Adam FOJUD[1], Piotr BONIECKI[1], Maciej ZABOROWICZ[1], Dariusz LISIAK[4], Piotr ŚLÓSARZ[2], Marek STANISZ[2], Paweł STRZELIŃSKI[3], Adam KONIECZNY[5]

Poznań University of Life Sciences
[1] Department of Agriculture and Bioengineering, Institute of Biosystems Engineering,
[2] Department of Veterinary Medicine and Animal Science, [3] Department of Forestry
ul. Wojska Polskiego 28, 60-637 Poznań, Poland
[4] Institute of Biotechnology of Agri-Food Industry of prof. Wacław Dąbrowski name, [5] TAXUS SI Sp. z o.o.
e-mail: bonie@up.poznan.pl ; maciej.zaborowicz@up.poznan.pl

PROJECT OF A COMPUTER SYSTEM SUPPORTING EXTRACTION OF THE CHARACTERISTICS OF PORK HALF-CARCASES

Summary

In this paper it has been described a computer system for the processing and analysis of two-dimensional digital images of evaluated pork half-carcasses. The AOPW (pol. Analiza Obrazu Półtusz Wieprzowych) image analysis system was created in C#, in Visual Studio 2015, using the AForge.NET library. The development of the application was preceded by a requirement analysis, according to the software engineering procedures. Documentation in the form of UML diagrams was developed in Microsoft Visio. The AOPW application is used to analyze and extract the characteristics of pork half-carcasses contained in two-dimensional digital images acquired during the slaughtering process of pigs. The application may be a part of a new method for evaluating and classifying pig carcasses according to the applicable EUROP classification. The developed system was divided into two modules: the first for processing and filtering image, enabling e.g. edge and shape detection, sharpening and image binarization. The second allows for image analysis and acquisition of characteristics of pork half-carcasses - descriptors. The presented work was created within the research project of National Research and Development Center PBS3/B8/26/2015.
Key words: pork half-carcasses, evaluation of meatiness, expert system

PROJEKT SYSTEMU INFORMATYCZNEGO WSPOMAGAJĄCEGO EKSTRAKCJĘ CECH CHARAKTERYSTYCZNYCH PÓŁTUSZY WIEPRZOWEJ

Streszczenie

W pracy zaprezentowano autorski system informatyczny służący przetwarzaniu i analizie dwuwymiarowych obrazów cyfrowych, poddawanych ocenie półtusz wieprzowych. System o nazwie Analiza Obrazu Półtusz Wieprzowych (AOPW) został wytworzony w języku C#, w pakiecie Visual Studio 2015, z użyciem biblioteki AForge.NET. Opracowanie aplikacji zostało poprzedzone analizą wymagań, zgodnie z procedurami inżynierii oprogramowania. Powstała na tym etapie dokumentacja w postaci diagramów UML została przygotowana w programie Microsoft Visio. Aplikacja AOPW służy do analizy i ekstrakcji cech charakterystycznych półtusz wieprzowych, zawartych na dwuwymiarowych obrazach cyfrowych pozyskanych w trakcie procesu uboju trzody chlewnej. Aplikacja może stanowić element nowej metody oceny i klasyfikacji półtusz wieprzowych według obowiązującej klasyfikacji EUROP. Opracowany system został podzielony na dwa moduły: pierwszy przetwarzający i filtrujący obraz, umożliwiający m.in. wykrywanie krawędzi i kształtów, wyostrzanie oraz binaryzację obrazu; drugi pozwalający na analizę obrazu i pozyskanie cech charakterystycznych – deskryptorów. Przedstawiona praca powstała w ramach projektu badawczego Narodowego Centrum Badań i Rozwoju PBS3/B8/26/2015.
Słowa kluczowe: półtusze wieprzowe, ocena mięsności, system ekspertowy

