

Preface to the Special Issue “Modeling and Simulation in Engineering, 3rd Edition”

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1. Introduction

The topic “Modeling and Simulation in Engineering”, proposed in 2021 as part of the section “Engineering Mathematics”, and later as part of “Control Theory and Mechanics”, covers a large array of technical fields, thus arousing much interest among researchers. Two previous editions have already been published, one in 2022 (<https://www.mdpi.com/books/book/6451>) and one in 2023 (<https://www.mdpi.com/books/book/7679>).

The purpose of this Special Issue is to offer a platform for ongoing valuable research involving modeling and simulation methods in mathematical physics to present new simulation software applications in engineering or in the design of experiments.

We now have the pleasure of introducing “Modeling and Simulation in Engineering, 3rd Edition”, and a fourth one already being launched. This edition comprises eight original research papers that were selected from 18 submitted papers.

2. Description of Published Papers

The paper by A.S.M. Sharifuzzaman Sagar et al. (Contribution 1) proposes a method for error mitigation in UWB (ultra-wide band) range measurements for both line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios. A Gaussian Process-enhanced nonlinear function is proposed for mitigating range bias in LOS cases, while the case of NLOS propagation is identified using a deep learning model. The experimental setup uses State-of-the-Art devices and software (decawave UWB chip, Python as a programming language, PyTorch as the model design framework for the deep learning phase, and NVIDIA GPU in order to accelerate computations). Experiments conducted in various environments and settings proved the effectiveness of the method for range measurements. An uncertainty estimation of the model using the Monte Carlo dropout method was also conducted, showing a very low epistemic and aleatoric uncertainty.

In the paper by Tuan Ngoc Tran Cao et al. (Contribution 2), a second-order TSM (Terminal Sliding Mode) scheme is proposed for the trajectory control of differential drive mobile robots (DDMRs). A solution for the second-order differential equation satisfied by the state variable describing the robot motion is obtained. A cascaded control architecture for the DDMR is proposed using a P-type-only controller for kinematic control. Simulations show a fast convergence to the stable state and fast control of the tracking errors in the DDMR trajectory.

The paper by Hangjie Huang and Jinfeng Gao (Contribution 3) proposes motion controllers for trajectory control of mobile robots. The controllers use the Lyapunov stability



Received: 29 July 2025

Accepted: 5 August 2025

Published: 1 September 2025

Citation: Petrescu, C.; David, V. Preface to the Special Issue “Modeling and Simulation in Engineering, 3rd Edition”. *Mathematics* **2025**, *13*, 2801. <https://doi.org/10.3390/math13172801>

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theory and the backstepping method. The sliding mode algorithm was used to ensure a fast and stable convergence to zero of the trajectory tracking error. Simulations carried out in MATLAB/SIMULINK show the superiority of the proposed control algorithms compared to traditional PID controllers, especially in the presence of disturbances.

The paper by J. De Curtò and I. De Zarzà (Contribution 4) studies methods for propellant distribution optimization in different stages of space exploration missions that use chemical and electric propulsion systems. The optimization is based on the Sequential Quadratic Programming (SQP) method suitable for nonlinear processes, with the objective being to minimize the total propellant mass. The authors present a brief description of the mission planner, which must continuously calculate the vehicle speed variation, optimize the propellant distribution, and evaluate the propellant mass. The simulation results show that by integrating electric propulsion for specific mission stages, considerable propellant savings can be achieved. Other simulations were designed to investigate the variable propulsion efficiency and the effect of orbital perturbations during gravitational assists. The authors demonstrate that the propellant mass consumption can be minimized by this hybrid approach that combines chemical and electric propulsion.

The paper by Faryal Ali et al. (Contribution 5) proposes a traffic flow model that takes into account vehicle vibrations due to pavement conditions, defined by the Pavement Condition Index (PCI), calculated using field experiments. The proposed model and an existing Intelligent Driver (ID) model were used in simulations, showing that the proposed model is more suitable for evaluating traffic behavior. The solution to the first-order nonlinear differential equation satisfied by the vehicle speed is used to calculate the distance headway between vehicles in the steady state and also the traffic flow. Simulations show that the proposed model is better suited to predict traffic evolution in real time, thus helping the vehicle-adaptive cruise control system to adjust the speed and following distance by monitoring the traffic density.

