displacement method (WDM) was used for measuring the actual volume of pomegranates. Also, the sphericity and surface area are computed by using analytical methods. In this study, the neural MLP models were designed based upon the three nominal diameters of pomegranatesas variable inputs, while the output model consisted of each of the three parameters including the volume, sphericity and surface area. Priorto any ANN training process, the data normalized over the range of [0, 1]. Fig. 1 shows a MLP with one hidden layer. In this study, back-propagation with declininglearning-rate factor (BDLRF) training algorithm was employed. The mean absolute percentage error (MAPE) and the coefficient of determinationof the linear regression line between the predicted values fromthe MLP model and the actual output were used to evaluate the performance of the model.

Results and Discussion: The number of neurons in the hidden layerand also theoptimal values for the learning parameters η and αwere selected bytrial and error method. The bestresult was achieved with five neurons in the hidden layer. The results showed thatthe optimum modelof performance was obtained at constant momentum termequal to 0.8 and learning rate equal to 0.9. In this study, 300 epochs were selected as the starting points of the BDLRF. Some statistical characteristics of the actual values of volume were estimated by WDM, surface area was computed by equation (3) and sphericity of pomegranates was computed by equation (1) and the predicted values of them using the neural network method were shown in Table 1. The obtained results verified that the differences between theactual values and the estimated ones can be ignored. But, the predicted values of the volume using the MLP model in comparison with equation (2) are much closer to the actual values. Statistical comparisons of desired and predicted data and the corresponding p values are given in Table 2. The results showed that P-value was greater than 0.08 in all cases. Therefore, there was no significant difference between the statistical parameters. However, the P-value for equation 2 is much less than that of the MLP model. The results shown in Figures 2, 3 and 4 show that the coefficients of determination between actual and predicted data were greater than 0.9. Considering all the results in our study, the MLP model is more accurate than the WDM and analytical methods.

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Conclusions: In this paper, we first measure the actual volume of the pomegranate using WDM and equation (2). Also, assuming an elliptical fruit, the sphericity and surface area are computed analytically based on the three nominal diameters of a pomegranate. Finally, the results of achievements of the MLP designed revealed that the MLP model could be successfully applied to the prediction of thesphericity and surface area. Therefore, the MLP model can be a viable alternative to the analytical methods. However, this is possible only if there is a precise way to compute the three nominal diameters of pomegranates. In addition, according to the MAPE, the accuracy of the MLP model in prediction of volume of pomegranates was twicethe analytical method.

Keywords: Neural network, Pomegranate, Sphericity, Surface area, Volume