1. Introduction

The pork carcass classification has been in force in Poland since accession to the structures of the European Union. Since 2004 the EUROP system has been in effect, which covers all slaughterhouses whose slaughter exceeds 10 400 units a year [1]. This system determines the way in which the measurements should be carried out and also sets the classes describing the percentage of lean meat in the carcass. To evaluate this value, tools called choirometers and regression equations are used, developed for the needs of individual members of EU, dedicated to specific models of choirometers. In Poland, the approved meat assessment tools are: *CGM*, *IM-03*, *Fat-O-Meat'er II* and *UltraFom 300* [2]. The regression equations are variable and their verification is necessary due to the unstable characteristics of the slaughter value of the fattening pigs [3].

Given the need to conduct frequent studies on the correctness of the verification of the meatiness of pig carcasses and the rapid technological development, we started work on alternative methods of evaluating meat. In solving classification problems, artificial intelligence methods as Artificial Neural Networks *(ANN)* are commonly used [4]. Thus, when looking for an alternative way of evaluating meatiness, neural modelling methods were considered. In the Institute of Biosystems Engineering at the Poznan University of Life Sciences, they are one of the main instruments for solving research problems. *ANN* are successful, for example, for predicting the price of wheat [5] or evaluating marbled meat [6]. With very high accuracy, they are able to classify data and objects, often far superior to human capabilities [7].

In neural image analysis, it is important to have adequate images and software to extract the characteristics of

Adam FOJUD, Piotr BONIECKI, Maciej ZABOROWICZ, Dariusz LISIAK, Piotr ŚLÓSARZ,
Marek STANISZ, Paweł STRZELIŃSKI, Adam KONIECZNY

87

„Journal of Research and Applications in Agricultural Engineering" 2017, Vol. 62(3)

the examined objects. It is often sufficient for classification purposes to obtain information about the colour of an object, its colour saturation or luminance. However, in many cases, other parameters of the image are just as important. It has been assumed that for objects such as pork half-carcasses, the size of the essential parts of the pig may be significant.

As part of the work, it was planned to develop a software that would enable to create a learning set, which would be used in the next part of the research to produce a classification neural model for assessing the meatiness of pork half-carcasses.

2. The purpose of the work

The purpose of the work was to produce a computer program that analyzes two-dimensional images of half-carcasses of pork. The analysis of these images should serve to capture the characteristics of the examined objects, which will be collected then in a result file called the learning set. This collection should be prepared in such a way that it can be implemented in the artificial neural network simulator. As a result, a classification neural model for describing the relationship between the characteristic features of the image of pork half-carcases and the meatiness of the examined objects should be developed.

3. Methodology

The assumption concerning the application discussed in this work envisaged the use of two-dimensional images of half-carcass pork in it. Capturing these images in industrial conditions would require a camera, bright screen that would allow for automatic separation of the background and adequate lighting. In this paper, photographs were used and these required manual separation of the background from the examined object. These images were then sent to the created application, where, after analysis of the image, a set of learning data was created.

An application for image analysis of pork half-carcasses (*pol. Analiza Obrazu Półtusz Wieprzowych - AOPW*) was developed in accordance with the principles of software engineering. A set of diagrams of the application model were prepared, and then a suitable computer program was developed. The *UML* modelling phase began with the formation of functional requirements for the system. It contains all the functions that may be useful in the processing and neural image analysis of pork half-carcasses. The next step was to prepare a class diagram describing the components of the system and the relationships between them. For this pur-

pose, the *Microsoft* tool – *Visio w*as used. Mentioned diagram of the components of the system (classes, fields or methods), as well as use case diagram and activity diagram were prepared in this tool.