In the paper by I. de Zarzà et al. (Contribution 6), the authors propose a drone-based platooning system that uses UWB sensors for distance measurement and control. A multi-objective optimization technique is conceived and used in platoon management in order to optimize travel time, fuel consumption, and traffic safety. An agent-based simulation model is implemented in order to evaluate and compare the proposed system with existing methodologies in platoon management. The drones are used for monitoring and communication, collecting distance and speed data for all vehicles in the platoon. The multi-objective problem is transformed into a single-objective one, using the aggregation of objective functions biased with different weights. Based on the data collected from the drones, the algorithm decides to make a platoon or to split it and find other partners for some vehicles in the convoy. The efficiency of the proposed system is analyzed, proving to be cost-effective due to the small electrical energy consumption of the drones, compared to the economy of the fuel consumption of the heavy trucks. The limited time of drones' operation is also addressed by using multiple drones working in shifts or by using inductive charging platforms along the convoy route. The multi-objective optimization algorithm was written in Python and the simulations of drone platooning were conducted using the open-source software Mesa for agent-based modeling.

The paper by J. de Curtò et al. (Contribution 7) proposes a hybrid communication and navigation system for Earth–Moon communication and rover movement on the Moon's surface. The system uses UWB technology for high-precision positioning and multi-band orthogonal frequency division multiplexing (MB-OFDM) for high-data-rate communication. The proposed model takes into account the potential for interference and the compatibility with Earth-based networks. Various factors are considered in simulations, such as terrain generation, rover movement constraints, obstacle avoidance, and communication channel

modeling. Simulation results show that the proposed communication algorithm ensures efficient navigation and reliable data transfers between rovers and lunar landers.

In the paper by Gufran Abass and Suha Shihab (Contribution 8), a new state parametrization based on the shifted wavelet method is proposed for solving optimal control problems. Simulations are carried out for different test cases, showing that the solutions obtained with the proposed method are more accurate than the other methods presented in the literature. The mathematical derivation of the method is presented in detail and is based on the construction of a new shifted wavelet function with its operational matrix of derivatives.

3. Conclusions

As Guest Editors of the Special Issue Modeling and Simulation in Engineering, 3rd Edition, we would like to express our gratitude to all the authors who submitted their articles for publication in this Special Issue. We also express our gratitude and appreciation to the reviewers for their valuable observations, which helped to improve the submitted papers.

We hope that the papers selected for this Special Issue will attract a significant audience in the scientific community and further stimulate research involving modeling and simulation in mathematical physics and engineering.

Author Contributions: Conceptualization, C.P. and V.D.; writing—original draft preparation, C.P.; writing—review and editing, C.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

List of Contributions

1. Sagar, A.S.M.S.; Arefin, S.; Moon, E.; Prince, M.P.; Dang, L.M.; Haider, A.; Kim, H.S. Gaussian Process-Enhanced Non-Linear Function and Bayesian Convolution–Bayesian Long Term Short Memory Based Ultra-Wideband Range Error Mitigation Method for Line of Sight and Non-Line of Sight Scenarios. *Mathematics* **2024**, *12*, 3866.
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3. Huang, H.; Gao, J. Backstepping and Novel Sliding Mode Trajectory Tracking Controller for Wheeled Mobile Robots. *Mathematics* **2024**, *12*, 1458.
4. De Curtò, J.; De Zarzà, I. Optimizing Propellant Distribution for Interorbital Transfers. *Mathematics* **2024**, *12*, 900.
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8. Abass, G.; Shihab, S. Operational Matrix of New Shifted Wavelet Functions for Solving Optimal Control Problem. *Mathematics* **2023**, *11*, 3040.

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