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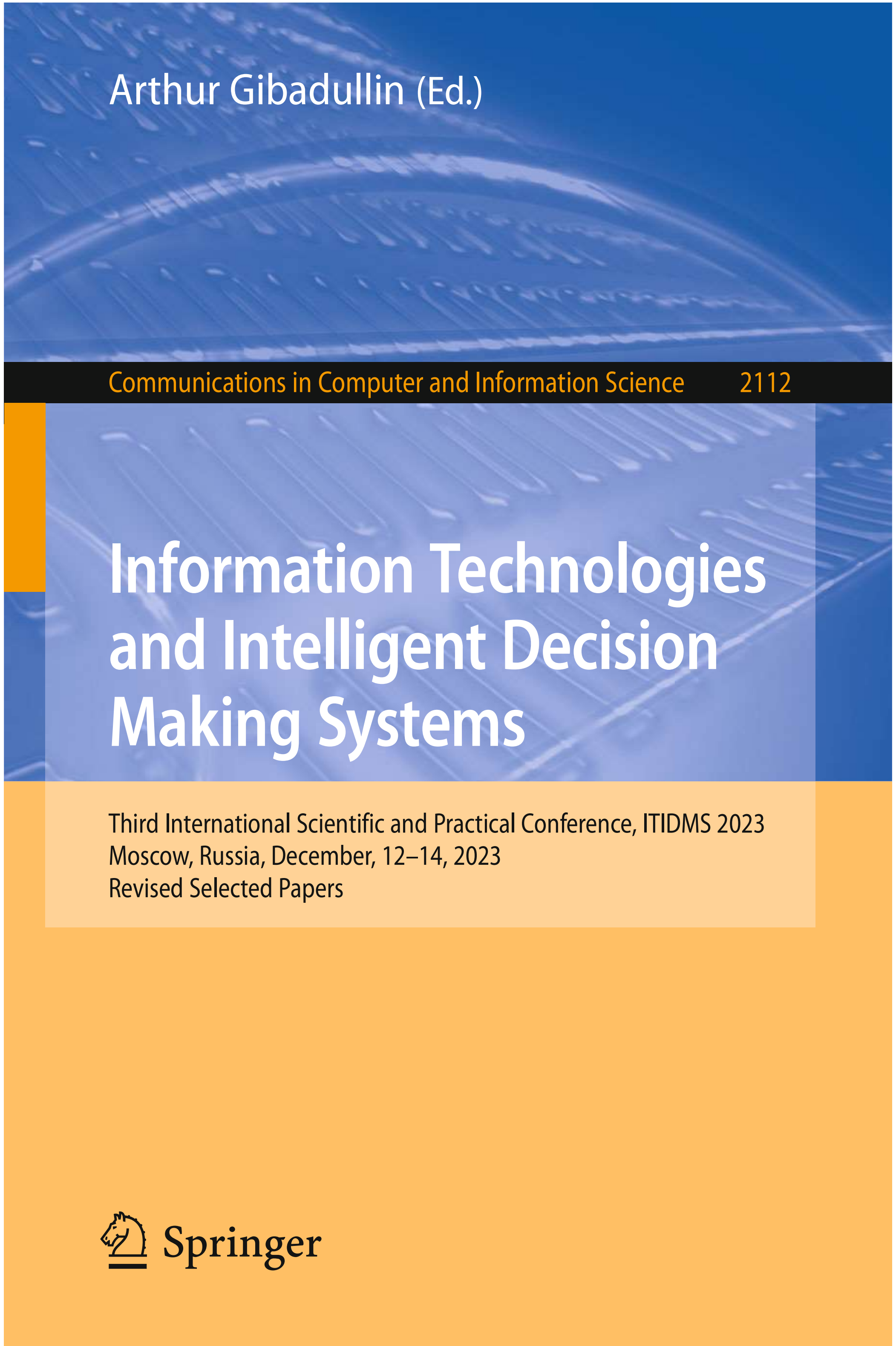

Arthur Gibadullin
Editor

Information Technologies and Intelligent Decision Making Systems

Third International Scientific and Practical Conference, ITIDMS 2023
Moscow, Russia, December, 12–14, 2023
Revised Selected Papers

Springer

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Preface

The Third International Conference "Information Technologies and Intelligent Decision Making Systems" (ITIDMS 2023) was held as a virtual event, December 12–14, 2023, on the Microsoft Teams platform due to COVID-19.

The conference was held with the aim of developing and exchanging international experience in the field of information, digital and intellectual technologies, within the framework of which proposals were formulated for digital, intellectual and information transformation, the development of computer models and the improvement of automated and computing processes. A distinctive feature of the conference was that it presented reports of authors from China, Vietnam, Uzbekistan, Russia, Korea, Finland and Israel. Researchers from different countries presented the process of transition of the information and digital path of development, and presented the main directions and developments that can improve efficiency and development.