The prepared application model has allowed to start the development of the system. For this purpose, the *Visual Studio 2015* development environment has been used. The entire application and software functionality has been prepared in it. The *AOPW* system was developed in a technology dedicated to .*NET Framework - Windows Forms* in *C#* programming language [8]. An external *AForge.NET* library was used also among others for implementing image processing functions [9].
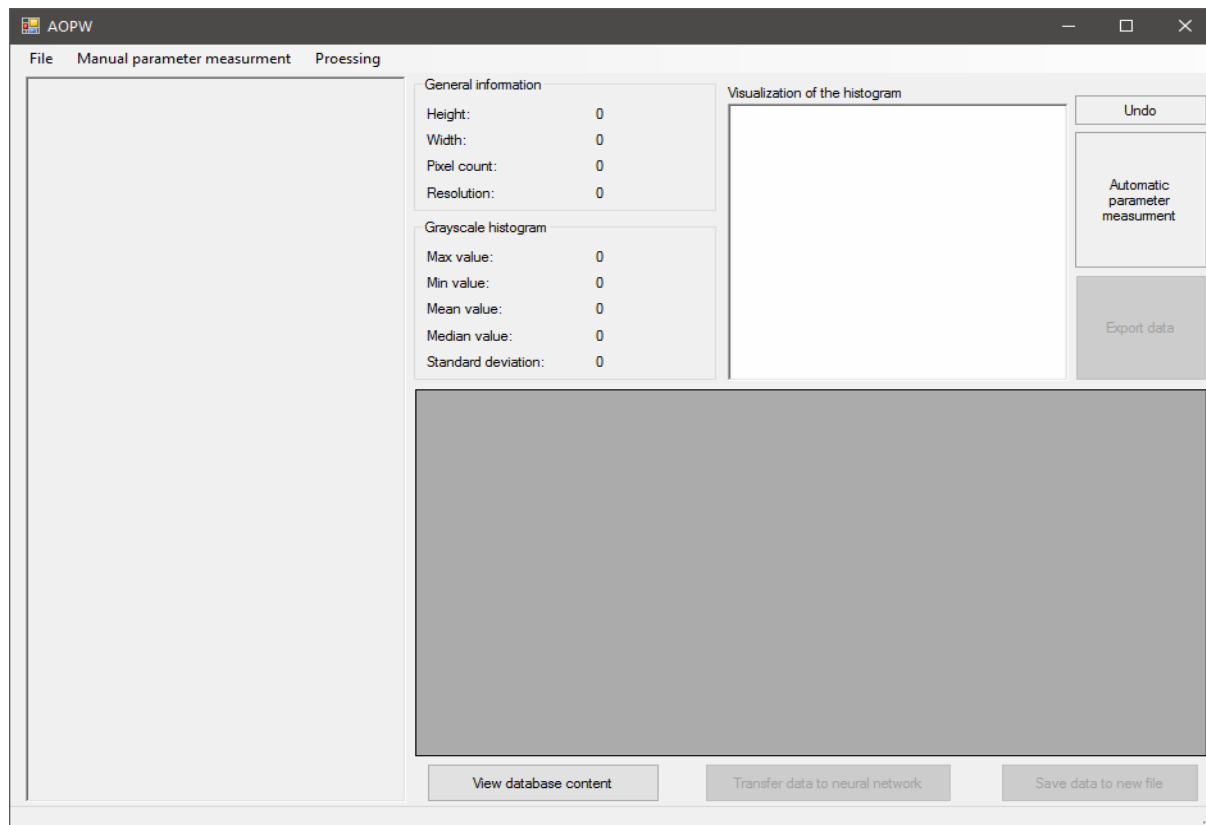
4. Application description

The *AOPW* program consists of two basic modules. In the image processing module, such functions as *edge detection*, *sharpening*, *morphological operations* or *binarization* are included [10]. They are important because of the purpose of the input images. There are two main functions in the analysis module: *automatic measurement* and *manual measurement*. The program also includes a test module to create a neural network model to assess the meatiness of the examined objects. This model is proposed by the program based on the learning data which are obtained during the analysis phase of the image. At this stage of application development, it is not a fully functional module, but it adequately demonstrates the possibility of solving the problem of evaluation of meatiness of pork carcass on the basis of neural image analysis. The scheme of operation of the program, and thus the process of evaluation of meatiness, is shown in figure 1.

