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Editorial

Special Issue "Symmetry in Optimization and Control with Real-World Applications"

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In the study of many real-world problems such as engineering design and industrial process control, one often needs to select certain elements/controls from a feasible set in order to optimize the design or system based on certain criteria. Such problems can be formulated as constrained optimization or optimal control problems.

Due to the existence of symmetry in certain systems in nature and engineering, many of the resulting mathematical models and optimization problems possess some form of symmetry. For example, in some constrained optimization problems, certain variables appear symmetrically in the objective and constraints functions. Hence, the study of optimization and optimal control problems with symmetry is important and has real-world applications in various fields. Methodologies and techniques in optimization and optimal control are also clearly indispensable for solving these problems.

In this Special Issue, we focus on the advancement of mathematically rigorous computational techniques, engineering mathematics, and real-world engineering applications in the areas of dynamical systems and control, optimization, operations research, and modelling of complex systems.

The following articles, prepared by leading scientists from all over the world, such as Australia, Chile, China, Egypt, Israel, Lithuania, Saudi Arabia, Thailand, USA, etc., were reviewed and selected for this Special Issue.

In "Simulated Annealing Hyper-Heuristic for a Shelf Space Allocation on Symmetrical Planograms Problem" [1], Czerniachowsk and Hernes study the allocation of products on shelves for effective decision making by retailers. The authors investigate a practical shelf space allocation model considering the number of facings, capping, and nesting of a product, and establish a simulated annealing algorithm to solve the planogram profit maximization problem. Through computational tests, the authors demonstrate that the proposed algorithm yields valuable results in an acceptable time.

In "Improved Salp Swarm Algorithm with Simulated Annealing for Solving Engineering Optimization Problems" [2], Duan et al. propose an improved salp swarm algorithm by introducing a simulated annealing mechanism based on symmetric perturbation into the salp swarm algorithm. The authors then evaluate the efficiency of the algorithm by comparing their results with those obtained from existing algorithms on various benchmark functions. The developed algorithm is then applied to solve various engineering optimization problems to demonstrate its ability and effectiveness in solving practical problems.

In "Hardware in the Loop Topology for an Omnidirectional Mobile Robot Using Matlab in a Robot Operating System Environment" [3], Constatin-Catalin et al. illustrate a hardware-in-the-loop architectural approach for the integrated development of an omnidirectional mobile robot designed to serve in a dynamic logistic environment. The authors also present the details of real-time motion control using robot operating system (ROS) nodes implemented in MATLAB. The proposed solution permits the live connection to

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the omnidirectional prototype platform, allowing to deploy algorithms and acquire data for debugging the location, path planning, and mapping information during real-time autonomous navigation experiments.

In "Least Squares Support Vector Machine-Based Multivariate Generalized Predictive Control for Parabolic Distributed Parameter Systems with Control Constraints" [4], Ai et al. develop a new multivariate generalized predictive control strategy using the least squares support vector machine for parabolic distributed parameter systems. The effectiveness of the proposed predictive control strategy is validated in the paper through a numerical simulation study on a typical diffusion–reaction process with radial symmetry.

In "A Heuristic Approach to Shelf Space Allocation Decision Support Including Facings, Capping, and Nesting" [5], Czerniachowska and Hernes develop a practical shelf space allocation model offering the possibility of horizontal and vertical product grouping, representing an item (product) with facings, capping, and nesting, with the objective of maximizing the retailer's profit. The authors also propose two adjustable methods to achieve results within a short time interval and evaluate the performance of the proposed approach through computational experiments.

In "Toward Applications of Linear Control Systems on the Real World and Theoretical Challenges" [6], Ayala et al. present a review of various real-world challenges which arise as optimization problems on different classes of control systems, in particular, linear control systems ΣG on Lie group G. The review focuses on controllability, the time-optimal Hamiltonian equations, and the Pontryagin Maximum Principle. The authors also show how to build ΣG through several examples on low-dimensional matrix groups.

