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Early Diagnostics of Animal Diseases on the Basis of Modern Information Technologies

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Abstract. The aim of the study is to develop models and algorithms for early diagnosis of diseases in cattle based on Sugeno's fuzzy inference, since the improvement and implementation of systems that allow early diagnosis of animal diseases based on modern information technologies is one of the most important tasks. To this end, the task of diagnosing animal diseases, their treatment and control by carrying out preventive measures with the further introduction of information and communication technologies in district and city departments and subordinate organizations has been solved. To solve these problems, theories of soft computing are used, the main component of which is fuzzy logic. The choice of a rational number of rules is made, while they can use the effective values of the membership function. This allows us to solve the task of diagnosing diseases in cattle, taking into account the setting of the parameters of the membership function to find an adequate solution. The scientific novelty is the construction of a knowledge base based on experimental data, the improvement of the Sugeno fuzzy logic model with symptoms of cattle diseases and the use of the Sugeno fuzzy algorithm to predict the causes, developmental features and clinical signs of diseases in cattle. Based on the developed program, the problems of classification, evaluation and comparison of the obtained results with the results of several algorithms are solved. The types and causes of cattle diseases are determined. The problems of assessment, classification and prognosis of diseases according to seventeen signs have been solved. In accordance with accepted clinical practice, the types of diseases in cattle can be classified into the following diseases - microelementoses, osteodystrophy, secondary osteodystrophy and ketosis diseases.

INTRODUCTION

In the modern world, in many countries of the world, animals suffer from various diseases. Improvement and implementation of systems that allow early diagnosis of animal diseases based on modern information technologies is one of the most important tasks. In addition, in the United States, the Russian Federation, Germany, the Netherlands, Australia, Ukraine, Kazakhstan, much attention is paid to the diagnosis, treatment and prevention of animal diseases using data mining of complex processes, when object data are characterized by fuzziness and incompleteness.

A significant obstacle in solving the tasks set are internal non-communicable diseases, among which a significant place is occupied by secondary osteodystrophy, ketosis, hypomicroelementosis and osteodystrophy in cattle. One of the main problems is the development of mathematical models based on the diagnosis of the disease and the analysis of experimental data.

The country is taking enhanced measures to reduce the incidence, treatment, prevention and control of non-communicable diseases of cattle.

In the development and improvement of the efficiency of animal husbandry, which is the main branch of agriculture, it is important to increase the number of livestock in state, farm and private farms, increase productivity, proper care, and protection from various diseases.

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Scientific research on the development of veterinary biological products for the rapid diagnosis, treatment and prevention of animal diseases is carried out by the world's leading research centers and higher educational institutions, these are the Civilian Research & Development Foundation Laboratory of Microbiology (USA), Department of Pathology, Bacteriology and Poultry Diseases, Faculty of Veterinary Medicine (Germany), PAAM Laboratory for Medical Microbiology (Holland), Division of Microbiology of Infections Diseases, Western Australian Center for Pathology and Medical Research (Australia), All-Russian Institute of Vaccines and Serums (Russia), Ukrainian Research Medical Veterinary Institute (Ukraine), Kazakhstan Research Veterinary Institute (Kazakhstan), Research Veterinary Institute (Uzbekistan) [1].

In [2], the factors that cause metabolic disorders and a decrease in the natural resistance and productivity of the body are classified into the following groups:

- Long-term feeding of animals with food products grown on soils with high acidity, lack of minerals (macro- and microelements) and acidosis-causing factors in the diet;
- Impaired function of glycogen synthesis in the liver as a result of a long-term unilateral and low-nutrition diet (less than 90-20 g of protein per 1 kg of food and a sugar-protein ratio of less than 0.8: 1), a decrease in the number of hyperketonemia, ketonuria, ketonolactia, a decrease in hemoglobin, erythrocytes, total protein, nitrogen and urea in the blood;
- The entry of sulfuric and phosphoric acids into the blood (intoxication) with excessive feeding of the concentrate type, an increase in the number of ketone bodies in the blood, a violation of the production of bile and the excretory function of the liver, a decrease in glycogen stores;
- The development of latent ketosis and secondary osteodystrophy due to the presence of more than 13% fatty acids in the silage;
- Ultraviolet rays and lack of oxygen in winter and early spring, hypodynamics, the use of a large amount of mineral fertilizers in places where food is grown, etc.

Excess protein and sugar-protein ratio in the diet of cows below 0.7-0.79, the development of dystrophic changes in the liver of animals in the absence of trace elements such as copper, cobalt, zinc, manganese, as well as minerals such as endogenous rickets, secondary osteodystrophy, postpartum hypocalcemia, lead to metabolic disorders.

Analysis of the obtained studies showed the need to solve the following problems:

- Development and implementation of targeted state programs in the field of veterinary medicine and all branches of animal husbandry, including the development of animal husbandry, coordination of selection work;
- Diagnosis of animal diseases, their treatment and control of preventive measures;
- Introduction of information and communication technologies in district (city) departments and subordinate organizations.

To solve these problems, it is advisable to use the theory of soft computing.

