"Control and Design of an Active Prosthesis Based on Adaptive Oscillators"

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ABSTRACT

Currently transfemoral prostheses are almost exclusively passive such that the user spends up to 60% of additional metabolic energy with respect to a healthy person. This contribution introduces the design of an active prosthesis whose interface is driven by an adaptive oscillator (AO).

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Control and design of an active prosthesis based on adaptive oscillators

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Introduction
Current transfemoral prostheses are almost exclusively passive such that the user spends up to 60% of additional metabolic energy with respect to a healthy person. This contribution introduces the design of an active ankle prosthesis whose controller is based on an adaptive oscillator (AO).

Control Method

The gait is separated in four states each obeying a different impedance law to match the torque/position relationship of a healthy ankle.

The transition between different states is triggered when the phase of an oscillator reaches a given threshold.

Our controller has two different adaptation mechanisms:
- **Continuous adaptation** of the oscillator frequency to the user gait frequency using an adaptive oscillator.
- **Discrete adaptation** of the thresholds to the user gait profile using foot sensors.

Simulation results

Simulations using Webots compared our controller to a more classical finite state machine. It showed that the fine threshold placement made the torque profile smoother as compared to the FSM-based controller.

Moreover, the mean square error between the real and desired ankle trajectory decreased by 45% and the foot clearance was significantly improved.

Prototype

To test our controller, we developed a prototype exploiting the principle of series elastic actuator (SEA).

SEA consists in introducing a compliant element (e.g. a spring) between the actuator and the load (i.e. the foot). As such, the spring stores energy during early stance and releases it during late stance.

The constructive parameters (lever arm, stiffness, etc.) were optimized using a genetic algorithm, with the objective to minimize the motor peak power, i.e. to maximize the energy transfer between the foot and the spring.

Future work

The first prototype is assembled. The next steps will be:
- to embed our controller and put it to test with patients.
- to adapt the controller to the patient gait.
- to improve the prototype.