Neural Network model as a new method to diagnose ketosis in dairy cows

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PRO-2017/25/N/NZ5/00793 National Science Centre, Poland

KETOSIS – metabolic disease

Ketosis as a metabolic disease is difficult to diagnose in subclinical form. Due to ketosis, cattle farmers and milk producers carry large economic losses, which is a result not only from the costs of diagnosing and treating this disease, but also from reducing milk production, reproductive disorders and the eliminate sick cows from the herd.

nadis.org.uk

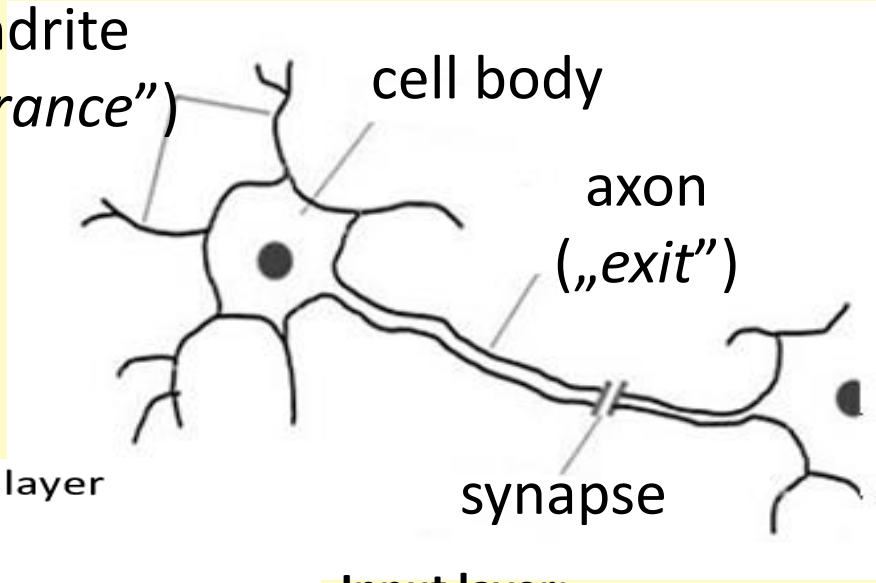
Diagnosis of ketosis

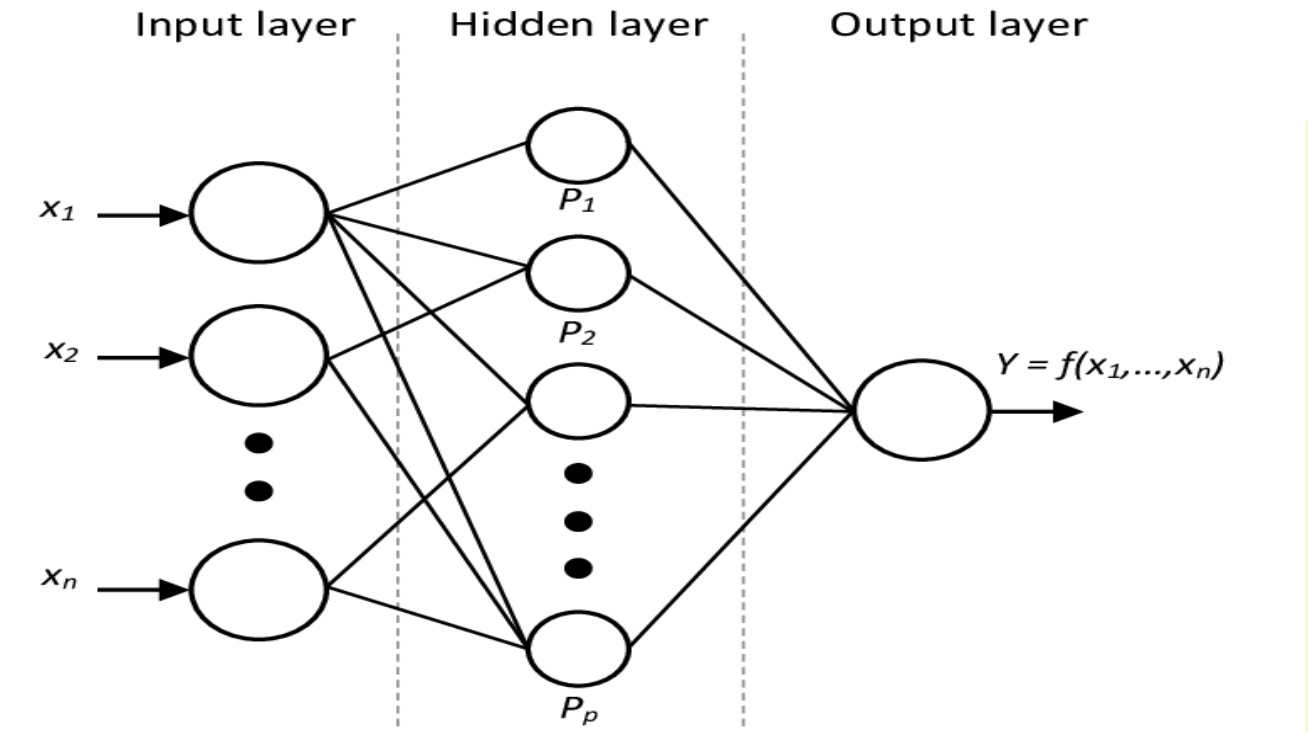
Diagnosis cow with clinical symptoms of ketosis– human glucometer,

