TOWARDS THE DEVELOPMENT OF AN AGENT-BASED MODEL FOR IMPROVING BUSINESS PROCESSES IN HIGHER EDUCATION INSTITUTIONS

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In today's environment of global competition among universities, the ability of higher education institutions (HEIs) to rapidly adapt to environmental changes and improve internal business processes plays a crucial role. One of the key indicators of effective university management is its position in international rankings, especially the QS World University Rankings (QS WUR). A high position in such rankings is not only a matter of reputation but also a decisive factor in attracting applicants, securing funding, and establishing international partnerships.

Given the complexity of HEI management systems and the multitude of interdependent factors influencing ranking outcomes, traditional approaches to change planning may prove insufficient. In this context, agent-based modeling emerges as an innovative solution, enabling the simulation of actions by individual agents (stakeholders in the educational process) who make autonomous decisions within a complex environment, taking into account both internal resources and external constraints.

This paper proposes an approach for developing an agent-based model aimed at optimizing the business processes of a higher education institution to improve its QS WUR ranking. The model integrates Agent-Based Modeling (ABM) for simulating the university's strategic decisions and Neural Network (NN) forecasting for evaluating the effectiveness of those decisions. It enables simulation of various managerial decision scenarios under resource constraints and provides a forecast of potential improvements in the ranking score. Particular attention is given to formalizing agent actions, structuring the model, and its potential integration into the university's decision support system.

A promising direction is the application of agent-based approaches to resource allocation optimization, as supported by current research. For instance, [1] presents a heterogeneous Markov chain model for effective allocation of diverse resources in complex systems. In [2], the MG-RAO algorithm is proposed for multi-agent systems with dynamic demands, based on reinforcement learning. Study [3] explores online optimization in open multi-agent systems where agents may join or leave, which is

especially relevant for the flexible resource management required in HEIs. Reference [4] offers a model for analyzing QS WUR score formation, revealing connections between internal activities and ranking performance.

The authors of [5] apply the agent-based approach to address constraints in multi-core computing systems, showcasing the benefits of decentralized methods. In [6], agent-based modeling is used to optimize emergency department resources, focusing on bottleneck identification and performance improvement.

The proposed model adapts the agent-based approach to the HEI environment using neural network forecasting. It simulates the actions and interactions of various agents (students, faculty, administration, employers, partners) within the educational ecosystem. Each action has a cost, and the model allows selecting actions with the best expected benefit-to-cost ratio. This enables capturing complex system behavior in response to management decisions regarding resource distribution.

The neural network regression model forecasts outcomes based on historical data, accounting for temporal dependencies and nonlinear relationships between parameters. This is especially valuable for long-term institutional planning. The agent representing the university aims to maximize its ranking score (Normalized Score) by selecting optimal actions within the defined environment, relying on neural network-generated predictions.

The model structure includes the following components: agents (students, faculty, administration, applicants, employers, alumni); QS WUR parameters (academic reputation, employer reputation, citations per faculty, internationalization including international faculty and students, student-to-faculty ratio, and others); and a neural module that analyzes QS WUR historical data and predicts the impact of changes (e.g., increased international collaboration or investment in research) on ranking position.

The proposed modeling approach forms an innovative foundation for strategic HEI business process management. Unlike static analysis methods, the agent-based model enables dynamic simulation of the university's behavior as a unified agent in a complex environment. This supports flexible decision-making and enhances predictability of outcomes.

Future research will focus on training the neural network model to forecast optimal strategies and testing the model on real historical data. The integration of agent-based modeling with neural forecasting creates a robust tool for strategic HEI development. This approach supports evidence-based decision-making at the leadership level and enables business process optimization to achieve better results in global education rankings.

References:

1. Razzaghi, T., Rausch, T., Dustdar, S. (2021). Multi-resource allocation for federated settings: A non-homogeneous Markov chain model. *arXiv preprint* arXiv:2104.12828. doi:10.48550/arXiv.2104.12828

2. Anagnostopoulos, I., Panagopoulos, G., Katsaros, D. (2021). Resource allocation in dynamic multiagent systems. *arXiv preprint* arXiv:2102.08317. doi:10.48550/arXiv.2102.08317

3. Raghunandan, M., Kumar, V., Srivastava, M. (2022). Resource allocation in open multi-agent systems: an online optimization analysis. *arXiv preprint* arXiv:2207.09316. doi:10.48550/arXiv.2207.09316

4. Grinchenko, M. A., Shaposhnikov, M. I. (2024). Analysis of higher education institutions' performance indicators based on QS World University Rankings assessment. *Вісник Національного технічного університету «ХПІ». Серія: Стратегічне управління, управління портфелями, програмами та проектами*, № 2 (9), 16–26. doi:10.20998/2413-3000.2024.9.3

5. Li, Z., Qiao, M., Zhu, H. (2022). Agent-based constraint solving for resource allocation in manycore systems. *arXiv preprint* arXiv:2204.06603. doi:10.48550/arXiv.2204.06603

6. Khalid, M. S., Ariffin, A. M., Rashid, R. A. (2013). Agent-based modeling and simulation of resource allocation in emergency departments. In *2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC)*, 139–144. doi:10.1109/BEIAC.2013.6560119