The conference sessions were moderated by Arthur Gibadullin of the National Research University "MPEI", Moscow, Russia.

Thus, the conference still facilitated scientific recommendations on the use of information, computer, digital and intellectual technologies in industry and fields of activity that can be useful to state and regional authorities, international and supranational organizations, and the scientific and professional community.

Each presented paper was reviewed by at least three members of the Program Committee in a double-blind manner. As a result of the work of the reviewers, 17 papers were accepted for publication out of the 54 received submissions. The reviews were based on the assessment of the topic of the submitted materials, the relevance of the study, the scientific significance and novelty, the quality of the materials, and the originality of the work. Authors could revise their paper and submit it again for review. Reviewers, Program Committee members, and Organizing Committee members did not enter into discussions with the authors of the articles.

The Organizing Committee of the conference expresses its gratitude to the staff at Springer who supported the publication of these proceedings. In addition, the Organizing Committee would like to thank the conference participants, the reviewers and everyone who helped organize this conference and shape the present volume for publication in the Springer CCIS series.

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Contents

The article [2] contains the basic principles of building a multichannel system for collecting and preprocessing information about the control object state based on the precision analog microcontroller ADuC7060/61 Analog Devices in real time. The authors of the study [3] present the result of the development of a hardware sorting mechanism for peripheral computing devices with limited area and power consumption. It is important to use intelligent transport systems as part of a "smart city", which advisably can be presented in the form of a five-level hierarchical architecture, at the lower level of which there are sensors and actuators [4]. In control systems, feedback between sensors and actuators is organized thanks to programmable logic controllers. It opens up wide opportunities for the introduction of intelligent systems for automation of technological processes, control of technological parameters in real time. In [5–8], the possibility of automating the micro-arc oxidation (MAO) process for obtaining oxide coatings on products made of metals and alloys of the light group is described.

The recognized world leader in the field of micro-arc oxidation is Keronite, which offers its own range of automated process equipment. For example, an industrial installation with a capacity of 100 kW allows the application of MAO coatings in a pulsed bipolar mode with an adjustable voltage and current amplitude, pulse frequency and duty cycle [9, 10]. IBC Coatings Technologies (USA) has developed an MAO installation that allows performing various types of electrolyte-plasma treatment using a controlled source of rectangular high-voltage pulses of technological current [11, 12]. MILMAN THIN FILM SYSTEMS PVT. LTD. (India) has developed an automated Plasma electrolytic power supply installation, which is equipped with a remote touch control panel for the convenience of the operator [13]. The company "Mao Environmental Protection Technology Dg Co., Ltd" (China) produces MAO installations of three main types: fully inverter (4th generation); with the possibility of parallel connection (5th generation); based on a process current source with short pulses and low energy consumption (6th generation) [14].

The identified promising scientific and technical solutions were used in the development of an intelligent automated system structure for obtaining protective coatings of light alloys by the method of micro-arc oxidation, presented by the authors in this article.

2 The Structure of an Intelligent Micro-arc Oxidation System

The main functional parts of the proposed intelligent system for obtaining micro-arc coatings are hardware and software, as well as an information content subsystem (Fig. 1).

The Structure and Principle of the Intelligent Micro-arc Oxidation System Operation

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Abstract. The purpose of the work is to create an intelligent technology for obtaining oxide coatings with specified properties through an automated system being developed. The developed intelligent system implements the method of micro-arc oxidation to obtain protective oxide coatings on products made of aluminum, titanium or their alloys. The intelligent system consists of hardware, software, and information content. The software is developed in the LabVIEW graphical programming environment. The intelligent application contains three subroutines: identification of the electrophysical model parameters and optimization of process parameters to obtain the required properties of oxide coatings; visualization of the coating parameters dependences in real time on influencing factors. The algorithm of the developed automated system functioning is presented. The presence of an intelligent application allows feedback for software, in which the process current source can change the oxidation mode depending on the coating state at a given time, taking into account the required target coating parameters (thickness, porosity, hardness, etc.). The advantage of the proposed intelligent system is the possibility of implementing a regime of controlled synthesis of oxide coatings with the required properties. In turn, it makes it possible to increase the reproducibility of the MAO coatings parameters, reduce the time for testing the technological process.

Keywords: Intelligent Automated System · Process Current Source · Information Content · Oxide Coating · Algorithm

1 Introduction

With the development of programmable logic controllers since the late 1960s, a new stage of the creation of methods and algorithms for controlling complex technical systems began. In the last decade, real-time object monitoring systems have become widespread in various fields, they are becoming intelligent tools capable of solving a wide range of management tasks. Such devices necessarily contain a microprocessor system for collecting and processing information. For example, [1] an intelligent integrated air pollution monitoring system with Internet of Things support, built on the basis of the Arduino hardware platform is presented.