The *AOPW* main window (figure 2) contains a number of controls that allow the user to interact with the program. The top bar of the application contains a context menu consisting of the *File* tab, which offers file-handling features, a *Button* for activating the *manual measurement* of the parameters function, and an *image-processing* tab. Below, on the left side of the window, a *PictureBox* control is provided to display the image opened by the user. The right side of the application view is occupied by groups of controls that display information about the image parameters. There are also buttons for undoing made changes, *automatic parameter measurement* and data export to the learning set.
A *DataGridView* control is below- it displays the data contained in the software database, and also there are 3 buttons that support operations on that data.
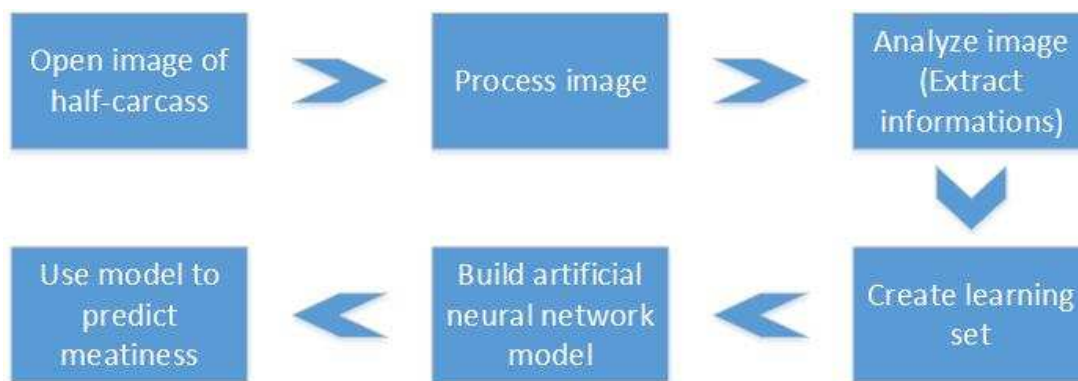

Fig. 1. Scheme of the operation of the *AOPW* application
Rys. 1. Schemat działania aplikacji AOPW

Source: own work / Źródło: opracowanie własne

Adam FOJUD, Piotr BONIECKI, Maciej ZABOROWICZ, Dariusz LISIAK, Piotr ŚLÓSARZ,
Marek STANISZ, Paweł STRZELIŃSKI, Adam KONIECZNY

88

„Journal of Research and Applications in Agricultural Engineering” 2017, Vol. 62(3)

Fig. 2. Main window of the *AOPW* application
Rys. 2. Okno główne aplikacji AOPW

Source: own work / *Źródło: opracowanie własne*
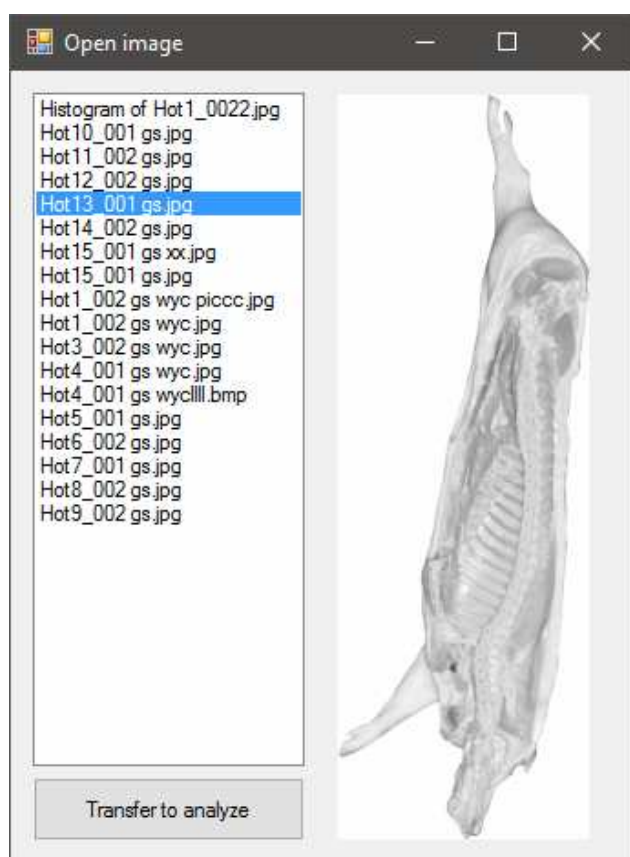
Source: own work / *Źródło: opracowanie własne*

