INFORMATION TECHNOLOGY FOR GRADING OF FOOD PRODUCTS WITH NEURAL NETWORKS

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***Summary**: The paper presented demonstrates the application of an information technology for food products grading. The food products have a varified shape and nonhomogenious structure because of which the grading of big production lots has been connected with a number of problems. The solution of these problems is possible only by utilization of contemporary information technologies, neural networks and creating quicklyfunctioning automatic devices.*

***Key words**: Information technology, Grading, Neural Network.*

Introduction

The grading of fruits and vegetables by quality is a rather labour-consuming process connected with many losses. That is why, up-to-date technologies and technical devices should be used. Such devices are automatic grading systems [1]. Recently, the attention of specialists of post-harvest technologies has been engaged more and more with the problem concenrning machines provision. These machines will help the automation of the labour-consuming process of production "grading".

Fruit and vegetables grading

The grading methods can be divided into subjective (organoleptic) and objective (technical, machine) methods.

As regards subjective methods, there are methodologies created, according to which tasters, specially trained and highly-qualified experts determine the quality of the products by means of the human organs of sense, for taste, flavour, tactility, vision and hearing. The subjective methods have such disadvantages like the nonidentity of perceptions in time as a result of fatique, absent-mindedness, age etc. differences, at the most.

The objective methods for grading are most generally with a physicochemical character and can be differentiated in the following groups: mechanical (measurement of shape, size, volume, weight, density, etc.); physical (heat conductivity, acoustics, electrical conductivity, dielectrical permeability etc.); chemical (photocolourimetry, thermochemistry, electrical chemistry, extraction, dissolution, flotation, filtration); electromagnetic (electrical and magnetic fields, RO, UV, VIS, IR), laser radiation, etc..

Optical methods for nondestructive qualification of fruits and vegetables

The products with surface flaws can be removed easily and surely by means of the well-known grading technologies [1], either by hand or automatically, while the internal flaws are ”invisible” and require some new technological decisions and technique that give information about the internal state of the products. Besides the internal flaws, caused by diseases and injured structure, some interest has been evoked by the internal quality, that has been expressed by degree of ripeness, inner colour, dry matter content, proteins, xenobiotics, etc..

One of the methods known by now [1] to the termine undestructively the internal quality are based on optical transmitance of the products in different sections of electromagnetic spectrum.

The analysis and the general conclusion of experimental data allows for a grading of fruits and vegetables according to their spectral properties by reporting the general characteristics concerning qualitative nature, as follows:

-the spectra of transmittance and reflectance have differences in (VIS) region as a result of the differences in their internal and external colour;

-in NIR regions, the dependences T(λ) /coefficient of transmittance/ and R(λ) /coefficient of reflectance/ show that the qualitative character of their spectra are similar and the state of the surface of the products (degree of permeability, moisture, defects, etc.).

Neural networks and graders

The artificial neural network (NN) are built on the principle of their biological analogues, the main analogue consisting of a big number of connected in parallel process elements – neurons, forming a network that can be trained to be able to solve complex problems of the identification, forecasting, grading, etc..

The typical artificial NN consists of layers with neurons, as it is shown on fig. 1. The input and the output layers consist of as many neurons, as are respectively the inputs and outputs of the network [2]. The number of neurons in the inner (hidden) layers can be determined according to the specific task.

The input vector signal $\boldsymbol{U_0}$ enters the first layer, while the outputs of the final $\boldsymbol{m}$ – layer form the vector of the outputs $\boldsymbol{U_m}$. The outputs of the hidden $\boldsymbol{k}$ – layer neurons enter the inputs of the neurons only of the next $\boldsymbol{k+1}$ - layer.

