Robustness Analysis of an Inertial Fusion Target using the Design of Computer Experiments Approach

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Abstract

Inertial confinement fusion targets must be carefully designed to ignite their central hot spots and burn (Lindl, 1998). Changes on the optimal implosion could decrease the fusion energy or even prevent ignition. In this poster we investigate the robustness of a Laser MégaJoule target (Giorla et al, 2006) against technological uncertainties such as fabrication defects and laser not perfect reproducibility. This robustness must be assessed in a very high dimensional parameter space whose variables include every characteristic of the given target and of the associated laser pulse shape, using high-fidelity simulations. Therefore, these studies would remain computationally very intensive and we use a metamodeling approach to reduce the computing time. The main difficulty of metamodeling the fusion energy of an ICF capsule is due to the very complicated shape of the response surface with cliffs in almost all directions. Among the several possible metamodels we have tested, the best one is a particular form of a neural network with a single layer of 25 hidden neurons. An iterative method adds new points in the data set by means of D-optimal experimental designs (Issanchou and. Gauchi, 2008). Finally, only a few thousands simulations are necessary to obtain an accurate metamodel on a huge 22-dimensional parameter space. The target robustness is then evaluated by transporting the input uncertainties through the metamodel with a Monte-Carlo method. We illustrate the results for different robustness metrics and we analyze the robustness sensibility to the target and laser specifications.

Bibliography

Lind, J. D., 1998. Inertial Confinement Fusion, the quest for ignition and energy gain using indirect drive, Springer-Verlag, New York

Giorla J., et al, 2006. Target design for ignition experiments on the laser Mégajoule facility, Plasma Phys. Control. Fusion 48, B75.

Issanchou, S., and J-P. Gauchi, 2008. Computer-aided optimal designs for improving neural network generalization, Neural Networks 21, 945.