Fig. 3. Built-in image browser
Rys. 3. Wbudowana przeglądarka plików graficznych

The program starts with loading the image of the pork half-carcass. User can do this in two ways: using a file system viewer under *Open* button in *File* tab, or using a browser built into an application that provides a convenient view of the selected image (figure 3). No matter which way the user chooses, the selected image will go to the *Picture-Box* in the main window. At the same time, the algorithm calculates basic image parameters such as height, length and resolution, and additional parameters for the histogram of grayscale image such as its maximum, minimum, average, median, and standard deviation value. In addition, the calculated values are visualized in a specially prepared window on the graph implemented by the *MSChart* library.

When user opens the image, he has the opportunity to use all the features that are included in the application. Access to functions such as *edge detection*, *histogram alignment*, *sharpening*, and *binarization* are available from the contextual drop-down *Processing* menu. All of the aforementioned functions have been implemented in the program to allow for the best possible interpretation of the displayed image during its analysis. For example, using one of the four available edge detection methods, user can bring the image into a form where finding the edges of the specific parts of the pork carcass will be much easier. A similar task will perform the *binarization* function (figure 4). A new open window with an image and slider will allow user to dynamically preview changes, and clicking the button at the bottom of this window will move the modified image to the main view.

The image, whether it was processed by the built-in processing functions or not, can then be analyzed. The analysis functions perform measurements on the image. The

Adam FOJUD, Piotr BONIECKI, Maciej ZABOROWICZ, Dariusz LISIAK, Piotr ŚLÓSARZ,
Marek STANISZ, Paweł STRZELIŃSKI, Adam KONIECZNY

89

„Journal of Research and Applications in Agricultural Engineering" 2017, Vol. 62(3)

user has access to manual and automatic measurement options. By selecting a manual measurement of parameters a new window will open, in which an image from the main window will be displayed (figure 5). In addition, the manual measurements view includes: a field for displaying instructions for performing measurements, fields for storing values for subsequent measurements, and buttons for starting functions of the measurement information and saving measurements. However, before the above described window opens, the user has to enter the value that in the program algorithm will match 10 pixels in millimeters. This value will depend on factors such as the distance from which the image acquisition process took place, or the focal length of the camera lens. The user measurement process can be performed by dragging measuring section on the image. This section is then measured by the program algorithm, and the value is displayed in the control. After completing all the measurements provided by the program, the application will inform user about it and then prevent further drawing of the sections. Then the user has the ability to transfer the re-

ceived data to the application memory and then in the main window, export them to the software database with the *Export data* button.

Similar to the function described above, is the function of *automatic parameter measurement*. It provides a window where user can use controls like:

- *DataGridView* - which gets the values measured by the parameter measurement algorithm,
- *TextBox* - in which user will enter data
- *Button* - used to start the function of saving selected information and cancel.