The results achieved in the field of artificial intelligence make it possible to set and solve problems associated with the construction of intelligent systems for processing complexly structured information and recognition [3, 4]. One of the important theoretical and applied problems of building intelligent systems is the development of a formal apparatus for building diagnostic models of intelligent behavior, as well as applied tools for building intelligent systems in which diagnostic models are implemented and their adequacy is checked [5, 6].

MATERIALS AND METHODS

At the moment, the main component of soft computing is fuzzy logic.

Fuzzy logic provides verbal degeneracy and interpretability of calculations [5]. Fuzzy logic has been successfully applied to many industries. In robotics, in the stabilization of an inverted pendulum system, in complex decision-making and diagnostic systems, data compression, TV and other areas.

The soft computing components of fuzzy logic, neural processing, and probabilistic reasoning complement each other rather than compete. More and more it becomes clear that it is advisable to use fuzzy logic, neural networks, probabilistic reasoning with genetic algorithms in combination, and not standalone. As L. Zade noted, "now the term Hybrid Intelligent Systems is becoming commonplace in relation to systems in which fuzzy logic, neural networks, and probabilistic reasoning are used in combination. From our point of view, Hybrid Intelligent Systems are rapidly developing systems of the future" [7].

The use of mathematical models in conditions of poorly formalized systems with insufficient data for the selection of signs of decision rules combined into sets, to solve the problem of diagnosing cattle is considered to be our main goal. The use of decision theory, fuzzy logic, the theory of measuring latent variables and the data analysis model of Wald and Shortleaf [7, 8] is considered relevant.

Currently, in modern aggregation models, membership functions of a fuzzy set are used:

$$UGN_e = \min_i \left[\mu_\omega(x_i)\right], UGN_e = \min_j \left[\mu_{\omega i}(Y_j)\right], UGN_e = \\ = \min_{ij} \left[\mu_{\omega e}(x_e), \mu_{\omega e}(Y_j)\right], \tag{1}$$

$$UGN_e = \max_i \left[\mu_{ye}(x_i)\right], UGN_e = \max_j \left[\mu_{yi}(Y_j)\right], UGN_e = \\ = \max_{ij} \left[\mu_{ye}(x_e, \mu_{ye}(Y_j)\right], \tag{2}$$

$$UGN_e = \max_q \min_i \left[\mu_{yeq}(x_i)\right], UGN_e = \max_q \min_j \left[\mu_{yiq}(Y_j)\right], \\ UGN_e = \max_q \min_{ij} \left[\mu_{yiq}(Y_j)\right], \tag{3}$$

Where q – number of reference objects "covering" the class y_e.

Obviously, in the case of intellectual analysis between the analyzed classes, the operation of linear, piecewise linear or non-linear dividing planes is possible according to the formula:

$$Z_e = F_e\left(A_{ei}, x_i\right). \tag{4}$$

Under these conditions, it is proposed to use decision rules of the form:

$$UGN_e = \mu_{\omega e}\left[D_e\left(Z_e\right)\right] \tag{5}$$

Where F_e – function that determines the type of separating surface Z_e, (linear, piecewise linear, quadratic, etc.); $D_e(Z_e)$ – function of the distance from the objects under study to the separating surface Z_e [10, 11].

An important task is to build a fuzzy model based on experimental data, improve the construction of a Sugeno fuzzy logical model with symptoms of cattle diseases and use the Sugeno fuzzy algorithm to predict the causes, developmental features and clinical signs of diseases in cattle.

This approach allows taking into account quantitative and qualitative (verbal) variables and does not require knowledge of specific sections of mathematics, allowing the expert to assess the situation only in his professional language. In addition, on the basis of experimental data, orthogonality ensures the independence and variability of variables (matrix columns) - the expert's uncertainty in all variables is "similarity", which corresponds to the expert's intuitive knowledge and allows them to be formalized in the form of a fuzzy model.

There are *m* rules in the knowledge base that look like this:

$R1$: IF $x1$, this is A_{11} … and … x_n this is A_{1n}, then u have it B_1
…
$R1$: IF $x1$, this is A_{i1} … and … x_n this is A_{1n}, then u have it B_i
…
R_m : IF $x1$, this is A_{i1} … and… x_n this is A_{mn}, then u have it B_m,

Where x_k, $k = 1 \ldots n$, - input variables; y - output variable; A_{ik} – fuzzy sets with membership functions. The system can be used in veterinary practice to effectively assess the early diagnosis and treatment of diseases in cattle.

RESULTS

Based on the developed program, the processes of solving a number of existing (model) problems of classification, evaluation and comparison with the results of several algorithms are considered. This part discusses the problem of determining the types and causes of diseases in cattle. In this problem, the tasks of assessing, classifying and predicting diseases according to seventeen features are solved. In accordance with accepted clinical practice, the types of diseases in cattle and the results of their diagnosis can be classified as follows:

- y_1 - ketosis;
- y_2 - osteodystrophy;
- y_3 - secondary osteodystrophy;
- y_4 - hypomicroelementosis.