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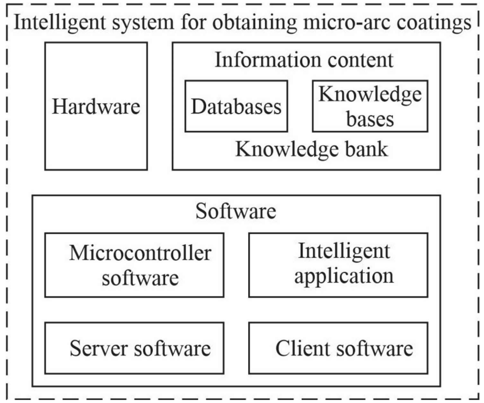

Fig. 1. The structure of an intelligent system for obtaining micro-arc coatings.

2.1 Hardware Part of an Intelligent System for Obtaining Micro-arc Coatings

The elements included in the hardware of the intelligent system (Fig. 2) are a galvanic cell, a process current source and a standby power source, measuring unit and control unit.

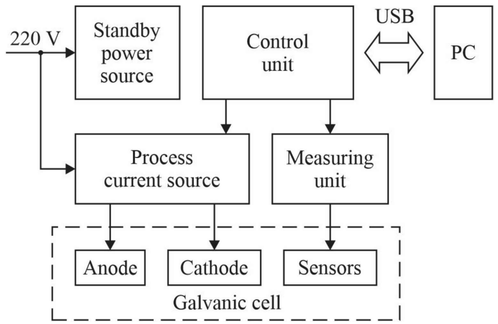

Fig. 2. Hardware part of the intelligent system.

The generation of a pulsed current for the formation of a micro-arc oxide layer on the sample is provided by a process current source. The process current source allows you to adjust a large number of electrical parameters of the output signal: amplitude, frequency, duration, polarity and pulse repetition mode, which makes it possible to effectively control the energy supply to the sample surface.

The standby power source is designed to power low-voltage circuits of measurement and control units, as well as other components of an automated system (for example, protection circuits). The standby power source is always on; it is used to control the switching on the process current source.

In the structure of the measuring unit, measuring channels, which are designed to measure both the control parameters of the technological process and the parameters of the oxide layers can be distinguished:

- Current strength, electrical voltage of the galvanic cell;
- The electrolyte parameters, which include its resistance, temperature and turbidity;
- Optical and acoustic parameters of micro-arc discharges;
- Coating impedance;
- Coating thickness (indirect determination by impedance).

The signals from the measuring channels are sent to the microprocessor control unit, which transmits them via the USB interface to the computer. Then, using the program, the measurement results are processed and used to construct the characteristic curves of the MAO process: the forming curve, dynamic current-voltage characteristics, etc. The output signals of the measuring channels also serve as an element of software feedback, through which the coating formation process is controlled.

The signals for controlling the nodes of the intelligent system are generated by the control unit, which provides a computer connection with the process current source and the measuring unit. The control unit includes a microcontroller, which, in turn, contains the following components: an analog-to-digital converter (ADC) for digitizing the analog output signals of the measurement module, a digital-to-analog converter (DAC) for controlling the process current source, a UART module (for communication with a computer), I/O ports for connecting external peripheral devices.

A galvanic cell is a bath with an electrolyte in which the anode (sample) and cathode are immersed. The bath is equipped with sensors of various physical quantities measured during the MAO treatment, as well as a protective fence. The galvanic cell is equipped with a cooling system on the Peltier element and a mixing system that circulates the electrolyte to maintain a constant temperature of the electrolyte and a continuous influx of ions to the sample surface.

2.2 Information Content Subsystem of the Intelligent System

The information content (Fig. 3) is a knowledge bank containing knowledge bases and databases. Conditionally, the knowledge bank contents can be divided into four subsystems. The MAO coatings subsystem contains information about the MAO coatings properties, as well as about the influencing factors of the MAO process. The subsystem of theoretical research concentrates knowledge about the physico-chemical laws applicable in the study and modeling of the MAO process, as well as about the currently existing mathematical expressions describing the relationship between the technological parameters of the MAO process, properties and quality parameters of coatings. The experimental studies subsystem includes information on methods and means of measuring the technological parameters of the MAO process and coating properties, their metrological characteristics, as well as on the technological modes used. The reference subsystem contains reference data on the MAO process mechanism and the MAO coatings application. All knowledge bases and databases available in the knowledge bank

8. Zeiler, M., Krishnan, D., Taylor, G., Fergus, R.: Deconvolutional networks. In: 2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp. 2528–2535. IEEE (2010)
9. Goodfellow, I., et al.: Generative adversarial nets. In: Advances in Neural Information Processing Systems, vol. 27, pp. 139–144 (2014)
10. Simonyan, K., Zisserman, A.: Very deep convolutional networks for large-scale image recognition. https://arxiv.org/abs/1409.1556 (2014)
11. Shi, W., et al.: Real-time single image and video super-resolution using an efficient sub-pixel convolutional neural network. In: 2016 Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1874–1883. IEEE (2016)
12. Isola, P., Zhu, J.Y., Zhou, T., Efros, A.: Image-to-image translation with conditional adversarial networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1125–1134. IEEE (2017)

have the possibility of additions, which allows you to add new and refine existing mathematical models and technological modes of the MAO process, adjust measurement methods, thus improving the entire system operation.

