ABSTRACT

We present TF8 a reaction force series elastic actuator to be used as a research platform for knee and ankle powered prostheses. The hardware design is optimized for minimum electric energy consumption during a walking stride. Actuator dynamics were kinematically clamped to healthy-subject gait data and subject to constraints on motor and power-electronics saturation limits, and geometry, resulting in optimal: motor, reduction ratio, spring stiffness and linkage geometry. Identical hardware can be configured as a knee, or an ankle by attaching standard prosthetic component adapters. The series stiffness can also be adjusted to match task performance requirements such as user mass or knee or ankle configurations. The actuator achieves biologically relevant kinetics and kinematics with 115 degree total joint range of motion, 200Nm peak torques, and 650W mechanical power, within a 1.7kg mass. The actuator has been tested with 7 subjects and has been demonstrated on a 70kg user jogging at 2m/s.

OBJECTIVES

1) To build a power dense actuator capable of approaching biological performance of human knee and ankles.
2) To build an actuator tuned for individual users and applications.

METHODS

Kinematically clamped optimization searches for minimum mass spring and linkage geometry to align power-stroke of actuator with kinetic requirements.

RESULTS

Closed-loop torque control bandwidth is 6.2Hz at a magnitude of 82Nm.

Ankle walking shows prosthesis tracking (purple) of biological data (grey).

Electric cost of transport for level-ground walking of the ankle is 0.05 with measured consumption of 28J. This matches well with estimates for ankle.

CONCLUSIONS

Preliminary results show adequate performance to achieve walking kinetics and kinematics for both knee and ankle while remaining within biological segment mass. Limits in impedance matching between the power electronics and motor limited identifying ultimate system capacity. Future work includes updated electronics and knee clinical trials.

REFERENCES


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