Paper ID: 59034
oral
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (3)

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# A NOVEL HYBRID APPROACH TO INTELLIGENT CONTROL INVOLVING NEURAL NETWORK AND GENETIC PROGRAMMING

**Abstract**

The proposed work aims to introduce a novel approach to Intelligent Control (IC) involving an Artificial Neural Network (ANN) and Genetic Programming (GP) for Access to Space applications. In the proposed approach, GP is used to evaluate offline the optimal control law of the chosen plant for a set of different failure scenarios, starting from no knowledge of the controller topology. To do so, an optimal trajectory found through a Multiple Shooting method is used as reference. Then the parameters of the produced control law are optimized for different failure scenarios in order to produce a database to be used to train the ANN. Finally, the ANN is used to modify the GP control law online in order to allow the system to cope autonomously with unpredicted variations of both environmental and/or system conditions. These two machine learning techniques were chosen accordingly to their role in the controller definition. The key feature of GP is its ability to autonomously design a controller even for complex systems, where classical controllers fail because of the high nonlinearity of such systems, producing an explicit mathematical equation which can be easily interpreted by the user. The ANN was chosen in the presented approach for its ability to learn the correlation between the values of the states of the plant at each time step and the control law parameters, for different operating conditions. Therefore, it becomes particularly interesting for control applications where it could lead to good online control performances. The proposed approach is tested on a realistic model of a reusable space access vehicle on different realistic failure scenarios. Such test case was chosen because space access vehicles are very complex and expensive systems which heavily rely on a robust adaptive controller, in order to avoid unforeseen situations. The proposed intelligent control approach could be a valid alternative to classical control methods and possibly it could help speed up the controller design phase, without losing precision or robustness.