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The Role of Intellectual Systems in Decision-Making in Uncertain Environments

Nurmakhamad Juraev [1], *Mubina Odiljonova* [2]

When making managerial decisions under uncertainty, the lack of information, risk factors, and subjective views influence the outcome. Uncertainty is the avoidance of exact solutions, that is, a situation where one deviates from the optimal result. In any management process, decision-making is a critical stage. Decision-making is the process of selecting the best option from available alternatives to achieve a specific goal. In other words, it is the process of finding the optimal solution to a problem or desired result and implementing it in practice. However, in real life, decisions are not always made based on complete information or under precise conditions. Subjective and objective thinking, uncertainty, and insufficient data affect the quality of decisions and their outcomes. In many cases, decision-makers act under the influence of uncertainty and unknown factors. Therefore, decision-making in an uncertain environment has become an important research area in economics, management, psychology, and mathematics.

The Concept of an Uncertain Environment and Its Causes

The effectiveness of any management system primarily depends on the correctness of decision-making. Decision-making is the process of choosing the best outcome from available options to achieve a set goal.

In reality, however, decisions are influenced not by complete information, but by uncertainty, risk, and random factors.

In recent years, intellectual approaches have been widely applied in management systems — such as artificial intelligence, expert systems, neural networks, and fuzzy models. The term “fuzzy” in English means “uncertain, vague,” that is, beyond precision. These approaches allow the development of correct decisions even in complex, uncertain, and dynamic conditions. Therefore, decision-making in an uncertain environment within intellectual systems is one of the most relevant contemporary scientific problems.

Uncertain Environment — this refers to external conditions in which the decision-maker or system does not have complete knowledge of outcomes or their probabilities. In such an environment, the following factors play a key role:

- Lack of information — required data is incomplete or unreliable.
- Variability of the external environment — economic, political, and technological factors change frequently.
- Human factor — subjective opinions, emotions, errors, and differences in experience.
- Randomness — processes whose outcomes cannot be predicted in advance.

Intellectual Systems — these are software complexes that analyze information similarly to human thinking, are capable of learning, and can make independent decisions. They are based on artificial intelligence and consist of the following components:

- Knowledge base
- Logical inference engine

[1] Fergana State Technological University, Fergana, Uzbekistan

- Learning module (machine learning)
- User interface

Decisions under uncertainty rely on human experience, intuition, and logical analysis.

Several models and approaches have been developed to scientifically support decision-making in uncertain conditions:

1. Probabilistic models

Outcomes are determined probabilistically, allowing decisions to be made based on statistical data.

2. Fuzzy logic models

Developed by L. Zadeh, this approach uses intermediate values ("partially yes," "mostly no," etc.) instead of a simple "yes" or "no." For example, a system can express a qualitative judgment like "high risk" with a probability of 0.8. This makes decisions more flexible.

3. Expert systems

An expert system transfers a specialist's knowledge to a computer and automatically makes decisions. It is widely used in medicine for diagnosis or in manufacturing for fault detection.

4. Neural networks

Artificial neural networks learn complex nonlinear relationships and make conclusions based on experience. They are self-learning and effective for forecasting and classification problems.

5. Hybrid systems

Recently, hybrid intellectual systems combining fuzzy logic, expert systems, and neural networks have been developed. They provide high accuracy in complex management, economic analysis, and forecasting.

Using intellectual systems in decision-making helps achieve precise results and increases the reliability of outcomes. These systems are applied in areas such as:

- Economic forecasting and investment analysis
- Transport management and logistics
- Medical diagnostics
- Monitoring of energy systems
- Climate change prediction
- Automation of production processes

For example, in manufacturing enterprises, an intellectual system can analyze uncertain production data and predict maintenance schedules in advance.

Expert evaluation methods

When information is lacking, expert knowledge is used. For example, assessing the risk of a new investment project relies heavily on expert opinions.

Today, information technologies are a key tool for reducing uncertainty.

Artificial intelligence, machine learning, forecasting systems, and simulation models allow the analysis of uncertain processes.

The advantages of managing uncertainty in intellectual systems include:

- Rapid and precise decision-making
- Reduced human errors

- Automated data analysis
- Improved system efficiency through self-learning (machine learning)
- Real-time monitoring of uncertainty levels

CONCLUSION

All this increases the level of accuracy and enables optimal outcomes.

Decision-making in an uncertain environment is one of the central problems for intellectual systems. Integrating fuzzy logic, expert systems, and neural networks enables effective management of uncertainty, risk reduction, and development of optimal solutions. Decision-making mechanisms based on intellectual systems approach human reasoning and significantly improve the quality of management processes.

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