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METHODOLOGY FOR FORMING PERSONAL COMPUTER SPECIFICATIONS BASED ON A FUZZY KNOWLEDGE BASE

МЕТОДОЛОГІЯ ФОРМУВАННЯ СПЕЦИФІКАЦІЙ ПЕРСОНАЛЬНОГО КОМП'ЮТЕРА НА ОСНОВІ НЕЧІТКОЇ БАЗИ ЗНАНЬ

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Abstract. *Fuzzy knowledge bases allow you to create intelligent systems that can work with fuzzy information, which is typical for the real world. This opens up new opportunities for solving complex tasks, such as pattern recognition, managing complex systems, making decisions under uncertainty, etc. The work considers the development of a fuzzy knowledge base for selecting the composition of computer components. Taking into account criteria such as price, user needs, compatibility, terms of use and operating temperature of components, a fuzzy intelligent system should provide an optimal set of components. The optimal selection of computer components requires a comprehensive approach, since there are a large number of factors that should be taken into account for optimal functionality and cost of the system. One of the effective tools for modeling and solving such tasks is a fuzzy knowledge base. Fuzzy systems allow you to work with vaguely defined concepts, which is ideal for tasks where exact answers are difficult or impossible to obtain. The developed methodology can be scaled to other areas of artificial intelligence.*

Keywords: *fuzzy set apparatus, fuzzy knowledge bases, artificial intelligence, linguistic variables*

Introduction.

In the modern world, where information is a key resource, the ability to effectively process and use knowledge is critically important. However, the real world is often characterized by uncertainty, incompleteness and contradictory data. In such conditions, traditional methods of information processing are not effective enough. That is why the creation of fuzzy knowledge bases acquires special scientific significance.

Fuzzy knowledge bases are an innovative approach to the representation and processing of knowledge, which is based on the theory of fuzzy sets. This theory allows you to operate with concepts that do not have clearly defined boundaries, such as "high", "warm" or "fast". Due to this, fuzzy knowledge bases can be successfully used in conditions of uncertainty, where traditional methods fail.

The scientific significance of the creation of fuzzy knowledge bases lies in their ability to solve a wide range of tasks that are difficult or insoluble for traditional artificial intelligence systems. Here are some examples:

• Pattern recognition: Fuzzy knowledge bases allow for effective pattern recognition, even when they are distorted or partially hidden.

• Complex systems management: Fuzzy knowledge bases can be used to manage complex systems, such as industrial robots or transportation networks, under conditions of uncertainty and change.

• Decision making: Fuzzy knowledge bases help make informed decisions in conditions of incomplete or contradictory information.

• Forecasting: Fuzzy knowledge bases can be used to predict complex phenomena, such as weather or economic trends.

In addition, the creation of fuzzy knowledge bases contributes to the development of fuzzy set theory itself, expanding its capabilities and areas of application.

Thus, the scientific significance of the creation of fuzzy knowledge bases lies in their ability to effectively work with uncertain information, solve complex problems, and contribute to the development of fuzzy set theory. This makes them an important tool for the development of modern information technology and artificial intelligence.

Developing a fuzzy knowledge base

Creating a fuzzy knowledge base is a complex and iterative process that requires a deep understanding of the subject area, fuzzy logic methods and modern information technologies. However, a successfully created fuzzy knowledge base allows you to effectively solve the problems of modeling, management and decision-making under conditions of uncertainty and fuzziness.

Strategies for developing fuzzy knowledge bases using Mamdana-type fuzzy inference rules are considered in [1]. Creating an intelligent expert system using the fuzzy set apparatus is given in [2]. Creating a fuzzy expert system for regulating the level of electricity generation of nuclear power plants is described in [3].

We will begin the development of a fuzzy knowledge base (using at least 5 linguistic variables) for the task of selecting components for a computer (taking into account price, user needs, compatibility, terms of use and operating temperature of components) by defining the input and output sets.

For this task, we will distinguish the following input sets:

- Price;
- User needs;
- Component compatibility;
- Terms of use;
- Operating temperature of components.

The output set will be:

- Computer component class

Now let's write the basic "if, then" rules to display the relationship between the input data and the output result.