Carrier i in., 2004; de Roose i in., 2007;
van Knegsel i in., 2010…
(*KetoTest; KetoCheck; KetoStrip*)

Method based on logistic regression selecting cows at risk of ketosis - good specificity (90%), but lower sensitivity (60%)

Artificial Neural Network





Input layer:
accepts input data and sends to all neurons of the hidden layer

Hidden layer:
it processes data and directs it to the output layer neurons

Output layer:
calculates final results, i.e. gives a solution to the problem being analyzed

Objective of the work

Define the relationship between milk composition and β-hydroxybutyric acid level in blood as a indicators of ketosis

Multi-Layer Perceptron

(*Artificial Neural Networks*)

Research data

Material-Polish Federation of Cattle Breeders and Milk Producers (PFHBiPM)

The collection contains data about 2000 cows

INPUT DATA

- MILK [kg]
- FAT (TŁ) [%]
- PROTEIN (BI) [%]
- LACTOSE (LAK) [%]
- FAT to PROTEIN (T/B)
- SOMATIC CELLS (LKS) [tys.]
- UREA (MOC) [mmol/l]
- ACETONE (ACE) [mmol/l]
- β-hydroxybutyric ACID in milk (BHB_M) [mmol/l]

OUTPUT DATA

- β-hydroxybutyric ACID [mmol/l] in blood

Research methodology

The analysis used *STATISTICA*® software –
The MLP model networks was generated based on:

neural network - **MLP** - *multi-layer perceptron*

activation functions:

- linear
- exponential
- logistic
- hyperbolic tangent
- sinus

hidden layer - 8 to 15 neurons
different sets of input data(milk compositions)

Research methodology

- ✓activation function (epoch)
- ✓sensitivity analysis
- ✓coefficient correlation
- ✓ROC, AUC
- ✓sensitivity & specifity

Results

Multi-Layer Perceptron – **168 000 models**

activation functions in hidden leyers:

- linear
- exponential
- logistic
- hyperbolic tangent
- sinus

5 x 5 x 100 x 8 = 20 000 models

500 models left = best parameters of all

Results

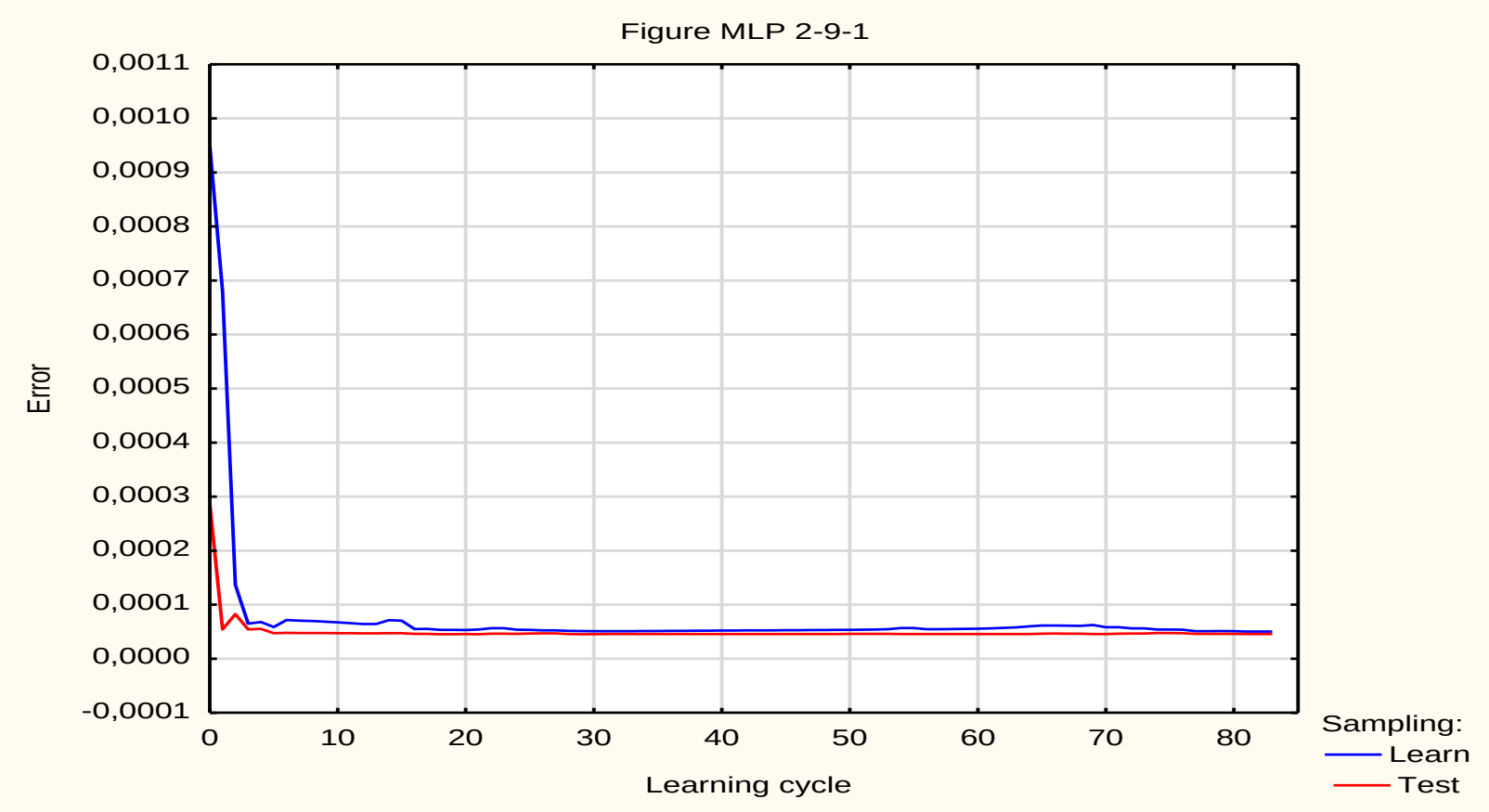


Figure MLP 2-9-1
0,0011
0,0010
0,0009
0,0008
0,0007
0,0006
0,0005
0,0004
0,0003
0,0002
0,0001
0,0000
-0,0001
Error
0
10
20
30
40
50
60
70
80
Learning cycle
Sampling:
Learn
Test

Results

8 neurons = none

9 neurons = slow learning process, high no. epoch (>180),

2-9-1 ; BHM; ACE

10 neurons = none

11 neurons = none

12 neurons = slow learning process (± 83 epoch); BHM; ACE

13 neurons = none

14 neurons = 98 and 87 epoch; BHM; ACE

15 neurons = 180 epoch; ACE; TB; BHM; TLP; BIP; LAP;

