OPTIMIZATION OF UNIVERSITY INTERNAL INDICATORS TO IMPROVE POSITIONS IN QS WORLD UNIVERSITY RANKINGS USING A GENETIC ALGORITHM

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In today's competitive environment, improving the position of a higher education institution (HEI) in international rankings is a strategic task for university leadership. One of the most influential rankings is the QS World University Rankings (QS WUR), which is based on nine key indicators: academic reputation, employer reputation, student-to-faculty ratio, citations per faculty, share of international faculty, share of international students, international research network, graduate employability, and sustainability [1]. Each indicator has specific calculation formulas based on the internal variables of the university, such as the number of publications, international students, cooperation, and others.

This research formulates a multi-criteria optimization problem: to determine such a set of strategic changes in HEI internal indicators that would maximize the overall QS score under existing budgetary, staffing, and time constraints. The challenge lies in the presence of nonlinear dependencies and partially inaccessible or approximated data (e.g., academic reputation indicators), which necessitates the use of optimization methods capable of handling such constraints [2].

The study analyzed approaches to solving the problem: linear programming, nonlinear programming, Bayesian optimization, deep learning, and agent-based modeling. Linear programming was unsuitable due to fractional and logarithmic dependencies in the objective function and constraints. Nonlinear programming requires complete formalization of functions and derivatives, which is impractical given the lack of full data and sensitivity to initial conditions.

Bayesian optimization is promising for working with “black boxes” – complex functions without an analytical expression and expensive computations. It combines stochastic search with surrogate modeling, gradually refining the solution. In higher education management, Bayesian optimization can be applied to find optimal managerial parameters such as research funding allocation, academic exchanges, or workload distribution to maximize performance indicators (e.g., QS ranking or internal KPIs).

Agent-based modeling can serve as a supporting tool for simulating system behavior and assessing the impact of management decisions over time. However, it is not a direct optimization method and cannot guarantee finding an optimal set of variables. Deep learning requires large, high-quality, representative datasets, which are not currently publicly available, making proper training impossible.

The most appropriate method selected is the genetic algorithm (GA). It does not require an analytical function, effectively handles nonlinear models, adapts easily to changes in the number of variables, and allows constraints (e.g., limits on the growth of international students or research budget) [2, 3]. GA simulates natural selection: generating a population of strategies, evaluating them using a quality function (QS Score), performing selection, crossover, and mutation, and gradually approaching the global optimum.

To implement the GA, a QS Overall Score function was developed based on nine components and their formulas. Variables included the number of Scopus publications, the number of international students, the share of international faculty, and the number of employed graduates. Constraints on maximum annual growth of variables were integrated. The GA was implemented in Python using the DEAP, NumPy, and Pandas libraries, with visualization conducted via Matplotlib and Plotly.

The application of GAs in educational strategic planning has been confirmed in prior studies [4–6]. For example, cellular and multi-objective GAs have been used for resource allocation and education quality improvement. Testing of the proposed model demonstrated that it can not only identify optimal internal indicators but also highlight variables with the greatest impact on the university’s overall ranking. The model can support decision-making by HEI leadership for strategic planning of institutional development.

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