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ATMOSPHERIC NEURAL NET APPLICATION TO MARTIAN ENTRY, DESCENT, AND LANDING

Abstract

EDL serves as one of the 16 NASA official technology roadmaps – however, many of the NASA developments in atmospheric flight from as distant as the 1960's remain the basis of our capabilities. One of the goals of both public and private industry is to update these heritage methods and implement new knowledge in the areas of aeroassists, descent and targeting, and landing systems in order to use them for upcoming missions to both planets and atmosphere-retaining moons. The development such systems only has the benefit of not only implementing recent advances in machine learning, but also of obtaining concrete spaceflight systems outcomes such as increased mass delivery, delivery accuracy, and stochastic robustness, and expanded entry speed envelopes which will help in critical upcoming missions. This research is based around the development and use of a robust Martian landing algorithm that will ensure a vehicle's completed mission in the presence of performance and perturbation uncertainties. Predictor-corrector methods are commonly used for on-board guidance in dynamic environments, however, has shortcomings that comes from its assumption of mean state evolution and model parameters. During reentry, the stochastic nature of the atmosphere and aerodynamic performance often leads to these predictions being inaccurate. One way this is currently being pursued is in the application of machine learning algorithms to the atmospheric perturbations experienced during the re-entry process. First, in order to apply the benefits of machine learning onto re-entry problems, it was necessary to create a re-entry framework to train the method on. To this end, a bank-modulated landing baseline code was created to test simple ballistic and guided results. In this work, a neural net will be trained on a series of Monte Carlo landing simulations for years of data of Martian atmospheric conditions through GRAM 2010, a NASA software being used for this research. The resulting net can then handle a new implementation of a trajectory with significantly less error than previous predictor-corrector models even for non-linear aerodynamic models, because of its training on atmospheric perturbations. A multi-layer, feedforward backpropagation neural network has been chosen for use due to its proven ability to handle unsteady dynamical systems. By applying the uses of neural nets to these stochastic atmosphere changes, any amount of guidance correction required as conditions change in the trained model will be reduced and the stability, efficiency, and precision of Martian landing systems will be greatly enhanced.