The automatic measurement process is included in the algorithm that segments the image of the pork half-carcass and then measures the length of each segment. The number of segments is entered by the user. The algorithm provides the possibility to save individual measured parameters by entering the corresponding numbers in the bottom left corner (figure 6).
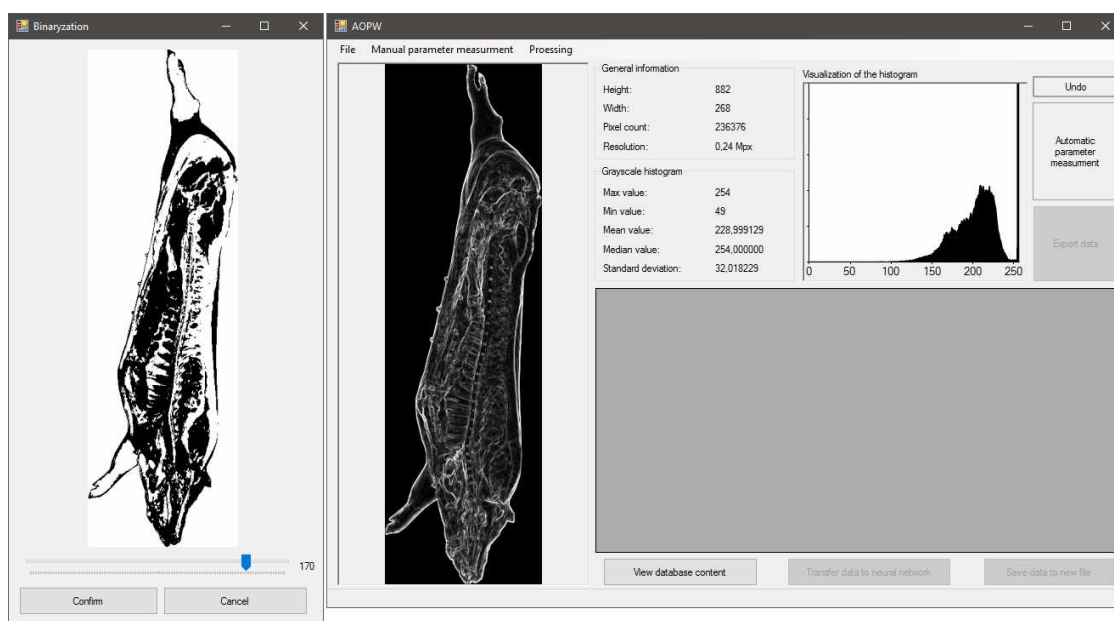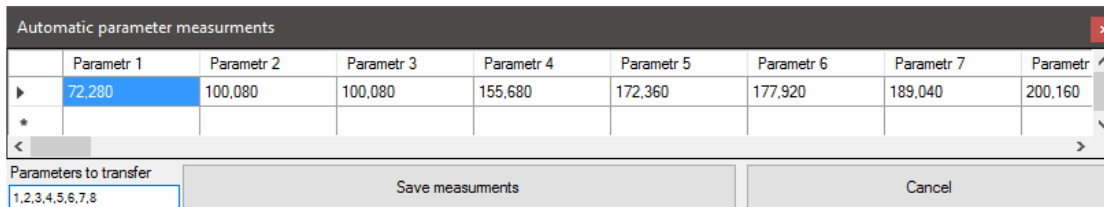