- If the price is low, the user needs are office programs, component compatibility is compatible, terms of use are a year, operating temperature is average, then the component class is low-power.
- If the price is high, the user needs are games, component compatibility is compatible with the adapter, terms of use are several years, operating temperature is high, then the component class is powerful.
- If the price is average, the user needs are 3D modeling, component compatibility is compatible, terms of use are many years, operating temperature is average, then the component class is medium-power.
- If the price is high, the user needs are office applications, the compatibility of components is compatible with the adapter, the terms of use are for many years, the operating temperature is low, then the class of components is powerful.
- If the price is low, the user needs are games, the compatibility of components is incompatible, the terms of use are for a year, the operating temperature is high, then the class of components is low-power.
- If the price is medium, the user needs are 3D modeling, the compatibility of components is compatible with the adapter, the terms of use are for several years, the operating temperature is high, then the class of components is medium-power.

• If the price is low, the user needs are office applications, the compatibility of components is compatible, the terms of use are for many years, the operating temperature is low, then the class of components is low-power.

• If the price is high, the user needs are games, the compatibility of components is compatible, the terms of use are for a year, the operating temperature is medium, then the class of components is powerful.

• If the price is average, the user needs are 3D modeling, the compatibility of components is incompatible, the service life is several years, the operating temperature is high, then the component class is medium power.

• If the price is high, the user needs are games, the compatibility of components is compatible with the adapter, the service life is many years, the operating temperature is high, then the component class is powerful.

From these rules, we define linguistic variables and the range of their possible values:

Input sets:

- Price (low, medium, high);
- User needs (office programs, games, 3D modeling);
- Compatibility of components (incompatible, compatible with an adapter, compatible);
- Terms of use (for a year, for several years, for many years);
- Operating temperature of components (low, medium, high).
- Output set:
- Class of components for a computer (low-power, medium-power, powerful).

Checking the completeness of a fuzzy knowledge base

Membership functions are required for generating fuzzy rules, and rules are required for performing fuzzy inference. In addition, when generating fuzzy rules automatically, it is necessary to ensure their completeness and consistency. A significant part of the methods for training fuzzy systems uses genetic algorithms. In the English-language literature, this is called Genetic Fuzzy Systems. A significant contribution to the development of the theory and practice of fuzzy systems with evolutionary adaptation was made by a group of Spanish researchers led by F. Herrera

[4].

Since the given rules for this example do not contradict each other and each value of any of the sets (input and output) was used at least once, the developed knowledge base model can be considered complete.

Fuzzy knowledge base modeling

Using the MatLab program (a package of applications for numerical analysis, as well as the programming language used in this package [5]. The system was created by The MathWorks and is a convenient tool for working with mathematical matrices, drawing functions, working with algorithms, creating working shells with programs in other programming languages. MATLAB is a powerful tool for working with fuzzy knowledge bases due to its numerous advantages that make it an ideal choice for developing and analyzing such systems.

Here are some of the key advantages of using MATLAB to work with fuzzy knowledge bases:

- Fuzzy Logic Toolbox: MATLAB includes a specialized toolbox called the Fuzzy Logic Toolbox, which provides all the necessary functions and tools for working with fuzzy knowledge bases. This toolbox includes functions for creating fuzzy sets, defining rules, fuzzification and defuzzification, as well as for modeling and analyzing fuzzy systems.

- Convenient development environment: MATLAB provides an intuitive development environment with capabilities for visually creating and editing fuzzy knowledge bases. Users can easily create and modify fuzzy sets, rules, and other system components using a graphical interface.

- Powerful modeling and simulation tools: MATLAB allows you to model and simulate the operation of fuzzy systems to analyze their behavior and optimize parameters. Users can easily specify input data and observe output results, as well as change system parameters to achieve desired results.

- Extensive visualization capabilities: MATLAB provides extensive capabilities for visualizing data and results of working with fuzzy knowledge bases. Users can plot fuzzy sets, display rules, and model results, making it easier to understand and analyze the system.

- Integration with other tools: MATLAB can integrate with other tools and extension packages to extend the functionality and capabilities of working with fuzzy knowledge bases. For example, users can use MATLAB together with other tools for signal processing, image processing, or statistical data analysis.

- Large user community and support: MATLAB has a large user community that provides access to resources, documentation, and support. Thanks to these advantages, MATLAB is a powerful and convenient tool for working with fuzzy knowledge bases, which allows you to design, analyze, and optimize complex systems based on fuzzy logic.