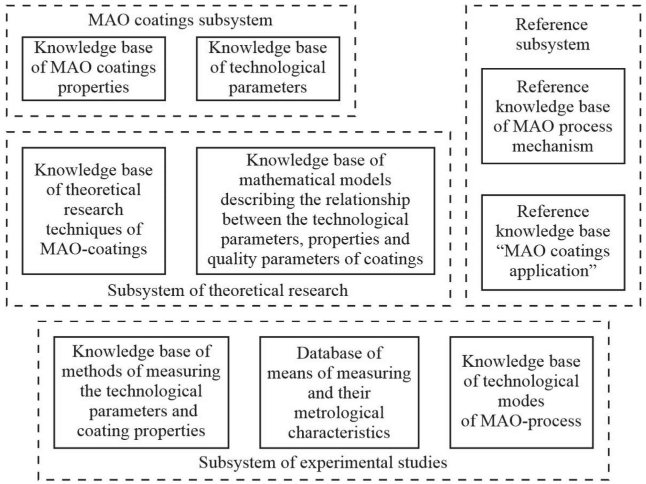

Fig. 3. Structure of the knowledge bank.

2.3 Software of the Intelligent Automated Micro-arc Oxidation System

The software includes microcontroller software and server software, an intelligent application that implements the methods of controlled synthesis of MAO coatings developed by the authors, and client software designed for user interaction. The microcontroller software is designed to control the process current source, process signals from measuring transducers and transfer the received information to a PC, as well as perform service functions (error messages, indication, etc.). The microcontroller software has been developed, which provides procedures for controlling the process current source; transmits signals for connecting measuring transducers and transmitting information from the output of measuring channels to a computer; performs service functions (for example, error reporting, indication, etc.). The server software is responsible for configuring the system and controlling the microcontroller. The intelligent application processes data from the output measuring transducers based on the proposed intelligent algorithms. In order to ensure the controlled synthesis of oxide coatings form control commands coming to the process current source, which varies the amplitude, duty cycle, frequency of current pulses intelligent algorithms and techniques are applied to the workpiece with a modifiable surface. The intelligent application structure is shown in Fig. 4.

development of appropriate algorithms and programs for predicting and identifying diseases of cattle is one of the priority tasks. These efforts are aimed at improving the quality of life of animals, effectively managing their health, and promoting agricultural development and food security [3, 4].

The purpose of this work is to develop models and algorithms for identifying diseases of cattle using the Sugeno fuzzy inference method and the concept of neutrosophical fuzzy sets. This will make it possible to create a diagnostic system capable of efficiently processing fuzzy and uncertain information about the health status of animals. Using fuzzy logic and neutrosophical fuzzy sets will allow us to take into account various aspects of uncertainty and fuzziness inherent in veterinary diagnostics, which will make the system more flexible and adaptive to a variety of conditions and situations. The expected result of the study will be the creation of an effective tool for the early identification of diseases in cattle, which contributes to their more successful treatment and prevention of the development of complications [5–7].

The purpose of this research is to develop improved algorithms and models for disease identification in cattle using neutrosophic sets and Sugeno fuzzy inference. This includes the creation of effective methods for processing the fuzzy and uncertain information characteristic of veterinary diagnostics, as well as the development of algorithms that can adapt to a variety of conditions and characteristics of specific disease cases. The main goal is to ensure accurate and rapid identification of diseases in cattle with a minimum number of false positive and false negative results. Successful completion of this task will significantly increase the efficiency of veterinary practice and improve animal health [8, 9].

The use of neutrosophic fuzzy sets and decision-making methods represents a promising approach to solve the problem of diagnosing osteodystrophy, secondary osteodystrophy, hypomicroelementosis and ketosis in cattle. Given that the symptoms of these diseases are interrelated and may overlap, and given the possibility that one disease can cause another, accurately identifying the type of disease can be difficult for veterinarians.

Issues related to the methodology for solving the problem of identifying diseases for studying the structure of classes of cattle, and identifying diseases based on neutrosophic fuzzy sets and decision-making methods, are relevant and promising in modern veterinary science and practice [10].

Studying the class structure of cattle using fuzzy set technologies allows us to take into account various factors, such as genetic, morphological and behavioral characteristics, which may influence their classification. This can be useful for more accurately determining breed quality, meat quality, milk quality or other characteristics, as well as for improving breeding programs and breeding methods. Defining diseases using neutrosophical fuzzy sets and decision-making methods makes it possible to take into account various symptoms and signs of diseases, as well as their interrelationship and influence on each other. This can be useful for more accurately diagnosing diseases, determining their severity and choosing optimal treatment and prevention strategies. Such approaches offer new prospects for improving the diagnosis, treatment and health management of cattle, which can lead to increased productivity and quality of livestock products, as well as improved animal welfare and reduced losses in livestock production.

