TESTING AND IMPROVEMENT OF A COMPLEX SYSTEM

Autonomous Planetary Rover Experimentation and Simulation

Statement of Project

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Introduction

The use of complex systems is constantly expanding in both aerospace engineering and numerous other fields, and with the spread of these systems, their complexity increases as well. Due to this complexity, the systems and any dependants often suffer from unreliable behavior. This behavior is undesirable in a complex system and may result in unsafe operating conditions or a mission failure.

A Monte Carlo (MC) simulation involves the use of stochastic numbers. Such a simulation is usually run thousands of times and statistics are taken that describe the behavior of the system that is being modeled. Monte Carlo simulations are already used for analysis and modeling in many fields, including molecular chemistry, economics, nuclear physics, radiotherapy, and even transportation engineering.

Although testing of systems used to be done experimentally, many fields are now using an analytical approach. Wing design is just one such area, and serves as a good example. Where in the past numerous wind tunnel tests would be performed, the airfoils are now developed on computers and then tested in a wind tunnel for confirmation.

A hybrid development approach will integrate the two current kinds of testing and development into one. Experimentation will be used in conjunction with computer-aided analysis to provide superior development capabilities. This will be done by using experimentation to refine a MC simulation and vice versa. The results from the MC simulation will then be used to change the system, a rover, with the intent of improving its performance on various tasks. It has been proposed that this hybrid approach will offer the most benefit to high levels of complex systems, but it seems that little research has been done in this area.

It is the intent of this project to use the hybrid development approach with an autonomous planetary rover, but at many varying levels of complexity. By varying the task that the rover must perform (such as the number of goals to achieve, total time for varying missions, locations to find, or the number of items retrieved), the overall complexity level of the system will change. The results of this project have the

possibility of providing great insight into the correlation between the improvement of complex systems and the methods used for their development.

Hypothesis

There is an increasing trend in performance improvement as system complexity increases when a hybrid development approach is used.

Objective

The objective is to successfully collect data for a system operating at various levels of complexity in order to measure a performance increase trend caused by the use of a hybrid development approach.

Strategies

The following strategies will be used to achieve the success criteria:

1. A rover must be obtained.
2. Define the varying complexity tasks and make a test metric.
3. Run initial tests with the rover to get baseline performance data.
4. Employ a hybrid development approach:
    a. Build a Monte Carlo simulation of the rover.
    b. Refine the simulation to fit the results from actual runs of the rover. More tests may be required here and this is a cyclical process. If results do not align, look for errors within the rover that can be corrected.
    c. Run the simulation and collect statistics which can then be used to suggest changes to the rover.
    d. Implement any changes to the rover that are a result of the statistics from the MC simulation.
5. Run the tests with the rover again for the same scenarios as in strategy 3 and collect data.
6. Analyze and compare the results from 3 and 5.

Success Criteria

Data that clearly supports or does not support the hypothesis that performance improvement will increase with system complexity.

Conclusion

This project will employ the use of a rover to test the idea that a hybrid development approach has more impact on high levels of complex systems than on those systems that are not as complex. It would be beneficial to the aerospace industry, as well as others, to illustrate some correlation between developmental approach and system complexity. Only one rover will be used, but it will perform varying tasks that will give the system different overall levels of complexity.