NEURONS	EPOCH	ACTIVATION FUNCTION	
2-9-1	11	Exponential	Hyp. tangent
2-9-1	152	Hyp. tangent	Sine
2-9-1	30	Linear	Linear
2-12-1	34	Exponential	Sine
2-12-1	57	Hyp. tangent	Hyp. tangent
2-12-1	83	Exponential	Linear
2-14-1	98	Hyp. tangent	Linear
2-14-1	55	Exponential	Linear
2-14-1	87	Sine	Linear
6-15-1	180	Linear	Linear
2-15-1	64	Sine	Linear
2-15-1	28	Sine	Linear

MLP	SENSITIVITY ANALYSIS					
	BHM	ACE	TB	LAP	TLP	BIP
2-9-1	8,510	3,711				
2-9-1	7,147	2,939				
2-9-1	6,470	2,617				
2-12-1	3,621	1,760				
2-12-1	6,862	3,180				
2-12-1	4,840	2,229				
2-14-1	5,454	3,774				
2-14-1	7,519	3,051				
2-14-1	5,582	3,640				
6-15-1	1,700	2,753	2,313	1,035	1,799	0,994
2-15-1	7,841	2,464				
2-15-1	6,636	3,395				

NEURONS	COEFFICIENT CORRELATION		
	learning	test	validation
2-9-1	0,967	0,738	0,650
2-9-1	0,969	0,737	0,650
2-9-1	0,968	0,738	0,650
2-12-1	0,968	0,739	0,650
2-12-1	0,971	0,533	0,615
2-12-1	0,968	0,730	0,649
2-14-1	0,968	0,715	0,646
2-14-1	0,968	0,731	0,649
2-14-1	0,968	0,717	0,646
6-15-1	0,970	0,536	0,543
2-15-1	0,968	0,744	0,650
2-15-1	0,968	0,729	0,649

MLP	AUC		CUT POINT	SENSITIVITY	SPECIVITY
	ROC	SE			
2-9-1	0,851	0,017	0,47	0,643	0,865
2-9-1	0,847	0,017	0,51	0,839	0,638
2-9-1	0,854	0,017	0,53	0,613	0,752
2-12-1	0,849	0,017	0,48	0,615	0,891
2-12-1	0,849	0,017	0,48	0,661	0,851
2-12-1	0,837	0,017	0,51	0,745	0,771
2-14-1	0,853	0,017	0,50	0,647	0,867
2-14-1	0,850	0,017	0,49	0,650	0,876
2-14-1	0,850	0,017	0,50	0,682	0,844
6-15-1	0,851	0,017	0,56	0,661	0,856
2-15-1	0,852	0,017	0,52	0,745	0,771
2-15-1	0,851	0,017	0,48	0,654	0,864

Summary

1. the higher the number of neurons - the lower the errors of learning, testing and validation,
2. 14 or 15 neurons - linear function (the hidden layer; the sine and exponential functions, hyperbolic tangent),
3. MLP network - content of β-hydroxybutyric acid (BHM), acetone (ACE) in milk,
4. only one network learned from six input variables (except BHM and ACE: fat, protein and lactose content and fat to protein ratio),

Summary

5. few of selected network - AUC-like measure, the are under the ROC curve = 0.85,
6. only for a network with 12 neurons - was slightly lower,
7. networks with the highest sensitivity = the lowest specificity;
8. 9, 14 and 15 neurons in the hidden layer = the best sensitivity and specificity,
9. MLP type neural networks based on 14 neurons = indicate the optimal cows at risk of ketosis.

Summary

MLP model - 14 neurons in the hidden layer =

application use in forecasting ketosis in dairy cows

β-hydroxybutyric acid (BHM) and acetone (ACE) in milk

models were characterized by a

sensitivity of 0.647 to 0.682

specificity of 0.844 to 0.876

Thank You for Your attention