Polychaete-like undulatory robots for search-and-rescue operations†

D.P. Tsakiris[1], A. Menciassi[2], M. Sfakiotakis[1], G. La Spina[2] and P. Dario[2]

[1] Institute of Computer Science – FORTH, Vassilika Vouton, P.O.Box 1385,
GR-71110 Heraklion, Greece
{tsakiris, sfakios}@ics.forth.gr

[2] Scuola Superiore Sant'Anna, Piazza Martiri della Libertà, 33, 56127 Pisa, Italy
arianna@sssup.it, {giannilaspina, dario}@mail-arts.sssup.it

Abstract

Mobility and control of locomotion are among the most significant problems for emerging robotic applications dealing with unstructured and tortuous environments. Such problems occur in search-and-rescue operations in collapsed buildings, in planetary exploration, even in endoscopic access to the human body.

Drawing inspiration from biology, where such problems have been effectively addressed by the evolutionary process, can help in designing agile robots, able to adapt robustly to a variety of environmental conditions. The study of lower animals in particular (invertebrates, lower vertebrates), is proving beneficial in determining the principles of biological motion control. A class of segmented worms, the polychaete annelids, offer an intriguing biological paradigm of locomotion on sand, mud, sediment, as well as underwater: they can be found living in the depths of the ocean, floating free near the surface, or burrowing in the mud and sand of the seashore. The variety of their morphology, sensory apparatus and nervous system structure is a direct consequence of their adaptation to so diverse habitats. Their locomotion is characterized by the combination of a unique form of tail-to-head body undulations, with the rowing-like action of the numerous lateral appendages, called parapodia, distributed along their segmented body. Both characteristics provide these worms with distinctive locomotory modes, increasing their terrain-traversing and their terrain-manipulating (e.g. digging) capabilities. Such capabilities could benefit, if properly replicated, a robotic system used in SAR operations.

The present work reports on the development of computational models of the mechanics and bio-inspired motion control of this type of locomotion, based on the Lagrangian dynamics of the system, on resistive models of its interaction with the environment and on neural control using central pattern generators, as well as on simulation studies demonstrating the possibility to generate polychaete-like undulatory gaits. A lightweight robotic undulatory prototype with eight segments has been developed, which is able of locomotion on sand (see figure below).

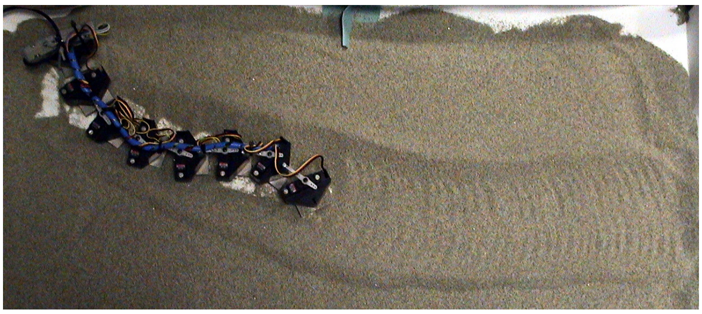

Figure 1: Robotic undulatory prototype moving on sand

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