8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

DISTRIBUTED PARALLEL GLOBAL OPTIMISATION ARCHITECTURE

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Key Words: *Optimisation, Parallel Computing, Evolutionary Optimisation, MDO.*

ABSTRACT

A distributed architecture to deal with global optimisation of engineering problems in a parallel computing environment is here presented. The proposed architecture is based on a two stage, multi agent optimisation system. Every agent is a single multiobjective optimiser based on a PSO approach enhanced with elitism and Tabu philosophy to maintain sparsity of the solutions in the research space and avoid early convergence to local optima[1,2,3]. The overall architecture is designed to efficiently obtain global optimum solutions in search spaces, coming from real engineering problems, which can be both continuous or discontinuous, multimodal, non uniform and constrained.

Figure 1 shows a high level block diagram of the optimisation architecture. The first stage is in charge of optimising the objective function $\underline{f}$ while minimising the constraint violation $\underline{g}$. This stage is controlled by a module called *flip* which exchanges the evolving populations between the two agents whenever the solutions stall to in non optimum or non feasible areas of the search space. When the feasible areas of the search space which are eligible for optimality feature are identified, the optimisation passes to the second stage. Here the *separation* module divides the criteria space to assign them to different agents. The *separation* module is based on the cone separation approach proposed by Deb[4], modified to focus the optimisation effort on the areas of the pareto fronts less described during the search process. This approach permits, especially in highly constrained, non uniform and discontinuous search spaces to describe uniformly and completely the Pareto optimum front.

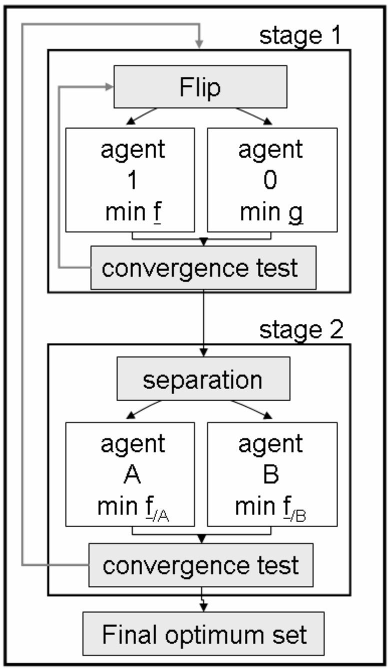

Fig. 1 Block diagram of the multi-agent, multi-stage optimisation architecture.

The connection between agents has been implemented trough an MPI protocol, permitting to the different optimisation processes to work in parallel. Tests on different test functions both constrained and unconstrained have shown the ability of the overall architecture to catch Pareto fronts of different nature. Comparisons on state of the art multi-objective Evolutionary Algorithms have been made to validate the optimisation system. In figure 2 results of the SPEA algorithm on the T2[2] unconstrained problem are compared to the solutions obtained in the same number of function evaluations with the proposed approach on the same problem with linear and non linear inequality constraints. The ability to reach and describe also limited areas of the search space without loosing performance is thus given.

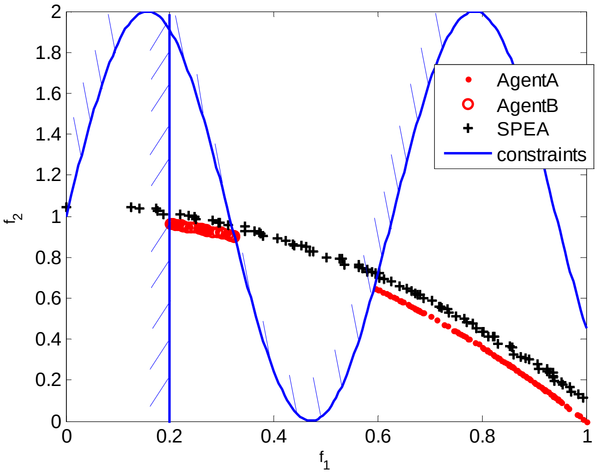

Fig. 2 Pareto fronts: proposed architecture on constrained problem vs SPEA on the same problem without constraints.

This architecture is now used to optimise difficult to solve engineering problems as the optimisation of spacecrafts during atmospheric phases are. This class of problems are known to be highly constrained problems with non continuous and multimodal search spaces.

To extend the capabilities of the proposed architecture, the first stage is used not only as a constraint handling mechanism, but also to subdivide different objectives between the agents thus improving the search capabilities to problems with high number of objectives.

REFERENCES

[1] Ventre G., Sobieszczanski J., ”Multidisciplinary optimization of a transport aircraft wing using particle swarm optimization”. Structural Multidisciplinary Optimization 26, 121-131, 2004.

[2] Zitzler E., Deb K., Thiele L., “Comparison of Multiobjective Evolutionary Algorithms: Empirical Results”. Evolutionary Computation 8(2): pgg. 173-195, MIT 2000

[3] Tan, K.C., et al, “A Tabu-based Exploratory Evolutionary Algorithm for Multiobjective Optimisation”, Artificial Intelligence Review, 19, 231-260 (2003).

[4] Deb K., “Parallelizing Multi-Objective Evolutionary Algorithms: Cone Separation”. KanGAL report nr. 017, 2004