METHODOLOGICAL FOUNDATIONS OF INTERACTIVE MODELING FOR INTELLIGENT CONTROL SYSTEMS IN DIGITAL ECONOMIC ENVIRONMENTS

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Abstract: This paper explores the role of interactive modeling methods in the synthesis of intelligent control systems for technical objects within the digital economy. The study focuses on how interactive simulation environments, human-in-the-loop modeling, and adaptive control design contribute to the reliability, flexibility, and efficiency of control systems operating in data-intensive digital infrastructures. An analytical and system-oriented approach is applied to examine interactive modeling as a tool for supporting decision-making during control system synthesis. The results indicate that interactive modeling enhances system configurability, improves coordination between control logic and digital platforms, and supports continuous system adaptation in dynamic economic conditions. The research emphasizes that interactive modeling methods are essential for aligning intelligent control systems with the requirements of the digital economy.
Keywords: interactive modeling, intelligent control systems, digital economy, technical objects, adaptive control, simulation technologies, decision support systems

Introduction

The digital economy is characterized by extensive use of digital platforms, real-time data processing, and intelligent automation across industrial and technical domains. Technical objects operating in such environments are increasingly complex, distributed, and interconnected. As a result, traditional approaches to control system synthesis, which rely on static models and predefined algorithms, are often insufficient to ensure system efficiency and adaptability.

Interactive modeling methods have gained attention as a means of addressing these challenges. By enabling continuous interaction between the designer and the system model, interactive approaches support exploratory analysis, rapid configuration changes, and evaluation of alternative control strategies. In intelligent control systems, this interaction becomes particularly valuable, as control logic often combines algorithmic, heuristic, and knowledge-based components.

Within the digital economy, interactive modeling also facilitates integration with digital infrastructures such as industrial platforms, monitoring systems, and decision-support tools. This study examines interactive modeling not only as a simulation technique but as a methodological foundation for intelligent control system synthesis.

Object of Research

The object of this research is the process of synthesizing intelligent control systems for technical objects operating in digital economic environments, including automated industrial systems, cyber-physical installations, and smart technical infrastructures.

Subject of Research

The subject of this study is the application of interactive modeling methods in the design and synthesis of intelligent control systems, focusing on their role in improving adaptability, decision-making, and system coordination in the digital economy.

Purpose of the Research

The purpose of this research is to analyze the effectiveness of interactive modeling methods in supporting the synthesis of intelligent control systems and to assess their contribution to system flexibility and performance under digital economy conditions.

Research Objectives

1. To examine the limitations of traditional control system synthesis methods in digital environments.
2. To analyze the functional capabilities of interactive modeling for intelligent control design.
3. To assess the role of human–model interaction in improving control decision quality.
4. To evaluate the contribution of interactive modeling to system adaptability and scalability.
5. To formulate methodological recommendations for applying interactive modeling in intelligent control engineering.

Research Methods

1. System Analysis: Examination of intelligent control system architectures used in digital economic infrastructures.
2. Analytical Modeling: Study of interactive modeling principles and their influence on control synthesis processes.
3. Simulation Review: Analysis of interactive simulation environments applied to technical control problems.
4. Comparative Evaluation: Comparison of static and interactive modeling approaches based on adaptability and configurability criteria.
5. Expert Assessment: Evaluation of interactive modeling effectiveness by specialists in control systems and digital technologies.

Main Results

The research demonstrates that interactive modeling methods significantly enhance the synthesis process of intelligent control systems by enabling continuous refinement of control logic and system parameters. Interactive environments allow designers to observe system behavior under varying operational scenarios and to adjust control strategies accordingly.

The findings show that interactive modeling improves coordination between control algorithms and digital platforms, facilitating smoother integration of control systems into digital infrastructures. The human-in-the-loop approach enables the incorporation of expert

knowledge, which is particularly important for technical objects with complex or partially uncertain dynamics.

Additionally, interactive modeling supports scalability by allowing control systems to be adapted to new operational requirements without complete redesign. This is especially relevant in the digital economy, where technical systems must evolve rapidly in response to technological and economic changes.

Conclusions and Suggestions

The study concludes that interactive modeling methods play a crucial role in the synthesis of intelligent control systems for technical objects in the digital economy. Their application enhances system flexibility, supports informed decision-making, and improves alignment between control logic and digital infrastructures.

It is recommended that interactive modeling be integrated into standard control system design methodologies and supported by appropriate software platforms. Further development of formal frameworks and guidelines for interactive modeling can strengthen its practical application in intelligent control engineering.

Practical Significance

The results of this study are of practical value for control engineers, system designers, and digital economy practitioners. Interactive modeling methods can be used to improve the design quality of intelligent control systems, reduce adaptation time, and support continuous system evolution. The findings may also inform educational programs and industrial standards related to intelligent control and digital system design.

Conclusion

Interactive modeling methods represent a key technological and methodological tool for the synthesis of intelligent control systems in the digital economy. By enabling real-time interaction, adaptive configuration, and integration with digital platforms, these methods address the growing complexity of technical objects. Their adoption supports the development of flexible, resilient, and intelligent control systems capable of operating effectively in rapidly changing digital environments.

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