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MULTI-OBJECTIVE MEMETIC ALGORITHM BASED ON LEARNING FOR SUSTAINABLE DESIGN OF FRP COMPOSITE STRUCTURES

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Abstract: An approach for decreasing costs in lightweight structures using FRP composite materials is proposed based on a hybrid construction where expensive and high-stiffness materials performs together with inexpensive and low-stiffness material. The optimal design of hybrid composite stiffened structures is addressed as sizing, topology and sustainable material selection in a multi-objective optimization framework. Minimum weight (cost), minimum strain energy (stiffness) and maximum sensitivity to sustainable factors are the objectives of the proposed structural robust design approach. The model performs the trade-off between the performance targets against sustainability, depending on given stress, displacement and buckling constraints imposed on composite structures. The design variables are ply angles and ply thicknesses of shell laminates, the cross section dimensions of stiffeners and the variables related to material selections' and structural distribution. A Multi-objective Memetic Algorithm (MOMA) searching Pareto-optimal front is proposed. MOMA applies multiple learning procedures exploring the synergy of different cultural transmission rules. These rules are associated with some kind of problem knowledge and learning classified as Lamarckian or Baldwinian. The memetic learning procedures aim to improve the exploitation and exploration capacities of MOMA. It is implemented the selfish gene theory using a fusion of concepts. The age structure performs together with feature-based allele's statistics analysis used in the learning procedure implemented inside a virtual population (VP) using the rules: (i) storage of the ranked solutions aiming to obtain the Pareto front and (ii) evolution as a virtual population of alleles. A self-adaptive genetic search incorporating Pareto dominance and elitism performs together in the proposed MOMA. Two concepts of dominance are used: the first one denoted by local non-dominance performs at the isolation stage of populations and the second one called global non-dominance performs on the age structured VP. The age control emulates the human life cycle and enables to apply the species conservation paradigm. The crossover operator applied to age-structured VP results from the development of new mating and offspring selection mechanisms considering age control and dominance. The concept of species associated with material choice and distribution on composite structures is used. A detailed analysis of solutions/individuals at the Pareto-optimal front reveals that they belong to different species. From this, it concludes that MOMA is successful in preserving the population diversity. Furthermore, MOMA is able to indicate alternative optimal designs based on different species what might be very important for the designers in multi-objective design sustainable optimization of stiffened composite structures.