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# EFFICIENT PARALLELIZATION OF EVOLUTIONARY ALGORITHMS FOR STRUCTURAL OPTIMIZATION PROBLEMS

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**Abstract.** Numerical optimization algorithms are increasingly used in the design process of aircraft structures due to an increasing complexity of this process. The new challenges are based on the application of new materials like carbon fibre reinforced plastics (CFRP), new structural concepts and increasing ecological and economical requirements.

**Keywords:** evolutionary algorithms; structural optimization problems; carbon fibre reinforced plastics.

Numerical optimization algorithms are increasingly used in the design process of aircraft structures due to an increasing complexity of this process. The new challenges are based on the application of new materials like carbon fibre reinforced plastics (CFRP), new structural concepts and increasing ecological and economical requirements. The resulting design variables are combinations of continuous and discontinuous design variables. Hence, especially evolutionary algorithms, like genetic algorithms, evolutionary strategies and differential evolution, are considered. The main idea of these algorithms is shown in Fig. 1.

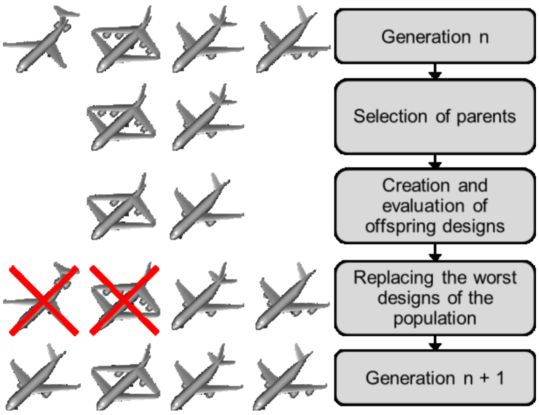


**Fig. 1.** Evolutionary algorithms

In every generation a certain number of parents are chosen to create offspring designs that have to be evaluated. Finally, some designs are selected to be the next generation.

A characteristic of aircraft optimization problems is a wide range in effort to determine the objective function values which varies from milliseconds up to hours. The reason for this wide variety is the possibility of utilizing handbook formulas or simple and fast methods to approximate the objective function values of infeasible designs on the one hand and complex finite element calculation of feasible designs on the other. Thus, there are very fast methods to decide whether a design is infeasible or not but the evaluation of near optimum designs takes much longer. This can result in a high amount of CPU idle time in case of the standard evolutionary optimization approach and the traditional parallelization techniques where each new design of one generation is evaluated on a single CPU or Core as shown in Fig. 2. In this figure MPI represents a standard for parallel computation in multi-processor environments.

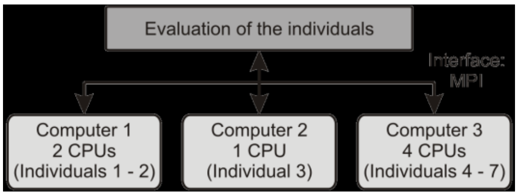


**Fig. 2.** Traditional parallelization approach

Some CPUs will idle until the analysis of the next generation is started if they only have to evaluate infeasible designs while others have to handle complex calculations on feasible ones. In a worst case scenario every design is evaluated on a single CPU or Core, where one design is feasible and all others are infeasible. In this case a huge amount of calculation power and time is wasted.

Therefore, a new efficient parallelization approach is presented to avoid these idle times. Therein the generation based approach is rejected. The standard mutation, recombination and selection operators are still applied. This results in highly efficient structural optimization algorithms for modern super computer architectures with an increasing number of computational units.