Source: own work / Źródło: opracowanie własne

Fig. 4. Binaryzation window and main window after applying the edge detection method
Rys. 4. Okno binaryzacji oraz okno główne po zastosowaniu metody wykrywania krawędzi
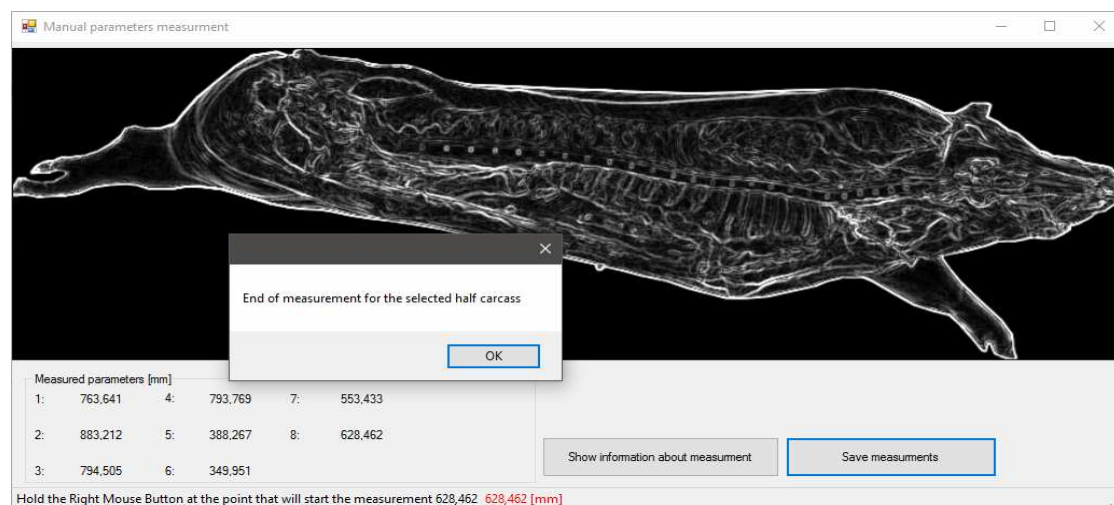
Source: own work / Źródło: opracowanie własne

Fig. 5. *Manual parameters measurement* window and information dialog box after the measurements
Rys. 5. Okno ręcznych pomiarów oraz okno informujące o zakończonych pomiarach

Adam FOJUD, Piotr BONIECKI, Maciej ZABOROWICZ, Dariusz LISIAK, Piotr ŚLÓSARZ,
Marek STANISZ, Paweł STRZELIŃSKI, Adam KONIECZNY

90

„Journal of Research and Applications in Agricultural Engineering" 2017, Vol. 62(3)

Fig. 6. Automatic parameter measurements window
Rys. 6. Okno pomiarów automatycznych

The application, as previously mentioned, has been provided with a software database. This database is a **.csv* file, which can also be used as a training set for the *STATISTICA Artificial Neural Networks* simulator. Its contents can be displayed directly in the program, using the *DataGridView* control *(DGV)* in the main view and the button *View database content*. In addition, the application allows user to manage the contents of this file. Thus, if the user's measurements do not meet his expectations, he can select the corresponding line in *DGV* and press the *Delete* key on the keyboard to delete the selected item. The program database file can also be saved to a new file, which can be exported out of the program. That file then can be used in the *STATISTICA* package.
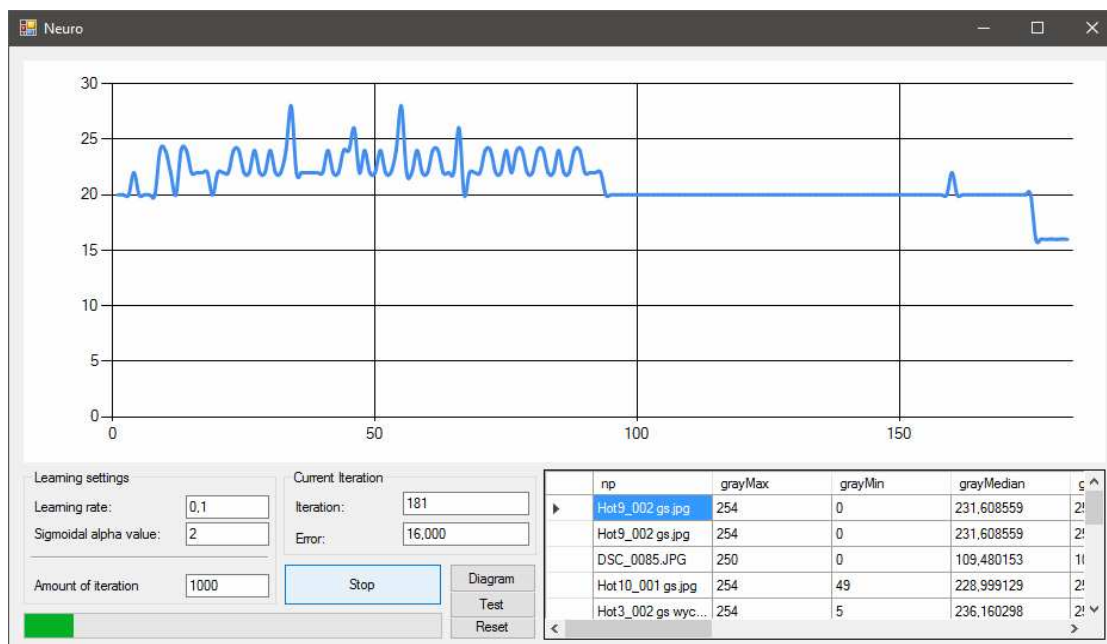
Attempts to meet the requirements of the assumptions of work decided to produce a test neural module, which would eventually become a fully functional complement to the program. The user can start the Artificial Neural Networks *(ANN)* module by selecting the button *Transfer data to the neural network*. It becomes active only after viewing the data collected during the analysis. When the *ANN* function is activated, a new window is open containing the following controls:

