AN APPROACH TO UNIVERSITY RESOURCE PLANNING BASED ON GENETIC ALGORITHMS AND NONLINEAR PROGRAMMING

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In the context of growing global competition among higher education institutions, improving universities' positions in international rankings, in particular the QS World University Rankings, has become a strategic objective and requires scientifically grounded approaches to development management. Achieving target values of ranking indicators under conditions of limited financial, human, and organizational resources necessitates the formalization of the resource planning problem using modern mathematical methods. This paper considers an approach to university resource planning based on a combination of nonlinear programming and genetic algorithms, building on the authors' previous research on modeling the impact of key QS WUR indicators on the strategic development of higher education institutions [1].

The resource allocation problem is formalized as a quadratic optimization model with Boolean variables and linear constraints, where the objective function minimizes the weighted quadratic deviation between current and target values of ranking indicators. Each indicator can be improved through the implementation of alternative managerial actions that require different amounts of resources, making the model discrete and nonlinear in nature. The presence of multiple criteria, interdependencies among indicators, and incomplete input data significantly complicates the application of classical nonlinear programming methods and limits their ability to find globally optimal solutions.

Given these limitations, the use of a genetic algorithm as a metaheuristic optimization method capable of efficiently exploring the feasible solution space is justified. Genetic algorithms are widely applied to constrained multi-criteria optimization problems and demonstrate high robustness to nonlinearity and the structural complexity of objective functions [2]. Within the proposed approach, each chromosome is interpreted as a scenario of resource allocation across the main areas of university activity, while the fitness function is defined by the value of the objective function of the mathematical model subject to resource constraints. The selection, crossover, and mutation operators enable the generation of a set of alternative managerial decisions and support an effective search for optimal scenarios.

An experimental study was conducted to evaluate the effectiveness of the proposed approach based on a genetic algorithm and a nonlinear optimization model using the National Technical University «Kharkiv Polytechnic Institute» as a case study. The experiments employed up-to-date QS World University Rankings indicator values corresponding to the current state of NTU «KhPI», as well as realistic constraints on the possible annual growth of indicators and the total volume of available resources. The modeling was performed for the problem of maximizing the integral QS Score under fixed resource units while accounting for nonlinear

dependencies. The experimental results showed that the genetic algorithm enables an increase in the overall QS Score of more than 5% compared to the initial value, generating alternative resource planning scenarios and demonstrating high flexibility in strategic analysis tasks. The use of the nonlinear optimization model made it possible to obtain well-grounded solutions with the most efficient use of available resources, confirming the adequacy of the proposed model and its suitability for practical application in strategic university development planning.

The combination of nonlinear programming methods with the heuristic capabilities of genetic algorithms provides model flexibility, adaptability to changes in weighting coefficients of ranking indicators, and support for scenario analysis.

The practical application of this approach allows for evaluating the efficiency of different university development strategies and formulating recommendations on the priority use of limited resources to improve positions in international rankings. The effectiveness of genetic algorithms for constrained optimization problems is also confirmed by contemporary research in this field [3]. The obtained results can be integrated into a decision support information system for strategic management of higher education institutions' development.

References: 1. Grinchenko, M., & Shaposhnikov, M. (2025). MATHEMATICAL MODELING FOR UNIVERSITY RESOURCE OPTIMIZATION BASED ON QS WUR INDICATOR. Bulletin of National Technical University «KhPI». Series: System Analysis, Control and Information Technologies, (2 (14), 54–61. https://doi.org/10.20998/2079-0023.2025.02.07. **2.** Huang, G., Hu, M., Yang, X., Wang, X., Wang, Y., & Huang, F. (2024). A Review of Constrained Multi-Objective Evolutionary Algorithm-Based Unmanned Aerial Vehicle Mission Planning: Key Techniques and Challenges. Drones, 8(7), 316. https://doi.org/10.3390/drones8070316. **3.** ALIOUI, Y., & ACAR, R. (2020). AN EVALUATION OF A CONSTRAINED MULTI-OBJECTIVE GENETIC ALGORITHM. Health Sciences Quarterly, 4(2), 137–146. https://doi.org/10.26900/jsp.4.011