Diagnostics of Animals Diseases Based on the Principles of Neutrosophic Sets and Sugeno Fuzzy Inference

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Abstract. This study is devoted to the development of improved methods for diagnosing cattle diseases based on the principles of neutrosophic sets and Sugeno fuzzy inference. The study proposed new algorithms and models that can effectively process fuzzy and uncertain information characteristic of veterinary diagnostics. The goal of the work is to create a diagnostic system that will have high accuracy and the ability to adapt to various conditions and characteristics of specific disease cases. The expected result of the study is aimed at developing an effective tool for the early detection of diseases in cattle, which will significantly improve the efficiency of veterinary practice and animal welfare.

Keywords: Diagnostic System · Fuzzy Logic · Fuzzy Sugeno Model

1 Introduction

Currently, animals in many countries are susceptible to various diseases. Improvement and implementation of systems based on modern information technologies for the development of methods for early diagnosis of diseases in animals is one of the key tasks. This is important not only to ensure the health and welfare of animals, but also to prevent the spread of diseases that can have serious consequences for livestock production, human health and the economy as a whole. The use of modern information technologies, such as machine learning, data analytics, sensors and telemedicine, can significantly improve diagnostic capabilities, enabling rapid detection and response to diseases, which contributes to effective control and control [1, 2].

Research based on mathematical modeling using fuzzy logic and neutrosophical fuzzy sets is actively being conducted in the world scientific community. These works are aimed at improving and developing computer diagnostic systems designed to identify various types of diseases and their causes in the early stages, as well as to improve treatment methods in veterinary medicine. In this regard, the creation of models for diagnosing animal diseases based on fuzzy logic and neutrosophical fuzzy sets, the

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Single-valued neutrosophical fuzzy sets and interval neutrosophical fuzzy sets are subclasses of neutrosophical fuzzy sets and a generalization of intuitive fuzzy sets and interval intuitive fuzzy sets. The properties of single-valued neutrosophical fuzzy sets and interval neutrosophical fuzzy sets are independently described by degrees of truth, uncertainty and falsity. The main advantage of neutrosophical fuzzy sets is that they provide a powerful formalism for handling information that may be incomplete, uncertain, and contradictory. Unlike conventional fuzzy sets, neutrosophical sets are able to effectively take into account this uncertainty and inconsistency, which makes them more flexible and universal in solving real problems [11].

Recently, various algorithms and methods have been proposed in various studies to deal with single-valued neutrosophical fuzzy sets and interval neutrosophic fuzzy sets [12, 13]. These works introduced basic operations on single-valued and interval neutrosophical fuzzy sets, such as addition and multiplication, as well as corresponding aggregation operators. The basic operational laws for elementary neutrosophical fuzzy sets, including single-valued and interval neutrosophical fuzzy sets, are determined. Weighted mixing aggregation operators were also proposed to combine elementary neutrosophical fuzzy information, which were then applied to the feature decision set [14, 15]. These developments promote more efficient and flexible use of neutrosophical fuzzy sets and their application in various fields, including veterinary medicine, for decision making based on fuzzy and uncertain information.

In work [16], shortcomings of some laws of functioning of unambiguous neutrosophical fuzzy sets were identified. As part of the study, certain principles of the functioning of interval neutrosophical fuzzy sets used for some aggregation operators were also improved. These improved principles were then explored through their application to the decision set based on interval neutrosophical fuzzy information.

In [17–21], a new operator was proposed, which is called the elementary weighted average interval neutrosophical fuzzy advantage operator. This operator was designed for use in a variety of feature-based decision making. The peculiarity of this operator is that, unlike previous works, where the main component was the clear values (weights) of single-valued or interval neutrosophical fuzzy sets, a new approach is introduced here. This approach allows us to take into account a wider range of uncertainty and inconsistencies in the data, which makes it more flexible and adaptive for solving decision-making problems in a fuzzy environment.

Problems with the protein and sugar -protein ratio in the diet of cows, especially if it falls below 0.7–0.79, can lead to the development of dystrophic changes in the liver of animals. This is especially true in case of deficiency of microelements such as copper, cobalt, zinc, manganese, and certain minerals, which can cause metabolic disorders. Micronutrient deficiency can lead to decreased development of microflora in the rumen, increased acidity and ammonia levels in the blood, which in turn causes acidosis and chronic intoxication.

Secondary osteodystrophy, osteodystrophy, microelementosis and ketosis in cattle can be caused by various factors, including diets deficient in calcium, phosphorus and other nutrients, and low sugar to protein ratios in the diet. Symptoms of deficiency of iodine, cobalt, vitamins A and D in cows kept in radioactively contaminated areas include various manifestations, such as dryness and parakeratosis of the skin, enophthalmos,

bradycardia and others. This highlights the need for careful control and balancing of livestock nutrition, as well as regular monitoring of micronutrient and vitamin levels in animals to maintain their health and productivity.

