Path Planning Startegies Inspired by Swarm Behaviour of Plant Root Apexes

Executive Summary

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Date: 31/01/2011

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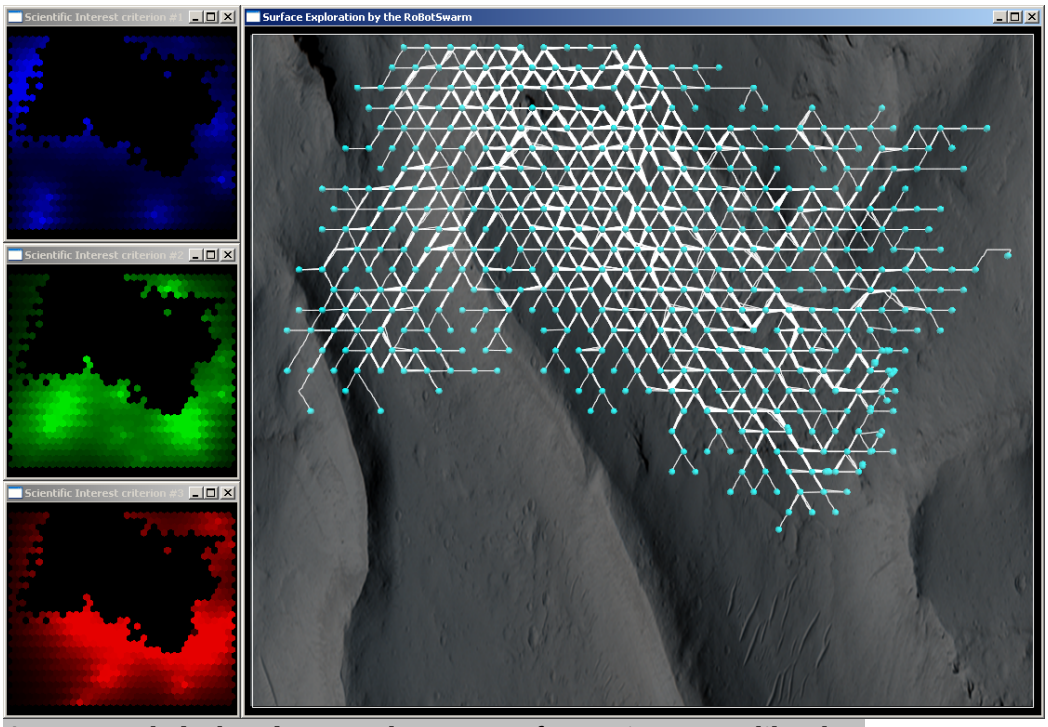
Ariadna ID: 09/6401
Contract Number: 22710

Research Category:
Biomimetics, Artificial Intelligence

Code and Title of the study:
09/6401 Path Planning Startegies Inspired by Swarm Behaviour of Plant Root Apexes
Contract characteristics :
University/Research Centre/Department: **:** UNINOVA-CA3, Computational Intelligence Research Group, New University of Lisbon, Faculty of Sciences, University of Lisbon, Advanced Concepts Team, European Space Agency
Academic researchers: Luís F. Simões, Cristina Cruz, Rita A. Ribeiro, Luís Correia, Tobias Seidl, Christos Ampatzis, Dario Izzo
Type of study: *4 months*

Picture:



A sensor web deployed over a planetary surface, using a root-like plan.

Motivation:

Exploring unknown environments and identifying potentially interesting or hazardous areas is a challenging task for an autonomous agent. In the absence of a priori provided maps or landmarks guiding navigation, researchers are considering multi-agent systems trying to exploit the inherent parallelism of such systems. Many scientific research works following this direction draw inspiration from biological swarm models. In such models, self-organised exploration strategies emerge at the collective level as a result of simple rules followed by individual agents. To produce the global behaviour, individuals interact by using simple (often indirect or

stigmergic) and mostly local communication protocols. Social insects are a good biological example of organisms collectively exploring an unknown environment, and they have often served as a source of direct inspiration for research on self-organized cooperative robotic exploration and path formation in groups of robots using swarm intelligence techniques. The starting hypothesis of this study is that roots also are a good example to get inspiration from as to design robust algorithms to explore unknown environments..

Methodology:

In this research, we model a root swarm system based on simple agents and used its principles to design a swarm robotic controller. The root model is considered as a multi-agent system with several goals and tasks: the simultaneous exploration and exploitation of different resources present in the soil where the root lives and grows. We obtain control structures for individual apexes, that when cloned on all apexes can reproduce biologically plausible global root patterns. Finally, we directly employ these control structures optimised in the context of biological systems to implement the exploratory behaviour of a swarm of robots. In this sense, our study goes beyond vague biological inspiration into direct application of the exploration strategy used by the biological system to the engineering application. The inherent risk of failure of such a direct transfer is theoretically mitigated by millions of years of evolution of the root exploration strategies; in practice, the results from this study confirm the applicability and efficiency of this algorithm.

Results:

- We have successfully modelled soil-root interactions for a herbaceous type of plant.

- We managed to grow a simulated root using the ansatzthat root apexes behave as a swarm

- We used the apex root controller we obtained in the first part of this work, to drive the deployment of a sensor web on a planetary surface

Publications:

Highlights:

We demonstrated have for the first time the potential roots have as a source of biological inspiration for the design of the decentralised control system of a swarm of robots performing a collective exploration task.