Although this product specializes in numerical computation, special tools work with the Maple software, making it a full-fledged system for working with computer algebra [6].

We will present this task in the form of fuzzy sets. Next, we rename the input and output sets, change the ranges of the sets, configure the function names and parameters, configure the input sets, the output set, and set the rules for the fuzzy knowledge base being created using Edit-Rules (Figures 1-2).

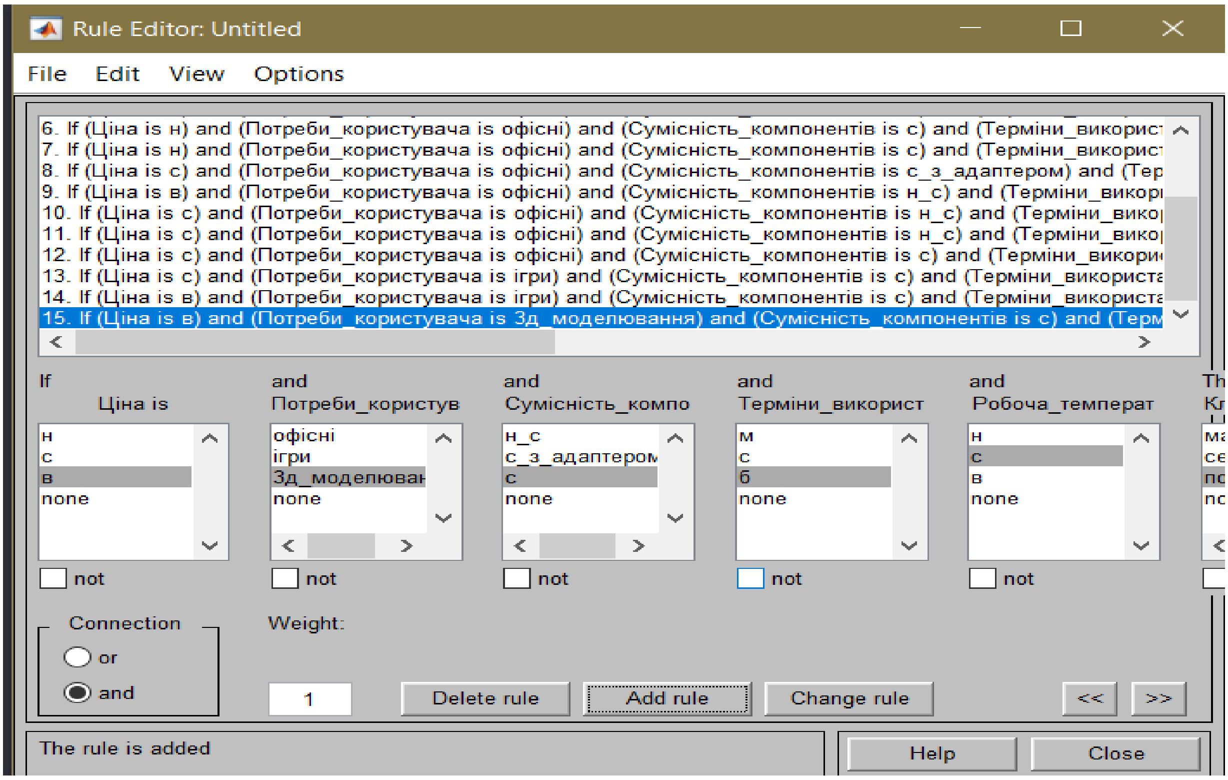

Figure 1 – Set rules – part 1

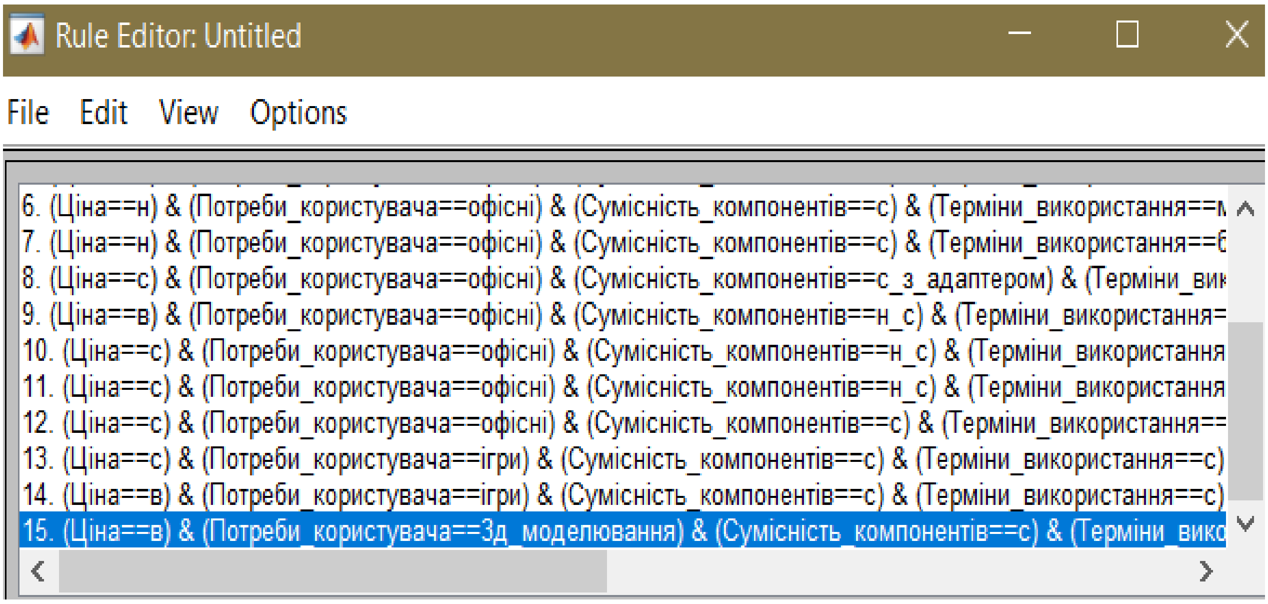

Figure 2 – Set rules – part 2

Testing a simulated fuzzy knowledge base

After modeling the appropriate fuzzy knowledge base, it is necessary to proceed to the View-Rules section to visualize the correlation between the input and output data. Term correlation in fuzzy knowledge bases is an important aspect that plays a key role in ensuring the efficiency and accuracy of such systems. Here are some of the key values of performing term correlation:

1. Increasing accuracy and relevance:

• Term correlation allows you to identify and establish relationships between different concepts and terms used in the knowledge base. This is especially important for fuzzy knowledge bases, where terms can have vague or ambiguous meanings.

• Establishing correlations allows the system to better understand the context and meaning of user queries, which helps to increase the accuracy and relevance of the results.

2. Eliminating redundancy and contradictions:

• Term correlation helps to identify and eliminate redundancy or contradictions in the knowledge base. For example, if two terms have similar meanings, the system can combine them or use one of them to represent both concepts.

• This helps to simplify the knowledge base and increase its efficiency.

3. Automatic query expansion:

• Term correlation can be used to automatically expand the user's queries. For example, if the user is searching for information about "big cities", the system can automatically add terms such as "megacities", "millionaires", etc. to the query.

• This allows you to get more complete and relevant results, even if the user does not use all possible term variants.

4. Support for logical inference:

• Term correlation is an important component of logical inference in fuzzy knowledge bases. Establishing relationships between terms allows the system to make logical conclusions and infer new information based on existing knowledge.

• For example, if the system knows that "all cats are mammals" and "all mammals have fur", it can conclude that "all cats have fur".

5. Improve interoperability:

• Term correlation helps improve interoperability between different systems and knowledge bases. If different systems use similar terms, establishing correlations between them allows for more efficient exchange of information and knowledge.

6. Simplify development and maintenance:

• Properly established term correlations can simplify the process of developing and maintaining fuzzy knowledge bases. A clear structure and logical relationships between terms make it easier to understand and edit a knowledge base.

7. Adapt to change:

• Term correlations can help a system adapt to changes in the subject area. If new terms appear or the meanings of existing ones change, the system can automatically or with the help of an expert update the correlations and ensure that the knowledge base is up to date.

In general, performing term correlation is critical to ensuring the efficiency, accuracy, and intelligence of fuzzy knowledge bases. This process contributes to better understanding and processing of information, which makes fuzzy knowledge bases a powerful tool for solving complex problems in various industries. The beginning of term correlation is shown in Figure 3.

