INDUSTRIAL AND SYSTEMS ENGINEERING OPTIMIZATION USING ARTIFICIAL INTELLIGENCE, SIMULATION, AND DECISION-SUPPORT SYSTEMS

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Abstract

Industrial and systems engineering plays a critical role in improving efficiency, productivity, and decision-making in complex organizational and manufacturing environments. The increasing complexity of modern industrial systems has led to the adoption of advanced optimization techniques powered by artificial intelligence (AI), simulation modeling, and decision-support systems (DSS). These technologies enable data-driven analysis, predictive insights, and intelligent optimization across production, logistics, supply chains, and service systems. This review presents a comprehensive examination of recent developments in industrial and systems engineering optimization using AI, simulation, and DSS. Key methodologies, application domains, benefits, challenges, and future research directions are critically analyzed, highlighting the transformative impact of intelligent optimization on modern industrial systems.

Keywords: Industrial Engineering; Systems Optimization; Artificial Intelligence; Simulation Modeling; Decision-Support Systems; Operations Research

1. INTRODUCTION

Industrial and systems engineering focuses on the design, analysis, and optimization of complex systems involving people, machines, materials, information, and energy. Traditional optimization approaches based on mathematical programming and deterministic models have been widely used to improve system performance. However, increasing system complexity, uncertainty, and data availability have exposed the limitations of conventional techniques.

Artificial intelligence, simulation, and decision-support systems have emerged as powerful tools for addressing these challenges. AI enables learning-based optimization and adaptive decision-making, simulation allows experimentation with complex system behavior, and DSS integrates analytical models with human expertise. Together, these technologies support intelligent, flexible, and robust optimization strategies across diverse industrial domains. This

review explores how AI, simulation, and DSS are reshaping industrial and systems engineering optimization.

2. LITERATURE REVIEW

2.1 Optimization in Industrial and Systems Engineering

Classical optimization methods such as linear programming, integer programming, and queuing theory have long been foundational in industrial engineering. While effective for well-defined problems, these approaches often struggle with large-scale, nonlinear, and stochastic systems.

2.2 Artificial Intelligence for Optimization

Recent literature highlights the growing use of AI techniques, including genetic algorithms, particle swarm optimization, neural networks, and reinforcement learning, for solving complex optimization problems. These methods are particularly effective in handling uncertainty, dynamic environments, and multi-objective optimization tasks in production planning, scheduling, and resource allocation.

2.3 Simulation-Based Optimization

Simulation modeling enables the analysis of complex systems that are difficult to represent analytically. Discrete-event simulation, agent-based modeling, and system dynamics have been widely applied to manufacturing systems, logistics networks, and service operations. Integration of simulation with optimization and AI has been shown to enhance solution quality and system understanding.

2.4 Decision-Support Systems

Decision-support systems combine data, analytical models, and user interfaces to assist decision-makers. The literature emphasizes DSS applications in supply chain management, healthcare operations, transportation systems, and strategic planning. AI-enhanced DSS provide predictive and prescriptive insights, improving decision accuracy and responsiveness. Despite significant progress, challenges remain in system integration, model interpretability, computational efficiency, and organizational adoption.

3. METHODOLOGY

This review adopts a **systematic qualitative research methodology** to analyze optimization approaches in industrial and systems engineering using AI, simulation, and decision-support systems. Peer-reviewed journal articles, conference papers, and authoritative reports published between 2015 and 2025 were reviewed.

The methodology includes:

- Classification of AI-based optimization techniques and simulation models
- Comparative analysis of decision-support frameworks and system architectures
- Evaluation of performance metrics such as cost reduction, efficiency improvement, and system robustness
- Identification of research gaps and emerging trends

The reviewed studies were categorized according to application domains including manufacturing, supply chains, logistics, healthcare systems, and service operations.

4. RESULTS AND DISCUSSION

The reviewed literature demonstrates that AI-driven optimization significantly enhances system performance compared to traditional methods. Simulation-based optimization enables effective evaluation of complex scenarios without disrupting real-world operations. Decision-support systems improve managerial decision-making by integrating analytical insights with human judgment.

Results indicate that integrated approaches combining AI, simulation, and DSS outperform standalone solutions in terms of efficiency, flexibility, and adaptability. However, challenges such as data quality, model scalability, interpretability of AI solutions, and resistance to organizational change remain key barriers to implementation.

5. CONCLUSION

Industrial and systems engineering optimization is undergoing a significant transformation through the integration of artificial intelligence, simulation, and decision-support systems. These technologies enable intelligent, data-driven, and adaptive optimization of complex industrial systems. This review highlights the benefits, applications, and limitations of current approaches while emphasizing the need for explainable AI, scalable simulation frameworks, and user-centric DSS design. Future research should focus on hybrid optimization models, real-time decision support, and human–AI collaboration to further advance industrial and systems engineering practice.

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