In the general case, each ***j–th*** layer (neurons # ***i, j***) converts the input vector into a scalar. This convertion can be done in two steps. First of all, it is the summary input signal for each vector that is formed, the separate inputs being multiplied by the synaptic weighting coefficients of connections and the results are summed up according to the expression:

$$V_i(j)=W_i(j,0)U_0(0) + \sum_{r=1}^{n_{i-1}} W_i(j,r)U_{i-1}(r) = W_i^T U \qquad (1)$$

Where $W_i(j)=[W_i(j,0), W_i(j,1), \ldots, W_i(j,n_{i-1}),]^T$ is a vector of the weighting coefficients, and $U=[U_0, U_1, \ldots, U_{m-1}]$ is the expansion vector for the inputs.

After that the discriminant function (1) is converted with the transfer (activating)

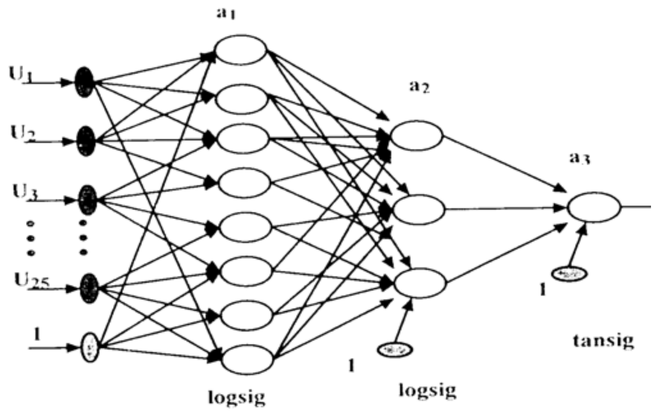

Fig. 1. The artificial neural network

function F_i specific for the network, that transforms the summary input obtained in the neuron output:

$U_i(j)=F_i\{V_i(j)\}; \quad (i=1,2,3,\ldots m; j=1,2,3,\ldots n_i)$ (2)

In (2) the nonlinear conversion F_i is assigned most often by means of the monotonous and limited function of sigmoidal curve $F_i(\nu)=1/(1+e^{-\lambda\nu})$ at nonnegative outputs of neurons or by means of tangenthyperbolical function $F_i(\nu)=(1-e^{-\lambda\nu})/(1+e^{-\lambda\nu})$, where λ is a parameter reflecting the abruptness of the curve slope. By accepting that the activating functions F_i $(i=1,2,\ldots\ldots,m)$ are uniform ones within one and the same layer and by reporting aquations (1), (2) and n_1-dimentional vector of the limiting weighing coefficients $W_i(j,0)$, s.c. bias, we can determine the connection between the inputs and outputs of the whole network in the folloing vector-metric form:

$$U_m=F_m\{W_m*F_{m-1}*\{W_{m-1}*\ldots*F_2(W_2*F_1(W_1*U_0+W_1(0))+$$
$$+W_2(0)+\ldots+W_{m-1}(0)\}+W_m(0)\}. \quad (3)$$

The analysis of (3) shows that the output of the neural network is a complex nonlinear function of the input vector Uo, that depends on the weighing coefficients W of the network. It has been proved that by means of using a bilayer neural network, practically every multidimensional function with a preliminarily assigned accuracy can be approximated.

Information technology for food products grading by using neural network

The qualification of food products by means of neural networks training methods is based on a complex of nonstationery random signals-realizations of the coefficients of transmittance (reflectanes), obtained by scanning the graded objects. These methods are objective, express and nondestructive.

Fig. 2 shows the realizations U_i obtained at the out put of the sensor block. They are in themselves the radio of spectral transmittance coefficients $U(n)= U_{\lambda 1} / U_{\lambda 2}$ at two different wavelengths λ_1 and λ_2 of onion of 3 grades D_k (k= 1,2,3). Along the X-axis, the number of recorded scanning points along the length of the bulb is marked by ***n*** (n=25). The function ***U(n)*** contains almost complet spectrophotometric information about the bulb and it is invariant as regards the disturbances and the thickness of products.