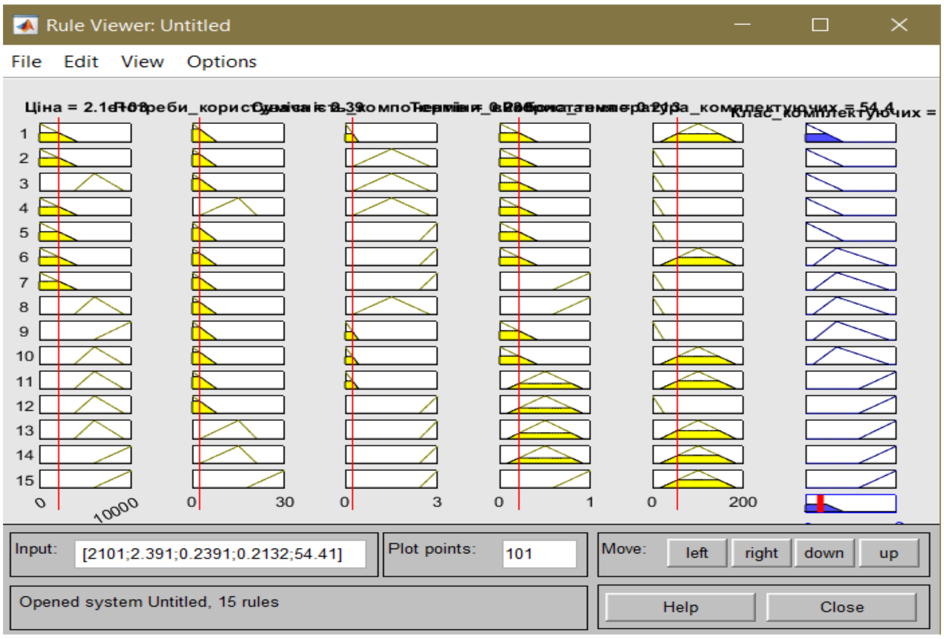

Figure 3 – Beginning of the term correlation process

We will use the created fuzzy knowledge base model to find the optimal class of components for the following input data:

- Price - high
- User needs - scope - 3D modeling
- Compatibility of components - compatible
- Terms of use - several years
- Operating temperature of components - above average

