SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy

Prof. Giovanni B. Palmerini
Sapienza University of Rome, Italy
Dr. Leonardo Chiwiacowsky
University of Vale do Rio dos Sinos, Brazil

ROOT'S LIKE NATURAL BEHAVIORS APPLIED TO GUIDANCE ALGORITHMS FOR SPACE EXPLORATION MISSIONS

Abstract

The behavior of living beings is currently object of remarkable interest in many fields of study, not limited to biological research. It can be assumed that many natural phenomena, even the most complex, are determined by the chaotic sum of very simple actions. The sum of this actions leads to the successful completion of a typical natural process. This is the basic concept of the so-called behavioral strategies: global goals can be reached thanks to the implementation of rudimental control rules that govern the motion of a large number of agents (corresponding to the flies in a swarm, the birds in a flock and so on). These systems have proven great robustness and autonomy when designed for robotic applications. In particular, space missions exploiting behavioral strategies have been already investigated, as for example for autonomous maneuvering of large fleets of small satellites.

The objective of the proposed paper, following the swarm behavior approach, is to reproduce the plant roots' behavior and to apply the relevant guidance laws to space exploration missions. In fact, the proven capabilities of roots to find the path for the richest nutrient location can be easily translated into the possibility of a formation of space probes to optimally explore a given target region, as for example the unknown ground surface of a planet. The basic laws governing the roots behavior can be implemented similarly to what usually done in the swarm behavioral strategies. Of course, a first step consists in an accurate modeling of the soil characteristics and plant growth models: in this way the behavioral strategy, once properly tuned, manages to reproduce the different root patterns that can be seen in nature. Then, the transfer of the root path planning to space exploration missions is investigated, comparing the characteristics of traditional guidance strategies, swarm behavior and root behavior strategies. Finally, the ability of the roots basic control laws to find out local and global maxima is also investigated as a possible mathematical optimization tool, to be developed as a general purpose algorithm.