By means of optical distribution and mixture the light received by each channel can be divided into parts embracing different sections of the spectrum so that at one and the same time from 3 to 8 different wavelengths to be used for udentification of products quality.They correspond to fixed sections in the spectrum from 550 to 1000 *nm* that are formed by 3 to 8 interferent filters with wavelengths, as follows:

1) informative wavelengths of transmittance : = 0,70 – 0,72 μm; 0,85 – 0,88 μm; = 0,98 – 0,99 μm;
2) informative wavelengths of reflectance : = 0,55 –0,58 μm; 0,65 – 0,68 μm.; = 0,70 – 0,72 μm; = 0,97 – 0,99 μm.

The signals obtained have been assigned in the form of numerical values that characterize individually each bilb. Each bulb has been scanned in such a way that numerical values about its transmittance can be obtained, of 25 slices. It is important to mention that these 25 slices of scanning are at one and the same and accurately determined distance from each other, in such a way that if, for example, the bulb is cut through them, equal by size slices will be obtained. If it happens so that the bulb is bigger or is equal to the whole length of scanning, 25 numerical data are obtained for each slice, but in case it is smaller and cannot fill up the entire region, a value of 0 will be observed in the slices, that are not covered by it.

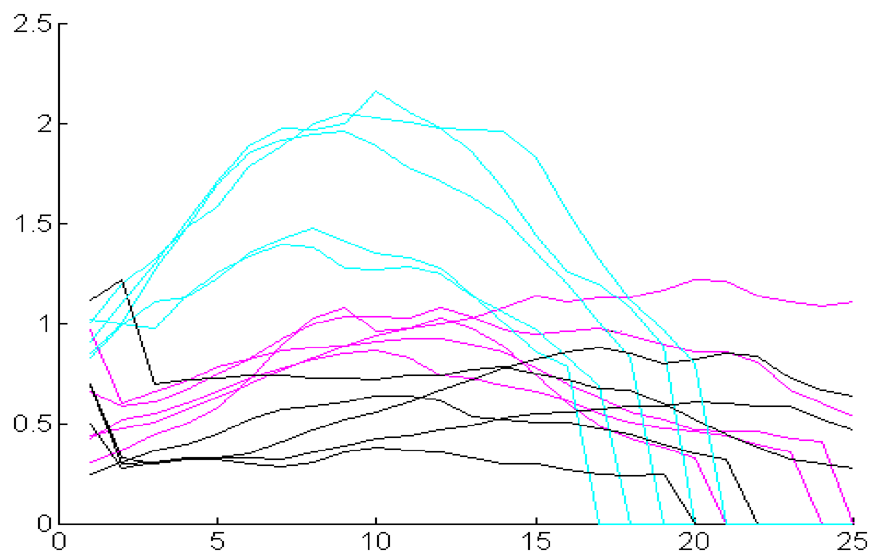

Fig.2. Spectral transmittance of onion I, II, III quality:
Grey –I quality;
Dark grey – II quality;
Black – III quality.

In that way, the bulbs data are positioned in one and the same table (matrix), that has 25 rows and columbs, as much as the bulb number – 96. In that sence, NN can be trained on the basis of the information from the data at the input vector for each bilb and the experts assessment.

From the diagrams presented concerning the first, the second and the third quality (Fig. 2) it is evident that the spectral transmittance of the bulbs having a higher quality is higher. Despite the diagrams cross each other ,they can be divided conditionally into three sections – for I, II and III quality.

For cheching the results from the training, logically the first quality is fixed for a value at the output greater than 0.5, second quality for a value between (-0.5) and 0.5 and third quality for a value smaller than (-0.5).

The neural network should be trained in such a way that it should be able to recognize these diagrams and to grade the onion according to its quality. For the purpose the onion spectral characteristics of onion have been measured. After an expert assessment the onions are divided into three fractions of quality – first, second and third quality. 25 bulbs have been used as a training excerpt of the neural network and 96 bulbs as a control excerpt for checking the network.

Conclusion

The information technologies and the neural networks are a contemporary device for food products grading. Their possibilities are used in onion qualification. The results obtained give good reasons to state that the information technology created so far successfully fulfills its purpose. The onion grading by this information technology is a prerequisite for further investigations and for its further improvement.

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