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NEUROEVOLUTIONARY HEBBIAN-LEARNING FOR INTERPLANETARY TRAJECTORY DESIGN

Abstract

With the dawn of an Artificial Intelligence (AI) Renaissance, especially in Deep learning and evolutionary techniques [1], it is necessary to address the synergies between AI and spacecraft Guidance. The use of evolutionary techniques, machine learning techniques and tree search methods for interplanetary trajectory designs, particularly in the early stages of mission design phase have been studied over the last few decades [2]. In this paper, we propose and study a novel idea concerning the application of Neuro evolutionary Hebbian Learning for the optimal guidance profile for an interplanetary spacecraft, which will be used in the mission design phase.

Current studies include Deep neural networks, Q-learning networks, Reinforcement learning and evolutionary algorithms which are used for spacecraft guidance. Evolutionary techniques are a class of global optimization techniques that uses meta-heuristic rules, which often uses natural paradigms such as Darwinian evolution to solve interplanetary optimization problems [3,4].

In this paper, we seek to use the Hebbian engrams and cell assembly theory [5] for the evolutionary learning of the spacecraft guidance. Unlike conventional evolutionary techniques, which uses the highest scoring neural layers to mutate, Hebbian theory states that the synaptic efficacy between two neurons should increase if the two neurons are 'simultaneously' active, and if two neurons on either side of a synapse are activated asynchronously, then that synapse is selectively eliminated. By employing a Neuroevolutionary Hebbian learning Algorithm which self evolves, all autonomous decision-making tasks for trajectory design during the mission design phase will be done at the maximum possibility of achieving the minima of loss, which is difficult using genetic algorithms where optimal solutions are often in highly discontinuous and rugged landscapes. The proposed method is validated for its effectiveness through numerical simulations.

References:

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