Orbital Recognition System for Space Debris Tracking Using Artificial Neural Networks: A Journey from Inner-Brain GPS to Outer-Space GPS

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Space debris emerges as an imminent threat to space vehicles in low earth orbit. Tracking space debris beforehand to alert spacecraft of a threat to maneuver spacecraft away from a collision path provides a solution to avoid catastrophic events. Conventional tracking tactics utilize statistical means to estimate one waypoint at a time using error covariance measures for orbit determination. However, tracking tactics are vulnerable to orbital variations of space debris because of the effects of external disturbances on orbital dynamics. Orbital variations of space debris evolve geometrical features into orbital patterns that can be recognized by machine learning. This research is invoked by the recent Nobel-winning discovery of the abilities of the brain's place and grid nerve cells in enabling a sense of location and navigation as an inner Global Positioning System. The potential of excitable neurons to transmit information through electrical signals via synapses is applied to this research. An orbital recognition system is presented to detect, track, and catalog space debris using machine-learning Artificial Neural Networks (ANN) trained by current and recorded data in a backpropagated manner. Training inputs for ANN-based orbital recognition display patterns of orbital geometries are discernible in Keplerian elements. Changes in Keplerian elements are then propagated from four past waypoints for orbital trajectory prediction. The sensitivity of the orbital recognition system versus Keplerian variations is analyzed to evaluate the robustness of the ANN system. An orbital-dynamics model is developed for simulation and animation of space debris randomly created in orbit. Simulated results are shown to validate effectiveness of this ANN-based orbital recognition approach.

Awards Won:
Second Award of $2,000
European Organization for Nuclear Research-CERN: Second Award of $1,500