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E. Andrada / J. Mämpel / H. Witte

InspiRat: Climbing driven by the trunk, a biologically inspired model based on rats' and caterpillars' locomotion.

Intelligent Mechanics in Robotics

Today there is an increasing necessity of automation in the control and inspection of cables and pipelines. Human being performing inspection is oft a dangerous work and sometimes impossible. On the other hand, the costs of having fixed sensors on big structures like buildings, fabrics, atomic plants or big ships are explosive. The idea behind the project InspiRat is to supply mobile sensors (small robots), which are able to move in small canals along linear structures. Up to now climbing robots were designed to scale walls with flat and smooth surfaces using vacuum [1] or adhesive forces [2]. Other climbing robots use gripping arms [3] or two gripping arms combined with a locomotory sub-system [4]. It is clear that these robots followed design rules which can not fulfill our specifications. On the contrary, the nature has found many succeed locomotion solutions which can match our necessities. In all these solutions, with the only exception of insects, the rhythmic bending of the trunk seems to play an essential role (current robots have passive and rigid trunks). Moreover, studies showed that trunk movements contribute up to 50% to the forward locomotion in reptiles and small mammals [5], and that the coordination between body stem and extremities has a great meaning for stable locomotion [6]. We argue, therefore, that not stiff but compliant elements are fundamental for walking and climbing in order to minimize energy consumption and control. Hereto, we first investigated biological principles capable to climb without extremities (like caterpillars). We then looked for small climbing animals in which the main motor for climbing is the interaction between trunk and extremities (like chameleons and rats). For the first model we have reduced the main locomotor principle assuming that the locomotion is caused by the trunk (this principle can be observed in caterpillars and rats in vertical climbing). Therefore, the model will have two functional elements: driving elements (locomotion, trunk) and grasping elements (to define contact between system and substrate). Based on a caterpillar-like configuration, we built the

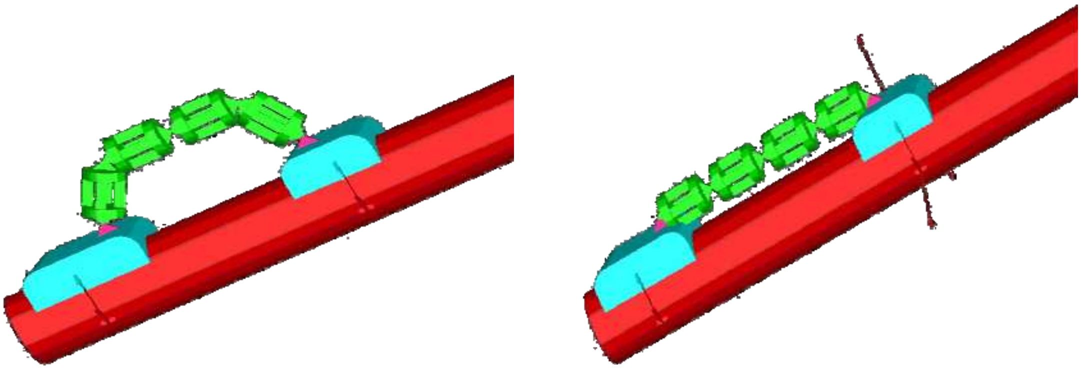

Fig. 1: Climbing model based on caterpillar's locomotion

model as follows: the trunk was divided in 3 cylinders and mutually interconnected via two revolute joints, upper and lower trunk segment were linked, respectively to forward and backward bodies via revolute joints. Both bodies are equipped with grasper. By the using of compliant connections within the trunk was possible to achieve vertical ascending and descending locomotion, and to ovoid small obstacles, by using only two motors for locomotion (see fig.1). Dynamical simulations were done using ADAMS®. In further steps of our study, we plan to perform kinematical and inverse dynamical analyses with rats and chameleons. Results of these studies may bring more light about the coordination between trunk and extremities in small reptiles and mammals. We then expect to use this knowledge to expand the present model, in order to make it suitable for robotic applications.

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