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Editors

Intelligent Engineering Optimisation with the Bees Algorithm

Springer

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Preface

The Bees Algorithm (BA) is a nature-inspired optimisation method that mimics the foraging behaviour of honey bees. It was first proposed by Pham, Ghanbarzadeh, Koç, Otri, Rahim and Zaidi in 2005 and has since been applied to a wide range of engineering problems, such as machine scheduling, computer vision, mechanical design, robot path planning, process control and many more. The BA has also been modified by various researchers to enhance its performance and adaptability.

This book provides an overview of some of the latest developments and applications of the BA in engineering optimisation. It consists of two parts: the First Part covers improvements to the BA, while the Second Part showcases applications of the BA in various engineering domains.

The First Part comprises four chapters. In the chapter "Enhanced Bees Algorithm Implementing Early Neighbourhood Search with Efficiency-Based Recruitment", Packianather, Imanguliyev and Pham introduce an enhanced version of the BA that implements strategies to improve the exploration and exploitation abilities of the algorithm. The chapter "Improving the Bees Algorithm Using Gradual Search Space Reduction" by Albakr and Pham proposes a technique that uses regional elimination to avoid premature convergence and stagnation. In the chapter "Local Optimal Issue in Bees Algorithm: Markov Chain Analysis and Integration with Dynamic Particle Swarm Optimisation Algorithm", Liu, Ang, Ng and Chaw study the convergence properties of the BA and its integration with a dynamic particle swarm optimisation algorithm. This is followed by the chapter "Development of the Bees Algorithm Toolkit for Optimisation in LabVIEW" by Sahin and Pham which describes a suite of BA optimisation tools embedded in LabVIEW, a popular system for data acquisition and control applications.

The Second Part consists of 16 chapters discussing various engineering applications of the BA. The chapter "Geometrical Optimisation of Smart Sandwich Plates Using the Bees Algorithm" by Duc and Quan presents the optimisation of the geometry of smart sandwich plates on Pasternak-type elastic foundations. The authors used the BA to maximise the natural frequency and the critical buckling load of the sandwich plates.

In the chapter "Integrating the Bees Algorithm with WSAR for Search Direction Determination and Application to Constrained Design Optimisation Problems", Baykasoglu and Senol propose integrating the BA with a weighted superposition attraction–repulsion approach for search direction determination. The authors describe the application of the resulting method to four constrained design optimisation problems.

How welding is performed can affect the final geometry of the welded component. The chapter "Bees Algorithm-Based Optimisation of Welding Sequence to Minimise Distortion of Thin-Walled Square Al–Mg-Si Alloy Tubes" by Wu and Wang discusses an integrated optimisation approach combining the BA with an artificial neural network model to find welding sequences that minimise distortion of thin-walled alloy tubes.

In the chapter "Hybrid Genetic Bees Algorithm (GBA) for Continuous and Combinatorial Optimisation Problems", Tran, Vu, Truong and Nguyen propose a hybrid Genetic BA for training a multi-layer perceptron and solving a two-stage flow shop scheduling problem and a just-in-time job shop scheduling problem. The authors also compare the results obtained with those of the Genetic Algorithm and Particle Swarm Optimisation.

The surface finish of 3D-printed parts depends on the parameters of the 3D printing process. The chapter "Optimisation of Surface Roughness in 3D Printing Using the Bees Algorithm" by Kamaruddin, Ridzuan and Sukindar describes how the BA was employed to find the parameter combination to maximise the surface quality of parts printed by fused deposition modelling.

The chapter "The Bees Algorithm for Robotics-Enabled Collaborative Manufacturing" by Xu, Yang, Ji, Liu and Liu examines the optimisation of collaborative manufacturing (and remanufacturing). The authors used the improved multiobjective discrete BA and the improved discrete BA-Pareto algorithm to balance a robotised disassembly line, select the optimum collaborative manufacturing service aggregation for a robotised assembly system and plan the task sequence for a human–robot collaborative disassembly operation to minimise human fatigue.

