

Introduction to the Special Issue on Advanced Approaches and Applications in Engineering

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Engineering is undergoing a profound transformation driven by rapid advances in computational technologies, intelligent algorithms, and data-centric methodologies. The increasing availability of engineering data, coupled with the development of artificial intelligence (AI), machine learning (ML), big data analytics, cloud computing, and advanced optimization techniques, has significantly expanded the capability of engineers to analyze complex systems, improve decision-making processes, and optimize engineering performance. These technological developments have accelerated the transition from conventional experience-driven engineering toward intelligent, data-driven engineering, where mathematical modeling, computational simulation, and intelligent decision-support frameworks play an increasingly important role. Against this background, the Special Issue entitled “Advanced Approaches and Applications in Engineering” was established to provide an international platform for presenting innovative computational methodologies and their practical applications across diverse engineering disciplines. The issue brings together contributions that demonstrate recent advances in numerical modeling, optimization, AI, uncertainty quantification, and intelligent decision-making, highlighting their effectiveness in addressing challenging engineering problems.

Modern engineering systems are characterized by increasing complexity, uncertainty, and interdisciplinary interactions. Engineering applications often involve nonlinear physical behaviors, heterogeneous data sources, stochastic environments, and conflicting design objectives, making traditional analytical approaches insufficient for solving many practical problems. Consequently, advanced computational approaches capable of integrating mathematical modeling, optimization algorithms, intelligent analytics, and simulation techniques have become indispensable for engineering research

and industrial practice. The motivation behind this Special Issue stems from the growing need to develop robust, efficient, and intelligent methodologies that not only improve engineering analysis and prediction accuracy but also provide reliable support for design optimization, operational management, and strategic decision-making under uncertainty.

The papers included in this Special Issue demonstrate the broad applicability of advanced engineering approaches across multiple engineering domains. A significant group of contributions focuses on numerical modeling and computational simulation for complex engineering systems. One study investigates the failure mechanisms and structural evolution of overburden strata in steeply inclined coal seams using a combination of physical experiments and FLAC3D numerical simulations. By systematically evaluating the influence of mining face length and gob-backfilling ratios, the study establishes quantitative guidelines for optimizing strata control while improving mining safety and sustainability [1]. Another contribution examines the deformation behavior of an ultra-high bridge pier subjected to varying wind and temperature conditions through ANSYS Workbench simulations. The results provide valuable insights into the coupled effects of environmental loading on bridge stability and offer practical guidance for construction and structural safety assessment [2]. These studies illustrate the indispensable role of computational simulation in understanding complex physical phenomena that are difficult to investigate solely through analytical or experimental methods.

Advanced computational mechanics and uncertainty quantification are also prominently represented in this Special Issue. One contribution integrates the Direct FE² multiscale finite element method with generalized Polynomial Chaos Expansion to quantify the influence of material uncertainties on the thermo-mechanical behavior of steel partition walls under coupled loading conditions. The proposed framework demonstrates high computational efficiency while providing reliable uncertainty assessment and sensitivity analysis for structural design [3]. Complementing this work, another study investigates the flexural behavior of ultra-high-performance fiber-reinforced concrete (UHPFRC) bridge decks through a combination of experimental investigations and nonlinear finite element modeling. By establishing predictive formulations for multiple failure modes, the study provides valuable design references for optimizing reinforcement configurations, structural durability, and sustainability in bridge engineering [4]. Together, these studies demonstrate how advanced numerical methodologies continue to enhance structural analysis, reliability assessment, and engineering design under increasingly realistic operating conditions.

Another important theme emerging from this Special Issue is the integration of AI-driven analytics into engineering decision-making processes. One article develops an AI-driven predictive analytics framework for transportation logistics by integrating multiple ML algorithms, including LightGBM, Random Forest, Linear Regression, and Support Vector Regression. By incorporating real-time information such as weather conditions, traffic status, inventory levels, and historical demand, the proposed framework substantially improves demand forecasting accuracy while enhancing supply chain agility and resilience [5]. This work reflects the increasing adoption of data-driven predictive intelligence for supporting operational planning and resource allocation in modern engineering systems.

Engineering optimization and intelligent decision-support methodologies also constitute an important research direction represented in this Special Issue. One study proposes a hybrid framework integrating Monte Carlo Simulation with Linear Programming to address uncertainty in multi-product, multi-stage supply chain optimization. Through stochastic scenario generation and deterministic optimization, the framework effectively balances profitability, service quality, and operational risks under uncertain demand and capacity conditions [6]. Another contribution presents

an integrated interval-valued hesitant fuzzy sets (IVHFS) and DEMATEL-ANP framework for competitive intelligence evaluation in smart factories. By simultaneously modeling expert hesitation and causal interdependencies among evaluation criteria, the proposed approach provides a comprehensive decision-support mechanism capable of assisting intelligent manufacturing enterprises in identifying strategic priorities under uncertain environments [7]. These studies collectively demonstrate the growing importance of integrating optimization, uncertainty analysis, and intelligent decision models for engineering management and industrial decision-making.

Taken together, these seven contributions reflect both the breadth and the advancement of contemporary engineering research through advanced approaches and practical applications. Computational simulation and numerical modeling are advancing toward higher fidelity, while AI and ML are increasingly integrated into engineering analysis to enhance prediction and decision-making. Meanwhile, uncertainty quantification, probabilistic modeling, and robust optimization are gaining importance for addressing complex and dynamic engineering systems. These developments reflect a shift toward intelligent, integrated, and data-driven engineering methodologies that will continue to drive future research and industrial innovation.

All submitted manuscripts underwent a rigorous peer-review process in accordance with the journal's editorial standards. Each submission was carefully evaluated for scientific quality, originality, methodological rigor, and relevance to the scope of this Special Issue. Through constructive reviews and multiple rounds of revision where necessary, the published papers collectively represent high-quality research contributions spanning computational engineering, intelligent analytics, optimization, and engineering applications.

The Guest Editors would like to express their sincere appreciation to all authors who contributed their excellent research to this Special Issue. We are equally grateful to the reviewers for their valuable comments, constructive suggestions, and dedicated efforts throughout the review process, which significantly improved the quality and clarity of the published papers. Finally, we extend our sincere thanks to the Editor-in-Chief and the editorial office for their continuous support, professional management, and invaluable assistance during the preparation and publication of this Special Issue.

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