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THE NEURAL ANALYSIS OF QUARTERS HEALTHINESS OF HIGH YIELD COWS IN SELECTED COWSHED

Summary

Commonly recognized predictive abilities represented by selected ANN (Artificial Neural Networks) topologies are widely used in practice. They often support the decision-making processes that occur in agri-alimentary processing, such as milk production. The aim of the study was to use ANN as a predictive tool in the estimation process of the influence of selected zootechnical characteristics of cows on the milk quality, which is determined by the standards defining the requirements compliance concerning the level of somatic cell counts in the obtained milk. The work resulted in creation of the optimum predictive model which is a neural topology of the MLP-6:17:1 (MultiLayer Perceptron). The performed analysis of the generated neural model's sensitivity to the individual input variables showed the impact of some of the zootechnical characteristics on somatic cell counts in the obtained milk.
***Key words**: neural model, cows, somatic cell counts*

NEURONOWA ANALIZA ZDROWOTNOŚCI WYMION KRÓW WYSOKOWYDAJNYCH W WYBRANEJ OBORZE MLECZNEJ

Streszczenie

Uznane zdolności predykcyjne, jakie reprezentują wybrane topologie SNN (Sztuczne Sieci Neuronowe), wykorzystywane są powszechnie również w szeroko rozumianej praktyce, np. wspomagają procesy decyzyjne zachodzące w przetwórstwie rolno-spożywczym, np. w branży mleczarskiej. Celem pracy było wykorzystanie SNN jako narzędzia predykcyjnego w procesie oceny wpływu wybranych cech zootechnicznych krów na jakość mleka krów, która określana jest przez normy definiujące spełnienie wymogów odnośnie poziomu zawartości komórek somatycznych w pozyskiwanym mleku. W pracy wytworzono optymalny model predykcyjny będący neuronową topologią typu MLP: 6-17-1 (MultiLayer Perceptron). Przeprowadzona analiza wrażliwości wygenerowanego modelu neuronowego na poszczególne zmienne wejściowe wykazała istotny wpływ wybranych cech zootechnicznych na liczbę komórek somatycznych w pozyskanym mleku.
***Słowa kluczowe**: model neuronowy, krowy, liczba komórek somatycznych*

1. Introduction

Biological processes are characterised by great complexity, mathematical nonlinearity and hard to define interdependence among the factors affecting their run. The fact remains of primary importance while identifying representative parameters of the processes taking place. The knowledge is crucial in the analysis process of structure and dynamics of biological phenomena being tested. AAN are one of the effective tools that enable solving the problems being discussed [6]. They are found useful in the research on complex empirical systems and are more and more frequently used to model the processes taking place in agricultural engineering [1, 2, 3, 5, 7, 8]. The rapid development of modern information technologies increases their wide usage. It is possible mainly because of the essential AAN property, which is the ability to 'train' (generate) neural models on the base of the empirical data available. Thus, it makes it possible to create describing models of the analysed issues without the necessity of possessing some detailed knowledge about the structure of biological processes being tested.

Another AAN advantage is their ability to convert information in a parallel and distributed way. That means the neural models are resistant to damaged and noisy data frequently occurring in the form of empirical data during the analysis of complex biological processes [9].

2. Research aim

The aim of the study was to evaluate the impact of selected zootechnical characteristics of the cows on somatic cell counts in the obtained milk. In order to do that, recognised predictive properties of generated AAN topologies were used. The research was carried out on the basis of data obtained in a selected farm in Great Poland Province, Poland.

3. Materials and methods

In order to carry out simulated computer experiment, whose aim was to evaluate the influence of selected zoo technical characteristics of cows on somatic cell counts in milk, a one-way neural networks simulator implemented in Statistica v.9.0 StatSoft [10] was used.

Somatic Cell Counts (SCC) in the obtained milk was chosen as a predictive output variable of the created neural model. There were four zootechnical characteristics of cows selected and they constitute representative parameters of a biological process being tested. They were classified as input variables of created ANN and were as follows: participation of *hf* blood, age of the cow, number of calvings, day of lactation.

Zoo technical data have been obtained from cows documentary cards, although they were not always fully

completed. The accepted zootechnical parameters varied due to the random selection of tested groups. Received set of empirical data consisted of 315 cases and for the purpose of further use, it has been traditionally divided into training, validation and testing sets in the ratio of 2:1:1. A part of a training data set is shown in Fig. 1.

In order to generate an initial set of neural networks topology an effective procedure was used. The procedure was implemented in commercial statistics packet Statistica in the form of automatic network designer (advanced version). This effective tool makes it possible to shorten the time of laborious searching of appropriate neural network topologies, trained with the adjusted empirical data.

Generated network set has been verified as far as quality is concerned and it was followed by a choice of a model with the best qualitative parameters. The next stage was optimisation process of initially selected ANN structure with the use of 'manual' procedures implemented in Statistica packet. The optimal network appeared to be neural topology type MLP:4-17-1 (MultiLayer Perceptron) which has got 17 neurons in the hidden layer. The network was trained in a hybrid way with the use of standard algorithms BP (BackPropagation) using 1500 epochs and CG (Conjugate Gradient) over 2800 epochs. The structure of generated neural network type MLP:4-17-1 is shown in Fig. 2.

