

# Efficiency Analysis of Design Space Resizing Technique Using Monte Carlo Simulation

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## ABSTRACT

In optimization problem, existing method of design was generally to find the optimum value in a space given by experience. But new and inexperienced research have uncertainty in determining the variable space of design. This paper is undertaken to understand the fact that the establishment of a design space made well in the beginning of design is important to find the optimum value, and verified the propriety of the given space of design and reset the space which is feasible and efficient.[1]

When the optimization problem is executed, generally the wider space of design is selected, the more time takes because of quantity of calculation. If all of the expected space is considered, the result is accurate, but it takes long time. So the choice of user is needed between accuracy of optimum value and time. This paper suggests the method that eliminates the space which is to fail and is less likely to succeed to find a proper space for design from all of the expected space. And this paper compares just conducting optimization in all of the expected space with this suggested method from the viewpoint of run time and accuracy of optimum value.

Through all of the expected space, sampling process is conducted by Design of Experiment and using this data, Response Surface [2] is generated. Monte Carlo Simulation [3] is used to compute in the whole points within the overall space of design variables. Monte Carlo Simulation is performed using Response Surface Method instead of analysis code and at each point the feasibility is checked by Probability of Success.

Probability of Success (POS) means the rates of passing all standards and below numerical formula is Joint Probability of Success. Equation (1) is POS for the Empirical Distribution Function [4] with  $M$  = number of samples, equation (2) is POS for the Joint Probability Model.

$$POS = \frac{1}{M} \sum_{j=1}^M I(z_{\min} \leq z_j \leq z_{\max}) \quad (1)$$

$$POS = \int_{c_{\min}}^{c_{\max}} f(z) dz \quad (2)$$

Using Probability of Success, to exclude the space which is easy to fail or which is less likely to succeed and to move the space which has not been included into the design space containing it, the mean and standard deviation of design variables in a successful case are

used. In this process, Chebyshev Inequality is used. Chebyshev Inequality means the probability of which a variable has any probability distribution existing over sigma from mean is less than any value.

$$P(|x - \eta| \geq \varepsilon) \leq \frac{\sigma^2}{\varepsilon^2} \quad (\text{for any } \varepsilon > 0) \quad (3)$$

As which number is multiplied to sigma, the space can be decreased or enlarged. The verification of feasibility is checked by drawing Probability Density Function and Cumulative Distribution Function.

For test of this process, arbitrarily 10 degree function which has 4 local minimum values in equation (4) is made.

$$f(x) = 0.0007x^{10} - 0.0351x^9 + 0.7387x^8 - 8.6617x^7 + 61.978x^6 - 278.83x^5 + 782.94x^4 - 1313.5x^3 + 1192.2x^2 - 468.56x^1 + 99.852 \quad (4)$$

This function has 15.33 of global minimum value when x is 7.81. Fig.1 show this function which is dash and response surface which is solid respectively iteration number is 2,4,7. Totally 8 iteration is performed and each iteration includes 100 times Monte Carlo Simulation. The range of variable can be less than half, from 6.37 to 8.56, of the first range, from 0 to 14, which still includes the minimum value. Through this test when degree is extended to 2 or more, the quantity of total calculation and total run time is more decreased.

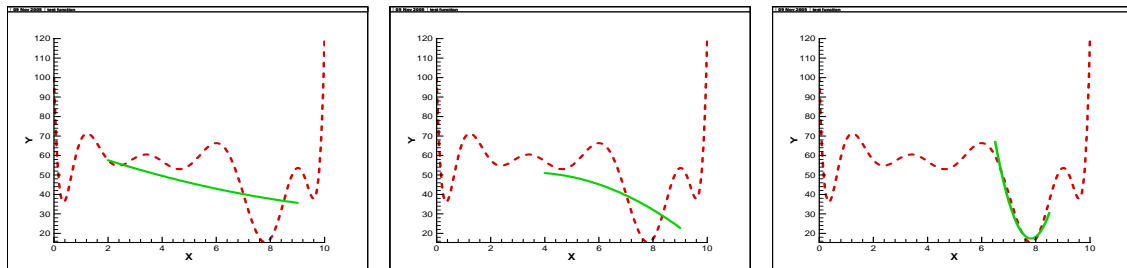


Figure 1. Test function and response surface

To validate the efficiency of this process, optimization of the satellite adapter ring is performed. It is started with the considered overall space and the space of design finally is decreased. The total time and optimum value is compared this process with that is applied by Genetic Algorithm [5] in considered overall space and efficiency is checked in each process.

## REFERENCES

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