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An Artificial Immune System-based Many-Objective Optimization Algorithm with Network Activation Scheme

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Abstract

In the research of multi-objective optimization algorithm, evolutionary algorithms have considered to be very successful tools. Artificial Immune System (AIS)-based algorithms as one of the viable alternative have also be widely developed in this domain. Over the years, researchers of evolutionary algorithms have extended their interest to many-objective situations; however works in AIS-based algorithms is rather scattered. This paper extends an AIS-based optimization algorithm to solve such many-objective optimization problems. The idea of ε-dominance and the holistic model of the immune network theory have been adopted to enhance the exploitation ability aiming for a quick convergence.

AIS-based Many-objective Optimization Algorithm

Evolutionary algorithms (MOEA) have shown to be the state-of-art tools for solving multi-objective optimization problems with 2 or 3 objectives. The application has been extended to many-objective situation with 4 or more objectives. With modification in the fitness assignment process and the evolution scheme, these algorithms achieve satisfactory results.

AIS-based algorithms are considered to be one of the viable alternatives in multi-objective optimization. A number of AIS-based multi-objective optimization algorithms have been proposed with promising results (Shang, 2012; Tsang and Lau, 2012). Majority of these studies focus on 2 to 3 objectives, with many-objective situations rarely being considered. The experiment in (Jarosz and Burczynski, 2011) had extended the application to 5 objectives. However, the study of many-objective optimization with AIS is still rare. This study therefore attempts to develop a novel AIS-based algorithm for solving many-objective problems.

In general, an AIS-based multi-objective optimization algorithm first generates the initial population. This population will go through cloning, variation, evaluation, network suppression and memory updating. Cloning and variation process generates modified solutions. Evaluation process assesses the fitness of each solution. Different fitness assignment scheme was proposed to increase the chance of domination. ε-dominance is one of them which relaxes the dominance requirement (Hernández-Díaz, et al. 2007). The resulting solutions are often dominated by solutions with lower or equal fitness in all objectives which are close enough to non-dominated solutions. Memory updating process selects population for next generation.

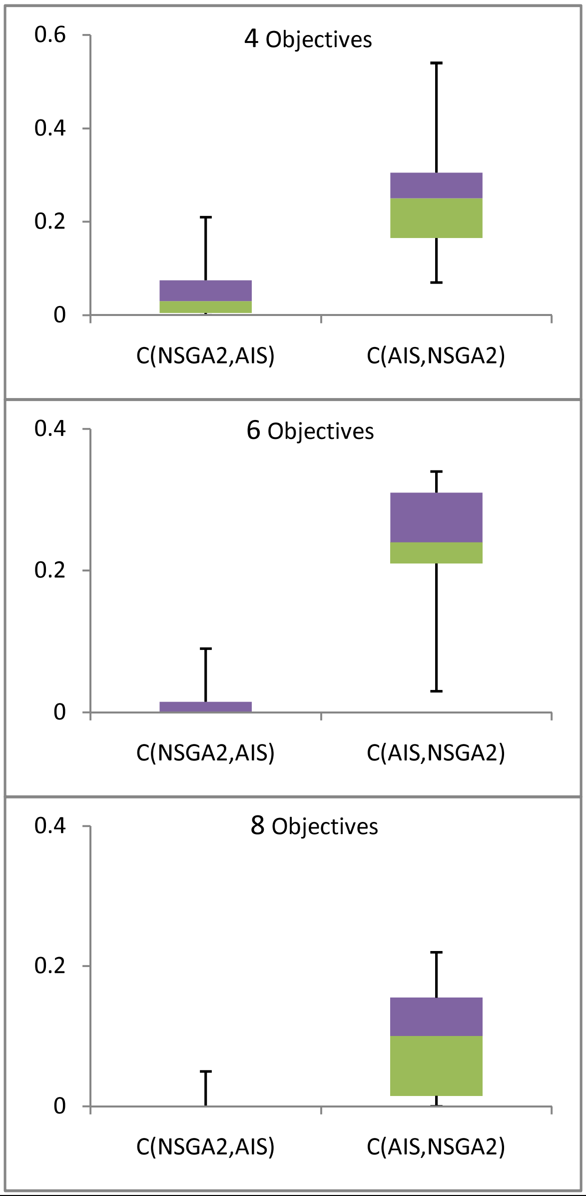
Inspired by the immune network theory, network suppression process provides a means to manage diversity. Such operation differentiates the AIS-based approaches from evolutionary algorithms in optimization. 'Near' solutions are suppressed to reduce redundant search. The concept of network interaction with suppression and activation had been implemented and tested on multi-objective optimization with promising results (Tsang and Lau, 2010). This study builds on the success in past studies and extends to many-objective situations. When a solution suppresses and dominates near solutions, this suppression hints a potential promising search if the exploitation can go further in the same direction from the dominated solution to the non-dominated solution. This suppression triggers the activation through generating new solutions on the identified high-potential space. The difference in decision variables define the search area and step size. New solutions will be generated based on the direction and step size as defined. Such an approach can supplement the dominance relation in identifying the searching area which accelerates the convergence through directed exploitation.

Experiment and Conclusion

The AIS-based approach enhanced with the proposed network activation scheme has been implemented and compared against the general AIS-based approach and some other conventional approaches. Test problems from the DTLZ family (Deb, et al. 2002), which are scalable to different number of objectives, are used for studying the performance in continuous functions.

Preliminary results comparing with the NSGA-II (Deb, et al. 2000) and using the Coverage C metrics (Zitzler, 1999) are shown. C(A,B) gives the proportion of solutions in B that are dominated by solutions in A. C(AIS, NSGA-II) is much higher than C(NSGA-II, AIS) for all 3 cases of increasing number of objectives. Box-plot is used as the presentation tools as it displays also the summary of the whole result including the outliners. The results show the potential of the AIS-based many-objective optimization algorithm.

Figure 1 C metric between NSGA-II and AIS



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