The program needs to be recognized y_1, y_2, y_3, y_4 types of diseases. When diagnosing in the laboratory, the following main parameters are taken into account (possible values are indicated in brackets, including x_1 - $x_{17} \in \{0,1\}$:

- x_1 - Temperature ^oC;
- x_2 - Pulse, in one minute;
- x_3 - Breathing, in one minute;
- x_4 - Rumination, in two minutes;
- x_5 - Number of erythrocytes mln/mkl;
- x_6 - Hemoglobin, g/l by the method (Sali's Hemometer);
- x_7 - Total protein, g/l (refractometry method);
- x_8 - Total calcium, mmol/l (Vigev Karakashov's method);
- x_9 - Organic phosphorus mmol/l (Pulse method by V.F. Kromyslov, modified by L.A. Kudryatsev);
- x_{10} - Glucose, mmol/l (color reaction with orthotoluidine);
- x_{11} - Reserve alkali (CO_2) about % (by the method of I.P. Kondrakhin);
- x_{12} - Copper mmol/l;
- x_{13} - Cobalt mmol/l;
- x_{14} - Manganese mmol/l;

- x_{15} - Zinc mmol/l;
- x_{16} - Number of ciliates in the rumen 1000/ml;
- x_{17} - The state of cicatricial fluid (Rameter) .
- y_j $(j=\overline{1,4})$. to determine the type of disease in cattle;
- y_1, y_2, y_3, y_4 - veterinary diagnostics;
- d_1, d_2, d_3, d_4 - results of computer simulation.

Below (Table 1) for comparison are the model results of the initial data and the results of verification diagnoses.

TABLE 1. Comparison of a fragment of initial data and model results, as well as verification diagnoses.

No.	1	2	3	4	5	6	7	8	9	10	11	12
x_1	38.8	38.5	39.4	39.2	39.5	38.9	39.3	38.7	39.4	38.5	39.2	39.5
x_2	72	75	72	80	78	76	68	74	68	76	78	76
x_3	28	25	24	18	18	25	28	19	22	28	25	22
x_4	3	3	4	3	4	3	3	3	3	3	2	3
x_5	4.92	5.80	5.28	5.32	5.55	5.59	5.62	5.68	5.56	4.68	4.55	4.62
x_6	99	102	97.5	89	95	98	108	111	116	84	88	86.5
x_7	70.5	64.0	72.5	68.2	66.4	72.4	81.2	64.3	60.2	68.2	66.4	58.9
x_8	2.62	2.70	2.65	2.56	2.55	2.85	2.75	2.68	2.94	2.24	2.19	2.48
x_9	1.44	1.54	1.42	1.30	1.55	1.52	1.58	1.55	1.50	1.28	1.30	1.34
x_{10}	2.41	2.26	2.36	2.32	2.37	2.28	2.74	2.64	2.57	1.75	1.63	1.64
x_{11}	49.8	44.5	50.1	46.3	43.8	48.7	50.8	42.5	51.i	42.i	45.8	47.3
x_{12}	12.7	14.5	15.2	13.6	10.6	14.2	13.8	16.5	13.6	10.1	11.4	12.0
x_{13}	0.46	0.50	0.54	0.52	0.48	0.56	0.52	0.58	0.48	0.40	0.35	0.42
x_{14}	2.55	2.60	2.58	2.52	2.54	2.58	2.64	2.66	2.68	2.29	2.32	2.35
x_{15}	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
x_{16}	460	420	501	456	478	458	432	482	475	320	318	344
x_{17}	6.62	6.58	6.60	6.50	6.54	6.75	6.78	6.65	6.74	6.20	6.26	6.35
y_1-y_2	y_2	y_4	y_4	y_4	y_4	y_4	y_1	y_1	y_4	y_1	y_2, y_1, y_4	y_4, y_2
d_1-d_4	d_2	d_2, d_4	d_2, d_4	d_2, d_4	d_2, d_4	d_2, d_4	d_2	d_2	d_2, d_4	d_2	d_2, d_4	d_2, d_4

DISCUSSION

Based on the capabilities of veterinary diagnostic and prognostic tasks, it is appropriate to create decision rules as standard decision modules that are available in the nodes of the network system. The size of tasks solved by one mechanism is good if they are associated with the technological process of a single solution. For example, the processes of making an inaccurate diagnosis according to the examination of a veterinarian; the process of determining the diagnosis with the evaluation of standard studies; the process of determining the diagnosis with the evaluation of data from special computer studies, etc.

The choice of a rational number of rules is made, while they can use the effective values of the membership function. This allows us to solve the task of diagnosing diseases in cattle, taking into account the setting of the parameters of the membership function to find an adequate solution.

CONCLUSION

The properties of the diagnostic problem of cattle diseases and the basis for the formation of a knowledge base are considered, since the systems for making semi-structured decisions under conditions of various types of uncertainty and, in particular, fuzzy uncertainty, represent an important class of intelligent systems.

As a result of the analysis, a scheme was developed for constructing a fuzzy inference for diagnosing diseases in cattle. This will allow for the further development of algorithms for constructing fuzzy logic and fuzzy neutrosophic models using the results of experimental tests conducted on cattle.

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