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Application of evolutionary algorithms for innovative educational management in modern uncertain environments in conditions of dynamic complexity

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Abstract. *The paper addresses the limitations of traditional educational management in unstable and complex environments. It highlights the potential of evolutionary algorithms and hybrid intelligent systems for adaptive decision-making, forecasting, and optimization. The study proposes integrating genetic algorithms, swarm intelligence, and machine learning to enhance flexibility and resilience in modern digital education.*

Keywords*: educational management, decision support, uncertainty, optimization, evolutionary algorithms.*

Introduction.

In today's rapidly developing global economy and fierce competition in the services market [1, 2], organizations are faced with increasing dynamic complexity and a high level of uncertainty [3-5] and risk. These factors complicate the process of making management decisions, reduce the accuracy of forecasts and increase risks in the field of innovation management [6-8]. Traditional approaches to optimization and classical control algorithms often prove ineffective when it is necessary to quickly adapt to changes in the external environment and complex relationships in the system [9-13]. In this regard, metaheuristic optimization algorithms (mainly evolutionary) - acquire special importance [14]. They provide a flexible and adaptive approach to finding optimal solutions in complex multidimensional problems, allowing to take into account uncertainty factors and rapid changes in operating conditions [15], [16], they demonstrate the ability to effectively learn and generate optimal management strategies in a changing market environment [17]. Thus, the integration of metaheuristic algorithms into the practice of innovative management opens up new prospects for increasing the competitiveness of organizations, rational use of resources and making effective management decisions in complex and uncertain conditions.

The Main Part.

Modern educational systems operate in conditions of high dynamism, complex interactions and constant uncertainty. Global changes, technological innovations and crisis situations require educational institutions to be highly adaptable, able to make decisions quickly and effectively redistribute resources to ensure sustainable development.

One of the most promising tools in such conditions is evolutionary computing methods - algorithms based on the principles of biological evolution, including genetic algorithms, evolutionary strategies, swarm approaches and their hybrid modifications. These technologies allow you to optimize management processes, adjust strategies and predict possible scenarios for the development of educational systems under conditions of instability.

Effective use of evolutionary computing in adaptive management of education provides opportunities for:

- development of flexible and adaptive strategies for managing educational institutions;
- modeling and forecasting the dynamics of the development of educational programs;
- assessment of the effectiveness of the implementation of innovative technologies and teaching methods;
- reducing risks arising in conditions of crises and unforeseen changes;
- ensuring a personalized approach to learning and supporting the sustainability of the educational environment.

Thus, the integration of evolutionary computing with educational management systems creates the basis for intelligent decision-making and strategic planning in complex and uncertain conditions.

Conclusions.

The application of evolutionary computing methods in adaptive management of educational systems demonstrates a high potential for increasing their efficiency and sustainability in conditions of complex dynamics and uncertainty.

Creation of intelligent management platforms - "smart" decision support systems are being formed, capable of adapting to individual and organizational needs.

In the future, the application of evolutionary computing methods can become a key element of sustainable and adaptive education management, capable of functioning effectively in conditions of uncertainty and crises, ensuring strategic development and innovative improvement of the educational system.

Discussion.

As already stated above, the modern education system operates in conditions of high dynamism, global instability and constant challenges associated with uncertainty and crisis situations. This requires the use of new intellectual tools capable of providing adaptive management of educational processes and educational projects.

That is why the author puts forward a debatable thesis that currently the use of HYBRID evolutionary computing, which combines the principles of biologically inspired algorithms (genetic algorithms, evolutionary strategies, swarm methods) with the capabilities of other intelligent technologies - neural networks, machine learning, fuzzy logic and optimization methods, is of particular interest.

Such synthetic integration [18] allows us to create more stable and flexible decision-making algorithms [19], effective in a changing external environment, in complex conditions of uncertainty and crises [20], [21]. The main advantage of these technologies is the ability to integrate different approaches to analysis and optimization, providing multi-criteria decision-making and forecasting of complex processes in conditions of growing uncertainty.

They can be applied both at the strategic level of educational management (policy development, long-term programs), and at the tactical and operational levels (resource allocation, schedule optimization, innovation implementation). In addition, these methods open up prospects for the development of intelligent educational platforms that can adapt to the individual needs of students and the requirements of society.

In the long term, it is hybrid evolutionary computing that can become the basis of “smart education management systems” that provide a balance between innovation, resilience and adaptability, which is especially important in conditions of global crises and constant transformations.

Thus, hybrid evolutionary methods become a fundamental basis for creating new decision-making support systems in education.

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