Symptoms of deficiency of iodine, cobalt, and vitamins A and D in cows living in areas exposed to radioactive contamination can be varied and include the following: 86.7% of animals have dryness and parakeratosis of the skin, 26.7% have enophthalmos, in 90% - whitening of the conjunctiva, as well as bradycardia in 57.8% of cows. An enlarged thyroid gland and signs of mexidema were found in 3.35% of animals. In addition, anemia occurs in 92.6% of dairy cows, hypocalcemia in 93.8–100% of animals, and hypophosphatemia in 50–92.6%. There is also a decrease in the content of copper, cobalt and zinc in the blood serum in 90% of animals. These data highlight the serious consequences of deficiencies of important microelements and vitamins in animal diets, especially in conditions of radioactive environmental contamination. Providing cows with adequate nutrition and monitoring their nutrient levels play an important role in maintaining their health and productivity.

2 Methods and Models

This paper presents a new interval neutrosophic logic, which expands previous models, such as interval fuzzy logic- a logical method that uses ranges of values to describe the degree of uncertainty or fuzziness, intuitionistic fuzzy logic- a logical method that uses ranges of values to describe the degree of uncertainty or fuzziness and paraconsistent logic-logical approach in which states are possible that do not contradict themselves, taking into account not only the degree of truth or falsity of the statement, but also the degree of uncertainty. This allows additional information to be taken into account more reliably under conditions of uncertainty. The paper introduces mathematical definitions of interval neurosophical propositional calculus and interval neutrosophic predicative calculus. A general method for developing an interval neutrosophic logic system is also proposed, incorporating neutrosophics, neutrosophic inference.

The resulting intersection of two interval neutrosophic sets A and B, denoted C, is an interval neutrosophic set that includes elements present in both set A and B, which includes elements present in both set A and B. and in set B. Thus, the elements in set C are evaluated taking into account the fuzziness and uncertainty in both set A and set B.

Mathematically this can be represented as:

$$
\begin{aligned}
&C = A \cap B\\
&\inf T_C(x) = \min(\inf T_A(x), \inf T_B(x)),\ \sup T_C(x) = \min(\sup T_A(x), supT_B(x)),\\
&\inf I_C(x) = \max(\inf I_A(x), \inf I_B(x)),\ \sup I_C(x) = \max(\sup I_A(x), \sup I_B(x)),\\
&\inf F_C(x) = \max(\inf F_A(x), \inf F_B(x)),\ \sup F_C(x) = \max(\sup F_A(x), \sup F_B(x)),
\end{aligned}
$$

where C is an interval neutrosophic set representing the intersection of sets A and B.

This paper presents a new intervallic neutrosophical logic that extends previous models such as interval fuzzy logic, intuitionistic fuzzy logic and paraconsistent logic by taking into account not only the degree of truth or falsity of a statement, but also the degree of uncertainty. This allows additional information to be taken into account more reliably under conditions of uncertainty. The paper introduces mathematical definitions of interval neurosophical propositional calculus and interval neutrosophic predicative calculus. A general method for developing an interval neutrosophic logical system is also proposed, including neutrosophics, neutrosophic inference, neutrosophic rule base, neutrosophic type reduction, and deneutrosophics.

R^k: IF $x_1 = < T_{A_1^k}(x_1), I_{A_1^k}(x_1), F_{A_1^k}(x_1) >$ and $x_2 = < T_{A_2^k}(x_2), I_{A_2^k}(x_2), F_{A_2^k}(x_2) >$ and , ...,$x_n = < T_{A_n^k}(x_n), I_{A_n^k}(x_n), F_{A_n^k}(x_n) >$, Then $y_j = b_{j,0} + b_{j,1}x_1 + \ldots + b_{j,n}x_n$.

Here A_i^k is an interval neutrosophical set defined in space X_i with a truth membership function, $T_{A_i^k}(x_i)$, an uncertainty membership function $I_{A_i^k}(x_i)$ and a falsity membership function $F_{A_i^k}(x_i)$, where $T_{A_i^k}(x_i), I_{A_i^k}(x_i), F_{A_i^k}(x_i) \subseteq [0, 1]$, $1 \le i \le n$. B^k is an interval neutrosophic set defined by a space Y with a truth membership function $T_{B^k}(y)$, an uncertainty membership function $I_{B^k}(y)$ and a falsity membership function $F_{B^k}(y)$, where $T_{B^k}(y), I_{B^k}(y), F_{B^k}(y) \subseteq [0, 1]$.

