New adjustable compliant actuator MACCEPA 2.0 for energy efficient locomotion

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SUMMARY

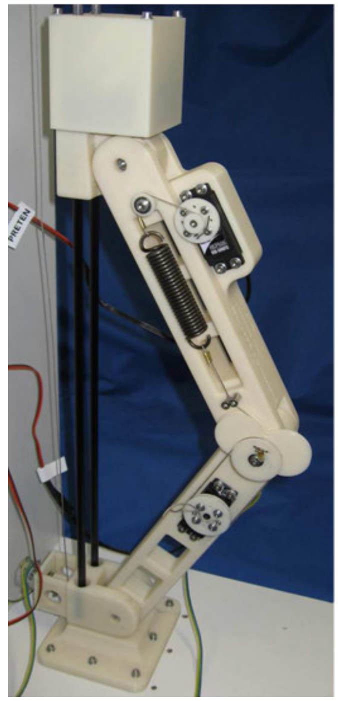
The MACCEPA (Mechanically Adjustable Compliance and Controllable Equilibrium Position Actuator) is an electric actuator in which the compliance and equilibrium position are independently controllable. This paper proposes an improvement in the actuator whereby the torque-angle curve and consequently the stiffness-angle curve can be modified by choosing an appropriate shape of a profile disk. This replaces the lever arm of the former design. Using this technique an actuator can be made that has benefits in terms of energy efficient walking, hopping and running robots. The actuator becomes stiffer when pulled out of the equilibrium position so the robot leg stiffness resembles more closely the linear stiffness found in humans. The ability to store and release energy is shown by simulations on a 1DOF hopping robot.

MACCEPA 2.0

Compliant actuation has been of increasing interest to the robotics community due to its interesting properties with respect to energy-efficient locomotion. The most well-known is the series elastic actuator (SEA) where the stiffness of the spring is fixed. Other designs allow for both joint and stiffness control at the cost of an extra actuator [1]. This paper presents an improvement of the former design of the MACCEPA [1]. The advantages of the MACCEPA actuator are that both the torque and stiffness are independently controllable, using independent dedicated motors. The device is not based on a traditional antagonistic setup, which has drawbacks regarding energy efficiency. The device uses a linear extension spring instead of a difficult to fabricate non-linear springs. Compared to other mechanisms, the design is simple and straightforward, and can be built with a very limited number of components. The actuator has both a large joint angle and stiffness range. In the new design the lever arm is replaced by a profile disk (see Fig. 2). Compared to the old design, choosing an appropriate shape for the profile disk allows that the torque-angle curve and consequently the stiffness-angle curve can be modified. This choice of the torque-angle curve can be used to make a spring with increasing stiffness which is required for legged robots and prostheses. In human and animal locomotion a linear spring behavior is observed, meaning that a stiffening evolution is required for the joint [2]. Also the torque-angle curve of a human ankle has a stiffening characteristic.

HOPPING ROBOT CHOBINO1D

To test the novel MACCEPA 2.0 and study the influence of controllable stiffness for hopping robots the 1DOF



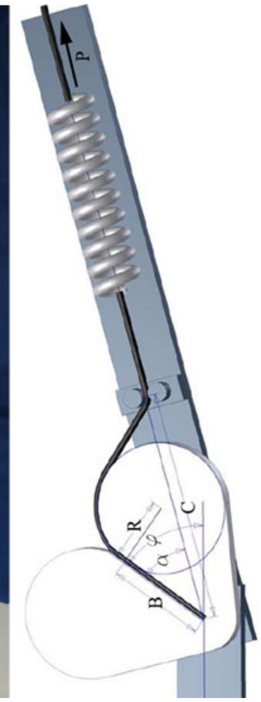


Figure 1: First prototype Chobino1D
Figure 2: Scheme of MACCEPA 2.0

hopping robot Chobino1D (Fig 1) is under construction. The parts are produced using Fused Deposition Modeling (FDM) rapid prototyping technology. Simulations show that the robot jumps higher than when a fixed stiff actuator setup is used (with the same motor) due to the initial energy being stored in the spring which is then suddenly released. Subsequent consecutive jumps are performed with the motion energy being stored and released by the spring element. The jumping height is adapted by controlling the equilibrium position. Frequency and knee bend is changed by controlling the pretension.

ACKNOWLEDGEMENTS

The author Bram Vanderborght is a post-doc researcher with a grant from the Fund for Scientific Research-Flanders (Belgium) (FWO). This work has been funded by the European Commission's 7th Framework Program as part of the project VIACTORS under grant no. 231554.

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