A STUDY ON FACTOR SCREENING IN COMPUTER-SIMULATION

Molina, G.J.[1], Garcia, J.O.[2], Fuentes, J.N.[2], Herrera, D.A.[2]

[1] School of Technology
Georgia Southern University
Statesboro, GA 30460-8045, USA
gmolina@georgiasouthern.edu

[2] Dept. of Aeronautics Engineering
Univ. Nacional de Cordoba
(5000) Cordoba, Argentina

Computer models of engineering systems often allow testing for a large set of factors. However, when little response-data are initially available, the effect of many candidate factors must be considered, some of which may not be significant to the studied responses. Factor screening is therefore required to minimize the number of considered factors. A study is presented on screening of geometric and aerodynamics-factors for their effects on lift for a tandem-biplane wing configuration, the so-called "Flying Flea". Had-hoc software was developed as an application of the lifting surface method of vortex-rings on the assumption of incompressible potential flux [1]. The computer code was successfully verified against wind-tunnel experimental data for a plane cell of constant airfoil geometry under the assumption of infinite wing-span [2]. This study shows that the code yields good estimation of lift values.

Saturated factorial experiments from classical design of experiments (DOE) could be particularly efficient for factor screening in field-experiments. However, saturated designs do not allow for an estimation of error, unless complete or selected partial replications of runs are included. A main concern of DOE designs is accounting for field-experiment randomness and non-repeatability of the runs. But when deterministic computer simulation is used the replication and randomization principles of classical DOE are not applicable, because repeatability error does not exist in the statistical sense; the dominant source of error comes from model bias and errors in numerical solution [3]. In this work, the estimation of effects from factors can still be done by simple computation of the factor "contrasts".

A saturated factorial experimental design was used to estimate from computer simulations the effects of seven factors on the lift-value responses. Initial screening was followed by a factorial design for some relevant interaction-effects between active factors. The results from screening suggest that some "geometric" factors, but wing "inflexion" may be of importance for CL values and Cl-alpha. The employed scheme, which explore breaking down screening in relatively small designs, also shows the feasibility of (a) combining after initial experiment two active factors into a single dimensionless-variable to reduce the number of studied factors, and (b) using specific knowledge about the problem (e.g., "expert knowledge") for helping screening. This sequence of orthogonal experiments illustrates the feasibility and risks of carrying out factor screening by computer simulation of experiments, and their analysis by simple contrasts on factor-effects. The authors are currently working on the use of the described software to further develop the ideas presented in this paper and to explore new screening methodologies, including "folder-over" experimental designs and Low Cost Response Surface Methods [4].

References

[1] Katz, J., Plotkin, A., *Low-speed aerodynamics, From wing theory to panel methods*, McGraw-Hill Inc., New York, NY, 1991.
[2] Rebuffet, P., *Aerodinamique Experimentale*, Librairie polytechnique Beranger, Paris, France, 1966.
[3] Giunta, A.A., Wojtkiewicz, S. F., Eldred, M.S., *Overview of Modern Design of Experiments Methods for Computational Simulations*, Proc. of the 41st AIAA Meeting, Reno, NV, Jan.2003, AIAA-2003-0649.
[4] Allen, T., Yu, L., *Low Cost Response Surface Methods from Simulation Optimization*, Quality and Reliability Engineering International, 18, 2002, pp.5-17.

Keywords: computer-simulation DOE