Final Report for NASA Grant NAG2-1180

02/01/98 – 01/31/01

Title: Design Space Exploration for MDO on a teraflop computer.


Institution: Multidisciplinary Analysis and Design Center for Advanced Vehicles, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Objective: Make efficient use of massively parallel computation for exploration of high-dimensional aircraft-configuration design space.

Approach: Three directions have been pursued: First, fully distributed control and sophisticated termination detection techniques have been used to manage computation on massively parallel machines. Second, several different global optimization algorithms have been adapted to operate as explorers rather than local optima generators. Third, new visualization techniques and software tools have been developed to help visualize aircraft designs in high dimensional (>25) spaces.

Accomplishments: Three graduate students were partially supported under this grant:
• Denitza Krasteva: M.S. (Computer Science) 1999
• Chuck Baker: M.S. (Aerospace Engineering) 2000
• Amit Goel: M.S. (Computer Science) 2000

Publications supported by this grant:


The application of advanced parallel computational techniques such as fully distributed control, dynamic load balancing, termination detection, and pthreads to realistic aircraft configuration design problems has been thoroughly demonstrated. Novel visualization techniques such as parallel coordinates have been applied to high dimensional (29) design spaces, and a problem solving environment visualization tool (VizCraft) was developed to show planforms, airfoils, violated constraints, and compare design points in 29 dimensional space. A massively parallel version of a global direct search optimization algorithm, DIRECT, has been developed and static and dynamic load balancing strategies successfully integrated.

Significance: Krasteva’s work with the 2048 node Intel Paragon at ORNL demonstrated that advanced computer science techniques such as distributed control and pthreads can be effectively applied to aircraft configuration design, and that high efficiency can be achieved on massively parallel machines for realistic engineering design problems. VizCraft, a visualization tool for aircraft configuration design, represents a notable attempt to visualize data in 29 dimensions. Baker’s work has established the feasibility of a massively parallel version of a global direct search optimization algorithm, DIRECT. However, the algorithm has not been validated on a massively parallel machine due to lack of machine access and termination of the grant.

Status/Plans: The grant has been completed. It is unfortunate that we were not able to get access to a truly massively parallel machine, such as one of the ASCI machines, in order to validate our proposed algorithms, particularly the global direct search optimization algorithm.

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http://www.aoe.vt.edu/hpccp/hpccp.html
Figure 1. Snapshot from nupshot utility of static load distribution, $P = 7$.

Figure 2. Snapshot from nupshot utility of GRR-MC with global task count termination, $P = 7$.

Figure 3. Snapshot from nupshot utility of RP with global task count termination, $P = 7$. 
Figure 4. **Vizcraft** design view window showing aircraft geometry and cross sections of the airfoil at the root, leading edge break, and tip of the wing.
Figure 5. Sample problem indicating evolution of global search strategy in DIRECT. Contours indicate function to be optimized. Search does not get trapped in local optima.