Artificial Ecosystems: An Artificial Life Approach to Multiobjective Optimization

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Abstract

Current evolutionary multiobjective optimization techniques while effective in approximating the shape of the Pareto front, suffer from high computational complexity due to explicit diversity management, archiving of good solutions, and population wide Pareto ranking for fitness evaluation, parent selection and recombination. We present an individual-based predator-prey ecosystem model for multiobjective optimization, where in at any given time instance, the prey population represents the current approximation of the Pareto front. The evolutionary pressure from the predators forces the prey population towards the Pareto front. The diversity of the prey population is obtained due to the spatial dispersion of the prey and localized mate selection and reproduction scheme.

The ecosystem consists of three components - predators, preys and an environment in which the predators and preys live. The decision vector of the multiobjective optimization problem is encoded as the genotype of the prey. The objective vector corresponding to the decision vector is the phenotype or observable characteristics of the prey. Predators are non evolving species and are able to observe the phenotype (objective vector) of the preys in their predation neighborhood and kill preys representing dominated solutions. Preys move around randomly in the environment, interact with each other for mate selection and reproduction and die, either due to old age or due to predation. A density dependent reproduction scheme is adopted for this model in which the number of offsprings a prey produces is inversely proportional to the average density experienced by it during its life. Such a reproduction scheme alleviates the need of modeling resource consumption by the preys, popularly used in individual-based predator-prey models.

The model mimics a self sustaining ecosystem, with the interactions between predators and prey having no adverse affect on the solution even after converging to the Pareto front. This characteristic of the proposed model appears promising for dynamic multiobjective optimization problems, where one or more objectives of the problem change over time. The proposed model is tested on well known benchmark multiobjective problems and is compared with NSGA-II, a popular evolutionary multiobjective optimization algorithm. Owing to its local interaction based reproduction and fitness scheme, the proposed model approximates the shape of the Pareto front orders of magnitude faster (in terms of fitness evaluations) than NSGA-II. Preliminary results for dynamic multiobjective optimization benchmark problems is also presented. Also a preliminary investigation into the efficacy of the proposed model for solving stochastic multiobjective optimization problems is also discussed.

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