06/6201 Attaching Mechanisms and Strategies Inspired by Spiders' legs

Type of activity: Medium Study (6 months, 35 KEUR)

Background and Motivation

Biological systems are capable to efficiently operate and agilely move in unstructured environments. Their design perfectly combines several cooperating subsystems. Spiders can climb on vertical surfaces, upside-down, build webs and can also walk on them. There are several engineering prototypes of bio-spider systems but they are mainly based on macroscopic observations of the animal's design. A closer look to the particular design of features and functionality of spider's attaching mechanisms together with a proper formulation of their strategies used for locomotion could lead to promising research results.

Space Applications

Locomotion is of increasing interest as it plays a fundamental role in the exploration of inhomogeneous and unknown environments. Operations in EVA and IVA could also benefit from innovative systems which efficiently move on spacecraft surfaces without the need of structured environments. Operations such as monitoring and inspecting could be performed by miniaturized systems able to autonomously move and operate while bio-mimicking spider strategies. In addition, the possible use of systems capable to agilely walk in artificial webs deployed in space and/or assemble space structures is of interest for future applications.

Research and Study Objectives

The objective of this study is to investigate the locomotion characteristic of spiders. Two aspects should be studied in detail: attaching mechanisms and locomotion strategies of spiders. The attaching mechanism of spiders enables them to walk over a diversity of surfaces and walk in a large variety of environments. For this purpose, many spiders have adhesive systems (scopulae hairs), miniaturized tarsal claws and serrated bristles at their tarsal tips that guarantee a high level of mobility and grasping capabilities. The morphology and design of the attaching mechanism perfectly fit in the locomotion strategies of spiders. Research on locomotion strategies and walking behaviour of spiders that utilises these attaching mechanisms is expected to lead to innovative control methodologies suitable for precise and low power consuming locomotion.

The proposed research avenue should lead to cover the following main points:

- Survey on attaching mechanisms in spiders and engineering prototypes.
- Propose an innovative concept of a bio-inspired attaching mechanism considering the influence of the space environment.
- Propose a novel engineering solution of the mechanism taking into account suitable micro-technology processes.

In addition, as a secondary aspect, the study should also focus on:

- Survey and analysis of locomotion strategies used by spiders to take advantage of their smart attaching mechanisms (e.g.: how they use their mechanoreceptors while walking on web)
- Propose bio-inspired locomotion strategies useful to maximize the effectiveness of the attaching mechanism.

References

[1] Rainer F.Foelix, “Biology of spiders”, Harvard University Press, 1982

[2] Bailey, S.A., Cham J. G., Cutkosky, M. R. and Full, R. J, "Biomimetic Robotic Mechanisms via Shape Deposition Manufacturing," Robotics Research: the Ninth International Symposium, J. Hollerbach and D. Koditschek (Eds), Springer-Verlag, London, 2000.

[3] M. Sitti and R.S. Fearing, “Synthetic Gecko Foot-Hair Micro/Nanostructures as Dry Adhesives,” Journal of Adhesion Science and Technology, vol. 17, no. 5, May 2003