05/6203 Bio-inspired distributed system for thermal (or particles) transport

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

Background

Animals and plants have a wide variety of sensors and actuators customized for particular purposes and uses. Some bio-perceptive systems have the particular characteristic to be distributed along surfaces and not localized in small areas. This feature makes it possible to have efficient actuators that do not influence the shape and the macroscopic characteristics of organs in which they are located.

An example of distributed actuators concerns motile cilia that are almost never found alone and beat in coordinated waves attached to cell's surfaces. In nature, they are employed for several applications. In the human trachea, for example, they sweep mucus and dirt out of the lungs. In the oviducts, the ovum is moved from the ovary to the uterus by beans of cilia.

Another example of distributed mechanism is the peristaltic wave motion which enables the intestine to transport food and digest it. Several other distributed systems exist in nature with multiple functions for the different uses.

Space Applications

Space systems usually rely on simple and reliable mechanisms since repairing operations in space are risky and expensive. However, new technologies, which are now emerging, will sensibly enhance performance of conventional systems while still meeting reliability requirements. One of the most used devices for thermal control in spacecraft is the heat-pipe. This device is based on natural convection inside sealed tubes having different temperatures at their ends. The efficiency of these devices is pretty low as pumps are not desirable in vacuum environments. The possibility to have miniaturized actuators distributed on heat pipe surfaces able to realize forced air convection is a very appealing and compelling solution.

The same distributed mechanism could also be employed by space digging systems for particles' transport. In fact, distributed actuators could be embedded on thin flexible tubes used to convey particles from under planet soils. This solution could enable the complexity reduction required by traditional systems.

Study objectives

This study is aimed at assessing the feasibility of bio-inspired distributed systems for thermal transport. During the study the following tasks should be covered:

- Review of studies (if any) related to thermal transport using distributed actuators.
- Survey of natural distributed systems that may enable new strategies for thermal mitigation.
- Preliminary concept design of a thermal system ventilated by distributed actuators.

Short References

- http://www.cytochemistry.net/Cell-biology/cilia.htm
- http://www2.oakland.edu/biology/lindemann/cf.htm
- http://www.cheresources.com/htpipes.shtml
- http://www.transterm.ro/overview.htm