$$
\begin{aligned}
&\text{If } x_1 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle \bigwedge x_2 = \langle [0.75, 0.95], [0.1, 0.15], [0.1, 0.2] \rangle \bigwedge \\
&x_3 = \langle [0.6, 0.75], [0.1, 0.2], [0.2, 0.25] \rangle \bigwedge x_4 = \langle [0.5, 0.6], [0.2, 0.25], [0.25, 0.35] \rangle \bigwedge \\
&x_5 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle \bigwedge x_6 = \langle [0.4, 0.5], [0.2, 0.3], [0.35, 0.45] \rangle \bigwedge \\
&x_7 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle
\end{aligned}
$$

Then $y_1 = 4,9 + 7,8x_1 - 6,9x_2 - 1,5x_3 - 0,3x_4 + 0,37x_5 + 0,06x_6 - 0,003x_7 y_1 = 4,9 + 7,8x_1 - 6,9x_2 - 1,5x_3 - 0,3x_4 + 0,37x_5 + 0,06x_6 - 0,003x_7$

$$
\begin{aligned}
&\text{If } x_1 = x_1 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle \bigwedge x_2 = x_2 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle \bigwedge \\
&x_3 = x_3 = \langle [0.3, 0.4], [0.15, 0.25], [0.45, 0.5] \rangle \bigwedge x_4 = x_4 = \langle [0.4, 0.5], [0.2, 0.3], [0.35, 0.45] \rangle \bigwedge \\
&x_5 = x_5 = \langle [0, 0.05],[0.05, 0.01],[0.8, 0.95] \rangle \bigwedge x_6 = x_6 = \langle [0.05, 0.2], [0.1, 0.15], [0.65, 0.8] \rangle \bigwedge \\
&x_7 = \langle [0.3, 0.4], [0.15, 0.25], [0.45, 0.5] \rangle
\end{aligned}
$$

Then $y_2 = -0,6 - 1,45x_1 + 1,7x_2 + 0,34x_3 - 0,1x_4 - 0,2x_5 - 0,07x_6 - 0,03x_7 y_2 = -0,6 - 1,45x_1 + 1,7x_2 + 0,34x_3 - 0,1x_4 - 0,2x_5 - 0,07x_6 - 0,03x_7$

$$
\begin{aligned}
&\text{If } x_1 = x_1 = \langle [0.6, 0.75], [0.1, 0.2], [0.2, 0.25] \rangle \bigwedge x_2 = x_2 = \langle [0.6, 0.75], [0.1, 0.2], [0.2, 0.25] \rangle \bigwedge \\
&x_3 = x_3 = \langle [0.75, 0.95], [0.1, 0.15], [0.1, 0.2] \rangle \bigwedge x_4 = x_4 = \langle [0.5, 0.6], [0.2, 0.25], [0.25, 0.35] \rangle \bigwedge \\
&x_5 = x_5 = \langle [0.75, 0.95], [0.1, 0.15], [0.1, 0.2] \rangle \bigwedge x_6 = x_6 = \langle 0.3, 0.4], [0.15, 0.25], [0.45, 0.5] \rangle \bigwedge \\
&x_7 = \langle [0.75, 0.95], [0.1, 0.15], [0.1, 0.2] \rangle
\end{aligned}
$$

Then $y_3 = -3,42 - 0,6x_1 + 7,8x_2 + 1,7x_3 - 0,2x_4 - 0,04x_5 - 0,19x_6 - 0,9x_7 y_3 = -3,42 - 0,6x_1 + 7,8x_2 + 1,7x_3 - 0,2x_4 - 0,04x_5 - 0,19x_6 - 0,9x_7$

3 Results

The program was developed and the results were collected. The report includes precision, recall, F1 measure, and support information for each class, as well as overall precision, macro-average precision, weighted precision, and overall support. The confusion matrix shows the number of correctly and incorrectly classified examples for each class (Fig. 1).

Classification Accuracy: 0.8888888888888888
Classification report:
precision recall f1-score support

ketoz 1.00 0.86 0.93 22
mastitis 0.77 1.00 0.87 23
pneumonia 1.00 0.78 0.88 18

accuracy 0.89 63
macro avg 0.92 0.88 0.89 63
weighted avg 0.91 0.89 0.89 63

Confusion Matrix:

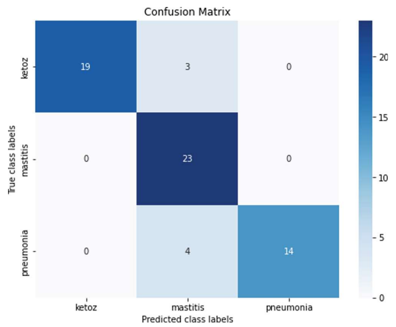

Fig. 1. Confusion Matrix.

Classification Accuracy This is the percentage of correctly classified samples from the entire data set. In this case, the classification accuracy is 88.89%, which means that the model correctly classified 88.89% of the samples.

