Final Report for NASA Grant NAG-2-1179
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Title: Design Space Exploration for MDO on a Teraflop Computer

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Objective: Development of global optimization techniques suitable for identifying promising regions in high dimensional aircraft configuration design space.

Approach: Different optimization methods have been examined to evaluate their ability to efficiently search the design space to locate promising regions. Multistart local optimization methods as well as global search techniques were examined and modified to compare their performance on high dimensional design space.

Accomplishments: One graduate student, Steven Cox, has been supported under this grant. The work has been reported in the following publications:

S. E. Cox, R. T. Haftka, C. Baker, B. Grossman, W. H. Mason, L. T. Watson, "Global Optimization of a High Speed Civil Transport Configuration", *Proc. 3rd World Congress on Structural and Multidisciplinary Optimization*, CD-ROM, Buffalo, NY, 1999, 6 pages.

S. E. Cox, R. T. Haftka, C. Baker, B. Grossman, W. H. Mason, L. T. Watson, "Global Multidisciplinary Optimization of a High Speed Civil Transport", *Proc. Aerospace Numerical Simulation Symposium '99,* Tokyo, Japan, June, 1999, pp. 23-28

S. E. Cox, R. T. Haftka, C. Baker, B. Grossman, W. H. Mason, L. T. Watson, "Global Optimization for Noise and Multiple Local Optima", *Proc. International Workshop on Multidisciplinary Design Optimization,* Pretoria, South Africa, August 7-10, 2000, pp. 50-59

S. Cox, R.T. Haftka, C. Baker, B. Grossman, W. Mason and L. T. Watson, "Global Optimization of a High Speed Civil Transport", *Submitted for review to the Journal of Global Optimization*, 2000, *Accepted for publication*, 2001

The performance of three methods of optimization was demonstrated for optimization problems that lead to high dimensional, non-convex optimization problems. Multistart methods with a local optimizer (DOT) and a semiglobal optimizer were compared with a lipschitzian based space partitioning global optimizer for problems containing noise and multiple, widely scattered, local optima. The DIRECT optimizer, initially designed for less than 6 dimensions was shown to be effective with as many as 28 design variables and is particularly well suited for problems with large numbers of local optima. Multifidelity, parallel versions of the DIRECT algorithm are currently being examined for implementation on massively parallel, heterogeneous architectures.

Significance: The DIRECT optimizer has been shown to be an efficient method for searching noisy, high dimensional space. For smooth functions with hundreds of local minima due to small fluctuations, multistart methods were more efficient. However, as the number of dimensions increased, DIRECT performed better on the complex HSCT analysis where the design space is non-convex and the function is not smooth. It is tolerant of numerical noise and is well suited to conversion to a parallel code. When combined with a local optimizer, DIRECT quickly locates regions of interest while the local optimizer finds the actual optimum. This uses each algorithm in the manner it is best suited to and reduces the number of function evaluations needed to find the good local optima.

Status/Plans: The grant has been completed. Continued examination of the DIRECT algorithm to modify it for parallel implementation and multifidelity global optimization is on hold pending the location of another source for funding.

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