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DEEP LEARNING, REINFORCEMENT LEARNING AND DIGITAL TWIN FOR THE CREATION OF THE NEXT GENERATION INTELLIGENT ATTITUDE DETERMINATION AND CONTROL SYSTEM.

Abstract

With the increasing rewards as a result of the proliferation of Artificial Intelligence in major industries and the growing demands of the space industry, there is an increasing need for an intelligent system that can operate a spacecraft without the input of on-ground engineers. This will free up resources and bypass the issue of communication delays for long interplanetary missions. Intelligent control, active health monitoring maintenance and autonomous navigation are three key fields that need to be integrated to create this agent.

The present work explores the application of a deep learning framework to aid in attitude correction of a satellite following an impact from a foreign object and orbital decay. A Long short-term memory (LSTM) recurrent neural network is trained and tested. The input for the neural network as defined in the training set consists of attitude position residues generated by simulations on an air bearing satellite simulation table. The output is the control values needed to correct the perturbations using reaction wheels. The algorithm performance is evaluated based on a result comparison to a fine tuned traditional dynamic control system that uses a proportional–integral–derivative (PID) controller.

The LSTM coupled with reinforcement learning is found to achieve an accuracy of 91

This research also explores the use of a digital twin for the air bearing satellite simulation table. A comparison is done between the neural networks trained using the digital twin vs. using the physical model. A one to one correlation was found between the results from the two models. A digital twin enables iterative testing of algorithms and debugging without interacting with the hardware during mission time. This is incredibly useful when the digital twin is that of a real world satellite on a critical mission.