In "Dynamic Cost Ant Colony Algorithm to Optimize Query for Distributed Database Based on Quantum-Inspired Approach" [7], Mohsin et al. examine how the quantum-inspired ant colony algorithm, a hybrid strategy of probabilistic algorithms, can be devised to improve the cost of query joins in distributed databases. It is established that quantum computing can cover large query search spaces due to its ability to diversify and expand. The algorithm is used to identify the optimal join order to reduce the total execution time, and experimental results show that it provides faster convergence and better results than the classical model.

In "Investigation of Position and Velocity Stability of the Nanometer Resolution Linear Motor Stage with Air Bearings by Shaping of Controller Transfer Function" [8], Piščalov et al. study a precision positioning system as a symmetric system that is based on a symmetric linear motor. Controllers with different architectures are investigated to find the best controller that ensures a stable and small dynamic error of the displacement of the stage platform. The influences of the controller order on the displacement dynamic error at different velocities are also investigated.

In "Generic Existence of Solutions of Symmetric Optimization Problems" [9], Zaslavski studies a class of symmetric optimization problems that are identified with a space of objective functions and equipped with an appropriate, complete metric. By using the Baire category approach, the author proves the existence of a subset of the space of functions, which is a countable intersection of open and everywhere dense sets, such that for every objective function from this intersection, the corresponding symmetric optimization problem possesses a solution.

In "A Fast Non-Linear Symmetry Approach for Guaranteed Consensus in Network of Multi-Agent Systems" [10], Abdulghafor and Almotairi propose a non-linear mathematical model of a semi-symmetric quadratic operator (SSQO) to resolve the issue of consensus in networks of multi-agent systems (MASs). The model is based on the stochastic quadratic operator theory and has the feature of low complexity, fast consensus, and a guaranteed capability to reach a consensus. Through an evaluation of the proposed SSQO model and comparison with other existing models, the authors demonstrate that, in addition to the emulation effects of MAS consensus, their model can achieve average consensus.

In "Application of a Hybrid Model Using Mathematical Optimization and Intelligent Algorithms for Improving the Talc Pellet Manufacturing Process" [11], Buntam et al. focus

on the prediction of the moisture in the talc pellet process related to symmetry in real-world application problems. The authors introduce a hybrid model (HM) based on the combination of intelligent algorithms, a self-organizing map (SOM), the adaptive neuron fuzzy inference system (ANFIS), and either genetic algorithm (GA) or particle swarm optimization (PSO), referred to as HM-GA and HM-PSO. Three different measures are then used to evaluate the model for moisture prediction, and it is shown that the HM-PSO model achieves the best result.

In "Stability Analysis of Linear Feedback Systems in Control" [12], Rehman et al. present a stability analysis of linear time-invariant systems arising in system theory. The computation of the bounds of structured singular values for a family of Toeplitz matrices arising in linear time-invariant feedback control systems is presented by means of a low-rank ordinary differential equation (ODE)-based methodology. The proposed methodology is based on the inner–outer algorithm. Through numerical experiments, the authors show that their results for lower bounds of structured singular values are much tighter than that approximated by the classical methods implemented in MATLAB.

In "A Symmetric FBF Method for Solving Monotone Inclusions" [13], Gibali and Shehu introduce a forward–backward–forward splitting method with reflection steps (symmetric) in real Hilbert spaces for solving monotone inclusion problems. Weak and strong convergence analyses of the proposed method are established under some suitable assumptions. Moreover, the authors prove a linear convergence rate for an inertial modified forward–backward–forward splitting method.

In "Convergence Analysis of Self-Adaptive Inertial Extra-Gradient Method for Solving a Family of Pseudomonotone Equilibrium Problems with Application" [14], T. Bantaojai et al. propose a new modified extra-gradient-like method to solve pseudo-monotone equilibrium problems in real Hilbert space with a Lipschitz-type condition on a bifunction. The weak convergence of the method is established by using mild conditions in a bifunction. Moreover, the authors demonstrate the applicability of their results in solving fixed-point problems and variational inequality problems and illustrate the effectiveness of their proposed numerical algorithm through numerical examples.

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