Classification report: Classification report:

- Precision: This is the proportion of correctly classified positive samples among all positive samples predicted by the model. For example, for the class "ketoz" the accuracy is 100%, which means that all samples predicted as "ketoz" are actually "ketoz".
- Recall (recall): This is the proportion of correctly classified positive samples among all real positive samples in the data set. For example, for the class "mastitis" the recall is also 100%, which means that the model has detected all real examples of the class "mastitis".
- If 1-score: This is the harmonic average of precision and recall. It shows the balance between accuracy and completeness of classification. The F1-measure is close to 1 if both precision and recall are high.
- Support: This is the number of samples in each class.

Confusion Matrix (Confusion Matrix):

It is a square matrix where the rows represent the actual classes and the columns represent the predicted classes by the model. Each element of the matrix shows the number of samples that were classified correctly (diagonal elements) or incorrectly (off-diagonal elements).

4 Conclusion

This study develops improved methods for diagnosing diseases in cattle based on the principles of neutrosophic sets and Sugeno fuzzy inference. The proposed algorithms and models are able to effectively process fuzzy and uncertain information that is typical for veterinary diagnostics. The goal of the study is to create a diagnostic system that is highly accurate and capable of adapting to various conditions and characteristics of specific disease cases.

The expected result of the work is the development of an effective tool for the early detection of diseases in cattle. This will significantly improve the efficiency of veterinary practice and ensure animal welfare. The use of modern information technologies in combination with mathematical modeling based on fuzzy logic and neutrosophical sets makes it possible to create a diagnostic system capable of quickly responding to diseases and preventing their spread.

The model demonstrated good classification accuracy, amounting to 88.89%. This means that most of the samples were classified correctly. Analysis of the classification report allows us to see that the model copes quite successfully with the classification of all three classes (ketosis, mastitis, pneumonia), having high accuracy, completeness and F1-measure. This confirms the good performance of the model. The confusion matrix allows you to visually evaluate which classes were correctly or incorrectly classified. From the matrix, it can be seen that most of the samples were classified correctly, but there are a small number of errors in the classification of some samples. Based on this information, we can conclude that the model copes well with the classification task, but may require some improvement to improve accuracy and reduce the number of errors.

These results have important implications not only for animal health and welfare, but also for the economy and society as a whole. An effective diagnostic system will help improve control of animal diseases, reduce the risk of spreading infections and ensure sustainable development of agriculture.

References

1. Borisevich, V.B., Borisevich, Y.: Enzootic osteodystrophy of cattle in Poselye. J. Vet. Med. **5**, 41–43 (2005)
2. Samokhin, V.T., Ermoleva, T.G.: Correction of energy metabolism in dairy cows. J. Vet. Med. **9**, 44–45 (2004)
3. Firk, R., Stamer, E., Junge, W., Krieter, J.: Improving oestrus detection by combination of activity measurements with information about previous oestrus cases. Livest. Prod. Sci. **82**, 97–103 (2003)
4. Freddy, F.: Fuzzy classification of phantom parent groups in an animal model. Genet. Sel. Evol. **1297**, 41–42 (2009)

5. Orazbayev, B., Ospanov, E., Kissikova, N., Mukataev, N., Orazbayeva, K.: Decision-making in the fuzzy environment on the basis of various compromise schemes. Procedia Comput. Sci. **120**, 945–952 (2017)
6. Marzhan, Y., Talshyn, K., Kairat, K., Belginova, S., Karlygash, A., Yerbol, O.: Smart technologies of the risk-management and decision-making systems in a fuzzy data environment. Indonesian J. Electric. Eng. Comput. Sci. **28**(3), 1463–1474 (2022)
7. Mukhamedieva, D.T., Safarova, L.U.: Main problems and tasks of intellectualisation of information processing system. Int. J. Innov. Technol. Explo. Eng. **8**(9.3), 158–165 (2019)
8. Guo, Y., Sengur, A., Ye, J.: A novel image thresholding algorithm based on neutrosophic similarity score. Measurement **58**, 175–186 (2014)
9. Ye, J.: Single valued neutrosophic minimum spanning tree and its clustering method. J. Intell. Syst. **23**(3), 311–324 (2014)
10. Wang, H., Smarandache, F., Zhang, Y.Q., Sunderraman, R.: Single valued neutrosophic sets. Multispace Multistructure **4**, 410–413 (2010)
11. Zhang, H.Y., Wang, J.Q., Chen, X.H.: Interval neutrosophic sets and their application in multicriteria decision making problems. Sci. World J. **15**, 1–16 (2014)
12. Suyunov, A.S., Mirzayev, A.A., Urakov, O.A., Suyunov, S.: Field studies of electronic total stations in a special reference satellite geodetic basis. Proc. SPIE Int. Soc. Opt. Eng.E Int. Soc. Opt. Eng. **12564**, 125640Y (2023)
13. Liu, P.D., Wang, Y.M.: Interval neutrosophic prioritized OWA operator and its application to multiple attribute decision making. J. Syst. Sci. Complex. **29**(3), 681–697 (2016)