Abstract

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Project Title: Development of New Self-Adaptive Meta-Heuristics and Hyper-Heuristics for Optimisation of Structures with Welded Joints and Mechanism Synthesis

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The use of meta-heuristic optimisers has become a prominent part of engineering design as it is a powerful tool which responds well at low cost and has high performance. Using meta-heuristics are advantageous since they are simple to implement, robust, derivative-free, and capable of global search. They can be used to solve almost any kind of optimisation problem whether it is a single-, multiple- or many-objective design. However, inevitable shortcomings are a low convergence rate and a lack of consistency. Thus, there will always be needs to improve their performance and, up to the present time, the state-of-the-art has been self-adaptive meta-heuristics. The aims of this project are twofold. The first objective is to explore knowledge in the field of meta-heuristics. Adaptive meta-heuristics for single-objective, bi-objective and many-objective optimisation will be developed. The use of a hyper-heuristic concept in combination with adaptive schemes for optimisation will be investigated. Also, performance enhancement of optimisers for many-objective optimisation will be carried out. The second project objective is to implement the newly developed optimisers to two real engineering applications i.e. design of skeleton-like structures and mechanism synthesis. For structural optimisation, a finite element model for the skeleton-like structures with welded joints will be developed. For kinematic synthesis, two-dimensional multibody dynamic analysis codes will be created for analysing various types of mechanisms. The synthesis process will account for vibration and uncertainties. This research is expected to produce two training courses for structural optimisation and mechanism synthesis.

The development of the finite element model for frames with semi-rigid or welded joints has been presented. The model is accomplished based on finite element sub-structuring. The rest of the report will present onlt the applications of meta-heuristics for truss design instead of using this semi-rigid jointed frame since the design process for both structure types are similar and can be used to represent each other.

It has been illustrated that a powerful differential evolution for truss design can be achieved by means of self-adaptation. A new efficient adaptive penalty function technique for constrained optimisation using meta-heuristics has been proposed. The proposed adaptive differential evolutions is comparable to the state-of-the-art meta-heuristics found in the literature.

The use of many-objewctive meta-heuristics for design an automotive floor frame has been demonstrated. The hybridised real-code population-based incremental learning and differential evolution is modified and used with the objective function reduction technique for this design demonstration. The proposed algorithm is porwerful for the automotive floor frame design.

Studies on comparative performance of a number of state-of-the-art meta-heuristics for solving truss optimisation has been made. It has been found that those CEC competition winners are more powerful than other self-adaptive meta-heuristics.

It has been demonstrated how to improve the performance of a newly introduced meta-heuristic called symbiotic organisms search. The method is successfully improved by means of self-adaptation and it can be effective used for truss design.

Efficient synthesis of a six-bar steering linkage has been proposed. The hybridised real-code population-based incremental learning and differential evolution is used in combination with and adaptive penalty function to achieve the design results.

A new technique to solve path generation of a four-bar linkage has been proposed. Teaching-learning based optimisation is improved by means of self-adaptive population size, and use to solve the mechanism synthesis. Numerical results reveal that the proposed method is powerful for path generation.

Additionally, the research team not only focus on frame structures with semi-rigid joints but also other engineering application such as optimal reactive power dispatch, and optimisation of heat exchangers.

Keywords: Meta-Heuristics; Self-Adaptive Systems; Mechanism Synthesis; Structural Optimisation; Many-Objective Optimisation