The chapter "Bees Algorithm for Hyperparameter Search with Deep Learning to Estimate the Remaining Useful Life of Ball Bearings" by Kumar, Kumar, Gupta, Theinnoi and Pham shows how a two-parameter version of the BA was used to find the optimal set of hyperparameters for a Convolutional Neural Network combined with a Long Short-Term Memory. The resulting deep-learning system was able accurately to predict the remaining useful life of ball bearings in rotating machinery.

In the chapter "Bees Local Phase Quantisation Feature Selection for RGB-D Facial Expression Recognition", Mousavi and Ilanloo discuss the automatic recognition of facial expressions (anger, joy, surprise, disgust and fear) from colour and depth images. After extracting local phase quantisation features from the images, they employed the BA to select the appropriate number of features to maximise the final recognition accuracy.

The chapter "Optimisation of Convolutional Neural Network Parameters Using the Bees Algorithm" by Packianather and Alamri describes the combining of the BA and Bayesian Optimisation to improve the classification accuracy of a convolutional neural network. The engineering application considered by the authors is the detection of cracks in images of concrete.

The chapter "Ergonomic Risk Assessment Combining the Bees Algorithm and Simulation Tools" by Singh, Caterino, Rinaldi, Fera, Macchiaroli and Pham proposes a methodology for integrating BA optimisation and simulation to reduce the workload for workers on production and assembly lines. Simulation is first employed to obtain ergonomics data for different workers. Then, the BA is used as a tool for optimising the job rotations of the workers among the workstations.

Song, Guo, Li, Wu, Yang and Chen examine the problem of building a team of experts for a project in their chapter "A Knowledge Transfer-Based Bees Algorithm for Expert Team Formation Problem in Internet Company." The authors propose a BA that performs 'knowledge transfer' by searching multiple subpopulations and moving individuals from dominant subpopulations to weaker subpopulations.

The chapter "Green Vehicle Routing Optimisation Using the Bees Algorithm" by Satpathy, Das, Hartono and Pham describes the application of the BA to find the optimal set of vehicle tours to service a subset of customers while incorporating stops at fuel stations to refuel. This is the first study to use the BA to solve this so-called Green Vehicle Routing problem.

In the chapter "Utilising the Bees Algorithm for UAV Path Planning—A Simultaneous Collision Avoidance and Shortest Path Approach", Dasgupta, Kumar, Vaibhav and Ismail present the BA as a tool for UAV path planning. The aim is to determine the safest trajectory for an unmanned aerial vehicle (UAV), ensuring it reaches its destination from the starting point via the shortest path while avoiding obstacles along the way.

The chapter "A Tabu-Based Bees Algorithm for Unmanned Aerial Vehicles in Maritime Search and Rescue Path Planning" by Guo, Song, Li, Ou, Xing and Zhang also deals with path planning for UAVs. The context is maritime search and rescue. The authors adopt a reverse 'tabu' strategy to reduce the possibility of invalid search and speed up convergence.

The chapter "Pedestrian-Aware Cyber-Physical Optimisation of Hybrid Propulsion Systems Using a Fuzzy Adaptive Cost Map and Bees Algorithm" by Li, Liu, Wang, Gu, Zhou, Wen, Pham and Xu proposes a system to reduce hybrid vehicle emissions on pedestrians. The system uses a combination of the BA and a fuzzy adaptive cost map to optimise the rule-based power-split parameters in a Plug-in Hybrid Propulsion system.

Finally, the chapter "Surrogate Model-Assisted Bees Algorithm for Global Optimisation of Microwave Filters" by Lan, Qian, Castellani, Wang, Pham and Wang deals with a black-box optimisation problem where the objective function is unknown. The authors first constructed an approximate model of the unknown objective function. They then used the BA to generate candidate solutions. Only those solutions deemed promising by the surrogate model were subsequently investigated further using more accurate but computationally expensive means.

Our aim in compiling this book is for it to serve as a source of inspiration for readers who wish to explore the potential of the BA as an engineering optimisation tool. In addition to the small sample featured in the book, there are many more potential engineering applications of the BA. We warmly encourage researchers and practitioners to try the BA when they next require a simple and effective means to solve complex optimisation problems.

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