Mimicking the thigmotropic behaviour of climbing plants to design a tactile-based grasping device for the space environment

Executive Summary

Authors: R Vidoni[1] , T Mimmo[1], C Pandolfi[2]
with the cooperation of prof. S.Cesco[1] and F.Valentinuzzi[1]

Affiliation: [1] FAST-Faculty of Science and Technology, Free University of Bolzano, Bolzano (Italy), [2]ESA ACT- *Advanced Concepts Team*

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Contacts:

Renato Vidoni
Tel: +39 0471 017203
Fax: +39 0471 017009
e-mail: renato.vidoni@unibz.it

Tanja Mimmo
Tel: +39 0471 017161
Fax: +39 0471 017009
e-mail: tanja.mimmo@unibz.it

Leopold Summerer (Technical Officer)
Tel: +31(0)715654192
Fax: +31(0)715658018
e-mail: act@esa.int

Available on the ACT website
http://www.esa.int/act

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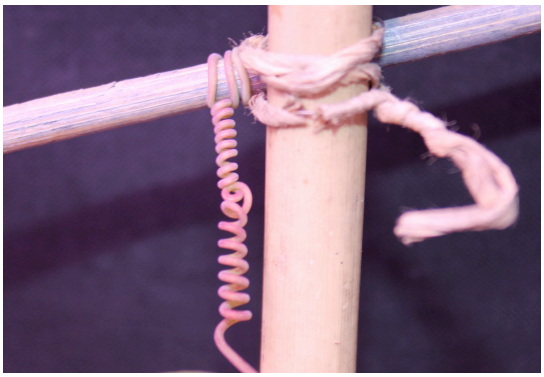
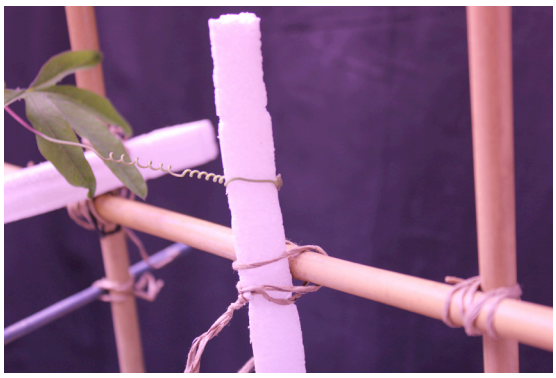
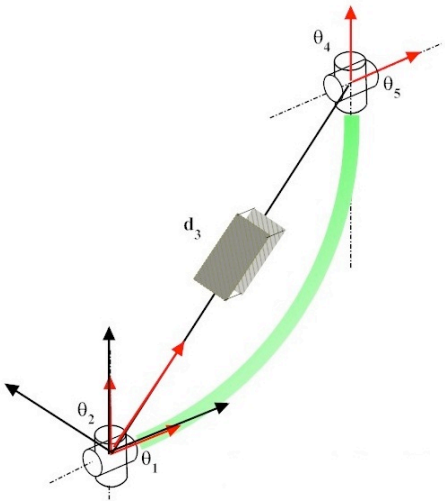
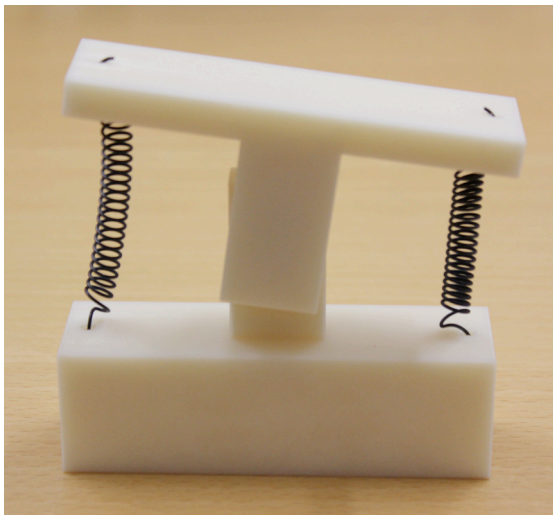
Picture:









Motivation:

Investigating and finding innovative concepts and solutions to understand and mimic the grasping and pulling behaviour of tendril bearing climbing plants.

Methodology:

This work aims at studying the rules and strategies behind the climbing plants that exploit tendrils from a bio-mimetic point of view. Such analysis will tackle these aspects to “read" the natural grasping behaviour also from an engineering point of view. Indeed, a robotic design phase requires a deep comprehension and evaluation of the plants principles.
Pea and passiflora plants have been chosen to monitor and study the tendril behaviours: circumnutation, coiling/grasping and free-coiling.
Plant behaviour has been translated into engineering models, rules and ideas. Different materials and techniques have been evaluated both to set-up future effective bio-mimetic mechanisms and to validate the experimental observations.
A robotic approach has been exploited to describe and simulate from a kinematic point of view a bio-inspired robotic tendril.

A practical realization of a modular bio-inspired grasping robotic tendril has been designed together with a proof-of-concept of a section for the modular structure.

Results:

- Tendrils grasp cylindrical, concave and convex supports either by coiling or by generating a hook.
- The helical spring shape structure formed due to the free-coiling phase has been optimized in terms of shape, stiffness and tension.
- Shape Memory Alloys (SMA) have shown to be effective in the mimicking of both the grasping and free-coiling phases.
- A kinematic tendril-like modular model has been designed and simulated, and SMA driven modules prototyped.

Publications:

Journals:

- T Mimmo, R Vidoni, C Pandolfi, F Valentinuzzi, S Cesco, **Novel insights in the tendril behaviour: enhanced grasping mechanism of passiflora spp**, to be submitted to *Plant Signalling and Behaviour*.

- R Vidoni, T Mimmo, C Pandolfi**, Towards a bio-inspired robotic tendril: from biological behaviours to innovative robotic solutions**, to be submitted to *Bioinspiration and Biomimetics*

International Conferences:

- C Pandolfi, T Mimmo, R Vidoni, **Mimicking the thigmotropic behaviour of climbing plants**, to be submitted to *Living Machines: the 2nd Int.Conf. on Biomimetics and Biohybrid Systems*, London, 29th July-2nd August, 2013
- R Vidoni, T Mimmo, C Pandolfi, **From tendrils to robots: modelling, simulation and design of a bio-inspired system**, to be submitted to *Austrian Robotics Workshop*, Vienna, May, 2013

Highlights:

Ni-Ti Shape Memory Alloys biomimetic materials can be used to reproduce the tendril free-coiling phase, the helical springs and the perversion phenomenon that generate the effective pulling capabilities.