- *Chart* - which will visualize the progress of network learning,
- *TextBox* - in which will be introduced the basic data about the behavior of the network,

- *Button* - that is responsible for starting and stopping learning, displaying a diagram, testing, and resetting,
- *DataGridView* - in which will be displayed data transferred from the master view.

Software Artificial Neural Networks are taught on the basis of the data contained in the database. User can set values such as *learning rate*, *sigmoidal alpha value*, or the *number of iterations*, and then run the learning process. It will be visualized on the graph and progress bar, and the iteration and error value assigned to the current state will be displayed in the text fields. The completed learning process provides the neural model and the ability to perform a test based on the set seen in the lower right corner of the screen (figure 7). This test is run by selecting a specific item from the *DGV* control, and then clicking the *Test* button. This results in a dialog box with information about the quality of the half carcass.

Evaluation of the correct functioning of the entire system will be possible only after obtaining a large set of input data. This collection should consist of images obtained under equal lighting conditions and present the tested objects in such a way that they can be automatically separated from the background. After obtaining such a set, it will be possible to fully validate and test the produced software, and to develop in particular focusing on the improvement of the artificial neural network module.

Fig. 7. Artificial Neural Network window during the learning process
Rys. 7. Okno Sztucznych Sieci Neuronowych podczas procesu uczenia

5. Summary

The paper presents the author's *AOPW* system for the processing and analysis of pig half-carcases, whose task consists in extracting the characteristics of these half-carcases and to generate a learning set for constructing neural models to evaluate the meatiness of the examined objects. It includes processing and image analysis modules, as well as an experimental Artificial Neural Network module, which will allow future development of a software neural model to assess the meatiness of carcasses on the basis of the collected training set.

6. Conclusions

1. The created *AOPW* program allows to analyze and extract the characteristics of pork half-carcases and export the acquired data to files that meet the requirements of the *STATISTICA* learning sets.

2. The *AOPW* application may lead to the development of studies on alternative meat assessment methods

3. The *AOPW* system can help to reduce the cost of industrial image analysis use in the meatiness evaluation process

7. References

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Adam FOJUD, Piotr BONIECKI, Maciej ZABOROWICZ, Dariusz LISIAK, Piotr ŚLÓSARZ, Marek STANISZ, Paweł STRZELIŃSKI, Adam KONIECZNY

92

„Journal of Research and Applications in Agricultural Engineering" 2017, Vol. 62(3)