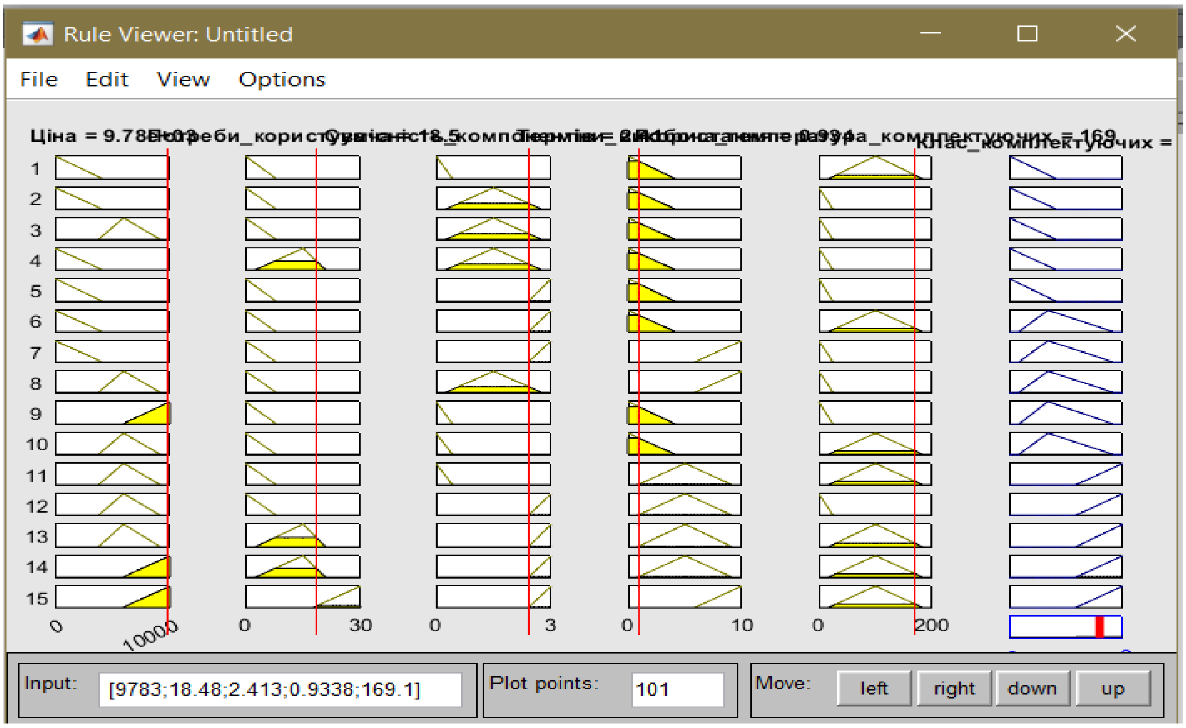

Figure 4 - Using the created knowledge base on a real example

We enter these input data into the model and obtain the result that the most optimal class of components is powerful, which is demonstrated in Fig. 4.

Conclusions.

During the creation of the methodology, the following theoretical aspects were considered:

1. Basic terms of fuzzy set theory: the study and understanding of the basic concepts of fuzzy logic is the foundation for further research.

2. Approaches to fuzzy set theory: the analysis of various approaches and their application in various areas indicates the flexibility and universality of fuzzy sets.

3. Operations on fuzzy sets: a detailed study of operations such as union and intersection provides the opportunity to effectively use fuzzy sets in practical tasks.

4. Fuzzy relations: consideration of aspects of fuzzy relations expands the understanding of the possibilities of modeling and analyzing fuzziness in various contexts.

The implementation of creating a fuzzy scalable knowledge base consists of the following stages:

1. Development of a fuzzy knowledge base: the implementation of a fuzzy knowledge base for selecting computer components emphasizes the practical application of fuzzy logic in modern technological tasks. Input and output sets and their correlation were identified.

2. Checking the completeness of the fuzzy knowledge base: assessing the completeness of the knowledge base allows us to verify that all necessary aspects are taken into account when making decisions and that the designed and implemented knowledge base is reliable enough to obtain optimal advice in specific cases.

3. Modeling the fuzzy knowledge base: the MatLab environment was used as a tool for modeling the knowledge base.

4. Testing the simulated fuzzy knowledge base: it was tested and determined that the results of the model on real data indicate its full adequacy to the subject area and effectiveness in making decisions on creating specifications for personal computers.

Creating a methodology for forming specifications for a personal computer (PC) based on a fuzzy knowledge base is an important step in the development of computer technologies using artificial intelligence methods. This approach allows taking into account the subjective and fuzzy requirements of users for a PC, which is especially relevant in the modern world, where there is a wide variety of configurations and components. The proposed methodology allows optimizing the configuration of a PC according to various criteria, such as performance, cost, power consumption, etc. An algorithm is created that allows forming a PC specification based on user requirements and a fuzzy knowledge base.

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Анотація. *Нечіткі бази знань дозволяють створювати інтелектуальні системи, які можуть працювати з нечіткою інформацією, що є характерним для реального світу. Це відкриває нові можливості для вирішення складних завдань, таких як розпізнавання образів, управління складними системами, прийняття рішень в умовах невизначеності тощо. В роботі розглядається розробка нечіткої бази знань для вибору складу комплектуючих для комп'ютера. Враховуючи критерії, такі як ціна, потреби користувача, сумісність, терміни використання і робоча температура комплектуючих, нечітка інтелектуальна система повинна надати оптимальний набір компонентів. Оптимальний вибір комплектуючих для комп'ютера вимагає комплексного підходу, оскільки існує велика кількість факторів, які слід враховувати для оптимальної функціональності та вартості системи. Одним із ефективних інструментів для моделювання та вирішення таких завдань є нечітка база знань. Нечіткі системи дозволяють працювати з нечітко визначеними поняттями, що ідеально підходить для задач, де точні відповіді важко або неможливо отримати. Розроблена методологія може бути масштабована на інші напрямки штучного інтелекту.*

Ключові слова: *апарат нечітких множин, нечіткі бази знань, штучний інтелект, лінгвістичні змінні*

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