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

Multi-Objective Design Exploration (MODE)

- Visualization of Design Space and Knowledge Mining

***Shigeru Obayashi[1], Shinkyu Jeong[2] and Takayasu Kumano[3]**

Institute of Fluid Science, Tohoku University
Katahira 2-1-1, Aoba-ku, Sendai, Japan 980-8577
[1]obayashi@ifs.tohoku.ac.jp, [2]jeong@edge.ifs.tohoku.ac.jp,
[3]kumano@edge.ifs.tohoku.ac.jp
http://www.ifs.tohoku.ac.jp/edge/indexe.html

Key Words: *Multi-objective Optimization, Multidisciplinary Design Optimization, Evolutionary Computation, Self-Organizing Map, Visualization, Data Mining.*

ABSTRACT

Multi-Objective Design Exploration (MODE) is presented to address Multidisciplinary Design Optimization problems. MODE reveals the structure of the design space from the trade-off information and visualizes it as a panorama for Decision Maker. The present form of MODE consists of Kriging Model, Adaptive Range Multi Objective Genetic Algorithms, Analysis of Variance and Self-Organizing Map. The main emphasis of this approach is data mining. The example illustrates the importance of the present approach because brief exploration of the design space could lead to finding design knowledge.

In Japan, a 5-year R&D project has been in progress toward the development of environmentally friendly high performance regional jet aircraft under auspices from New Energy Development Organization of Japan (NEDO) since 2003 [1]. In the project, several research programs have been investigated by industry-government-university cooperation [2]. The conceptual image of a regional jet aircraft is shown in Fig. 1. For the success of the project, a practical MDO system for regional jet wing design is required.

An MDO system was developed for a clean wing under the project [3]. The MDO system is based on the integration of Computational Fluid Dynamics (CFD) codes and the NASTRAN-based aeroelastic-structural interface code. Moreover, the Kriging model is employed to reduce computational expenses for function evaluations in MOGA. The resulting MDO tool has also been extended to an engine-airframe integration problem [4], which is one of the most important issues in the aircraft design. Shock wave generated at inboard of pylon may lead to flow separation and buffeting (Fig. 2). In order to prevent these phenomena, the lower wing surface near the pylon has been optimized.

Based on the results of the above multi-disciplinary optimization, knowledge mining has been attempted by using visualization of the design space. Figure 3 shows the

visualization result of the design space by using uniformly sampled solutions from the Kriging model. The upper left cluster appears the sweet spot in the design space.

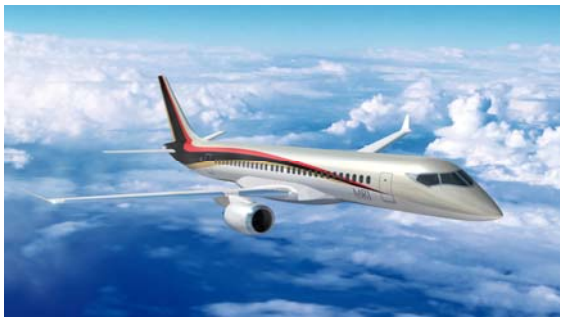

Figure 1. Environmentally friendly high performance regional jet aircraft.

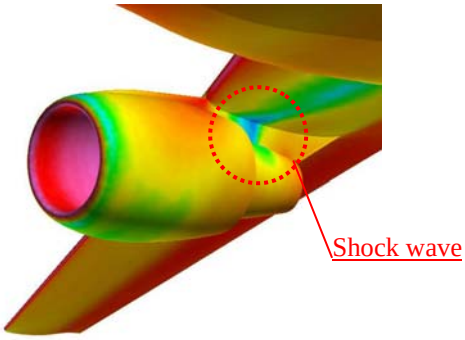

Figure 2. Surface pressure distribution near the nacelle-pylon at the cruising condition.

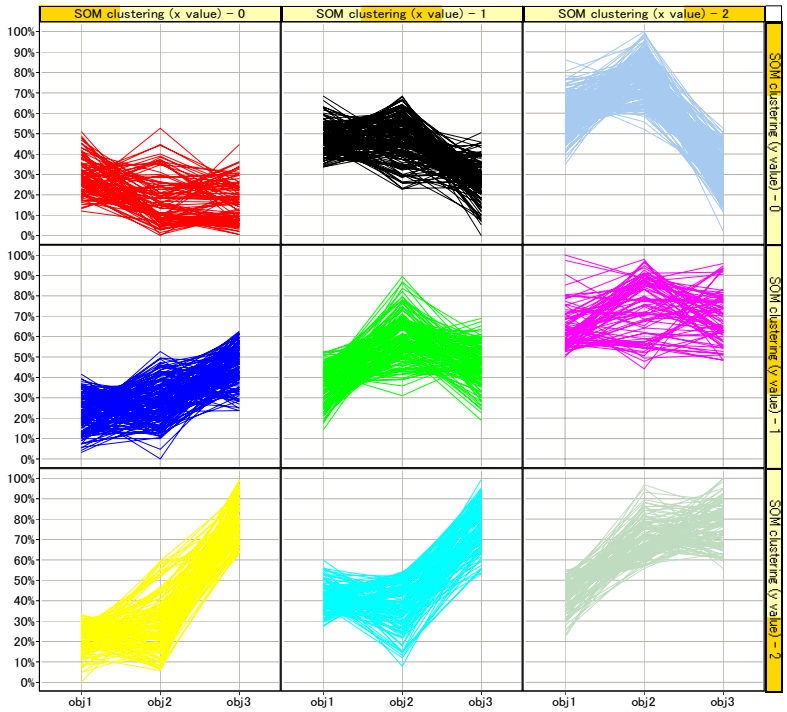

Figure 3. Distributions of the objective function values of the sampled solutions in the parallel coordinates for nine clusters found by Self-Organizing Map.

REFERENCES

[1] "NEDO" website, URL:http://www.nedo.go.jp/.

[2] K. Chiba, A. Oyama, S. Obayashi, K. Nakahashi, H. Morino, "Multidisciplinary Design Optimization and Data Mining for Transonic Regional-Jet Wing," Journal of Aircraft, Vol. **44**, No. 4, July, 2007, pp. 1100-1112.

[3] T. Kumano, S. Jeong, S. Obayashi, Y. Ito, K. Hatanaka, and H. Morino, "Multidisciplinary Design Optimization of Wing Shape for a Small Jet Aircraft Using Kriging Model," AIAA paper 2006-0932, 2006.