ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimisation (1) (4)

Author: Mr. Tao Cao
Shanghai Aerospace Control Engineering Institute, China, caotaoGNC@gmail.com

Prof. Changhong Dong
Beijing University of Aeronautics and Astronautics (BUAA), China, rainbowdong@buaa.edu.cn
Dr. Zhang Shuyu
Shanghai Aerospace Institute, China, zhsy6293@yahoo.com.cn
Mr. Fengbo Wang
Beijing University of Aeronautics and Astronautics (BUAA), China, wangfengbohao@163.com

# OPTIMIZATION OF LUNAR SOFT LANDING TRAJECTORY BASED ON HYBRID METHOD

**Abstract**

Based on the mixed-solving ideas, the fuel optimal lunar soft landing problem can be solved with Gauss pseudospectral method and the indirect shooting method. Ignoring the lunar rotation and other natural constraints, The two-body model of detector and lunar can be established with engineering constraints such as engine performance, fuel weight and so on. Based on the Pontryagin's maximal principle, the fuel optimal lunar soft landing problem can be simplified as a two point boundary value problem with variable final time. Then the problem can be solved in two steps. First, the equations of adjoint state were discretized together with the equations of state. Taking the state variables and the adjoint variables on discrete nodes as the optimization parameters, considering variables continuous as constraints, Gauss pseudospectral method could solve the problem successfully. The result may be not the optimal one because the transversal condition was not considered. On the other hand, the adjoint variables were calculated when the state variables solved. So the initial adjoint variables were gotten in this step. Then, the initial adjoint variables were listed by searching the neighborhood of gotten adjoint variables with the employment of the combinational algorithm, which is combined with Particle Swarm Optimization (PSO) for reducing the territory of searching region and Simplex Method (SM) for decreasing the time of obtaining suitable results. The hybrid method, which used the Gauss pseudospectral method to get the initial value of the adjoint variables and solved the two point boundary value problem with the indirect shooting method, combines the advantages of the direct method and indirect method. Relative to the indirect method, it avoided to guess the initial value of the adjoint variables and utilized the globe searching and local searching at the same time by using the combinational algorithm. Relative to the direct method, the most valuable advantage of hybrid method is that the optimality conditions were satisfied and the Convergence range was wider. The simulation results show that the Hybrid Method used for designing the soft landing trajectory gives good performance on steady, efficiency and accuracy, even some practical constraints are under considered.