4. Research results

The commonly recognised criterion of neural model's evaluation is the RMS error value (Root Mean Squared) which is generated by the network during operation on the set not used while the process of training is taking place (e.g. testing set). RMS error value for the received MLP-4:17:1 net amounted to 0.1. That means the generated neural model was of good quality, especially as far as its predictive instrument is concerned.

The analysis of input variables sensitivity to the quality of the generated neural model's operation was carried out. It aimed at estimating the level of essentiality of established representative features. The analysis of sensitivity gives a clue regarding the usefulness of individual input variables. It allows to indicate those variables that, without a loss of network's quality, might be omitted as well as key variables which cannot be omitted.

imput variables

output variable

learning vectors

L.p.	Participation of blood hf	Age of the cow	The number of calving	Day of the lactation	Number of somatic cells NSC
1	84	2551	4	392	145
2	84	2583	4	423	301
3	84	2611	4	450	74
4	84	2735	5	12	637
5	84	2763	5	40	57
6	84	2793	5	70	34
7	84	2825	5	102	24
8	84	2883	5	160	26
9	84	2917	5	194	27
10	84	2944	5	221	36
11	84	2978	5	255	554
12	84	3007	5	284	42
13	84	3041	5	318	72
14	84	3070	5	347	1421
15	84	3094	5	371	63
16	84	3125	5	402	82
17	84	3156	5	433	186
18	84	3183	5	460	153
19	84	3241	5	518	64
20	84	3275	5	552	370
21	84	3401	6	33	688
...	...	...	...	...	...
308	90	868	1	120	153
309	96	899	1	151	238
310	94	934	1	186	214
311	99	724	1	8	3287
312	97	755	1	39	74
313	97	790	1	74	2230
314	96	743	1	30	2019
315	98	778	1	65	675

Fig. 1. Part of training data set. Source: own research
Rys. 1. Fragment zbioru uczącego. Źródło: badania własne

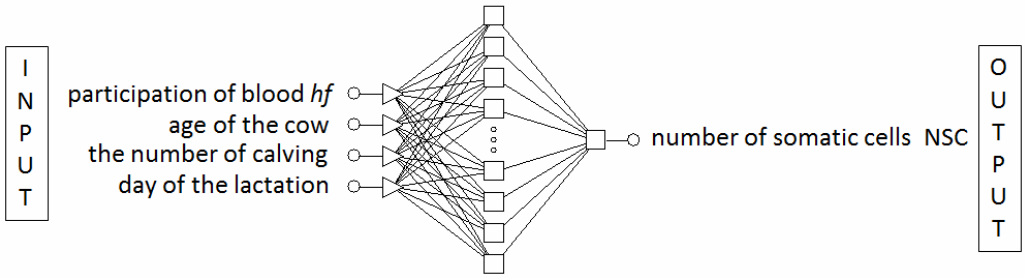

Fig. 2. Structure of neural network. Source: own research
Rys. 2. Struktura wygenerowanej sztucznej sieci neuronowej. Źródło: badania własne

A standard measurement of the above-mentioned analysis is the 'error ratio', giving information about the total error increase made by a model in case of not taking into consideration the input variable. The higher 'the error ratio' the greater the variable impact on the result of network running (then its importance reduces). It is accepted that 'the error ratio' equal or lower than 1 for a given variable has no influence on the quality of work of generated net [10]. Thus, this feature might be omitted during the model designing process, which enables the reduction of its dimensions. However, one needs to be cautious while drawing a conclusion. It is worth noticing that input variables are not usually independent. The analysis of variables sensitivity to the quality of neural network running reveals the loss resulting from rejecting the high rank variable. Nevertheless, the random dependence among variables (the rate is calculated independently for each variable) might not illustrate the real situation. Obtained error ratio for 4 input variables used for establishing the training data set can be found in table.

Table. The values of error ratio determining neural network sensitivity
Table. Wartości błędów ilorazów określających wrażliwość sieci neuronowej

	Participation of *hf* blood	Age of the cow	Number of calvings	Day of lactation
Error ratio	1.66	3.15	4.63	5.88
Rank	4	3	2	1

The analysis of sensitivity presented in table 1 enables to conclude that selected representative characteristics influence somatic cell counts in milk. Dominating variables occurred to be 'day of lactation' and 'number of calvings'. The two following features, namely 'participation of *hf* blood ' and 'age of the cow' (although remaining vital), are of lower importance.

5. Conclusions

The results of neural analysis prove some of the observations described by other authors. Ziemiński et al [11] indicate the differences in milk yield for cows with low SCC (up to 400 thousand per 1 ml) depending on the stage of lactation. Dorynek *et al* [4] claim that there is a correlation between SCC and daily milk yield as well as the number of calvings for cows. Following conclusions can be drawn:

- The optimal neural model used to predict SCC in the obtained milk is a multilayer perceptron consisting of 4 neurons in the input layer, 17 in the hidden layer and 1 neuron in the output layer.
- The good quality of MLP:4-17-1 neural network is confirmed by a small error RMS = 0.11. It was generated during the model's operation with the use of testing data set.
- The analysis of the generated neural model's sensitivity revealed the crucial impact of selected zootechnical characteristics of cows on somatic cell counts in milk. Dominating features occurred to be 'day of lactation' and 'number of calvings'.

This work has been funded by the Polish Ministry of Science. This study presents initial work started in the framework of governmental projects "*The influence of automatically controlled quarter pulsation system on the course of the final stages of cow milkings*" (No N N313 444937).

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