

FORCE-CONTROLLED ELASTIC ACTUATOR FOR LOWER-LIMB PROSTHESES

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INTRODUCTION

According to the Hansen's study on the non-disabled human ankle joint behaviour during walking [1], the ankle power is negative for the slow walking speed, near zero for the normal walking speed, and positive for the fast walking speed, at the other side heel contact moment. As walking speed is increased, percent time of double limb support during stance phase becomes smaller. These results show that an augmented system would be necessary to effectively mimic the behaviour of the ankle at fast walking speed, while behaviour can be mimicked using an efficient rotational spring at normal and slower walking speeds.

Several studies have been performed and presented in the literature to design better prosthetic devices in the field of externally powered lower extremity prostheses. Robinson et al. studied on the series elastic actuator [2], Blaya and Herr studied on the active ankle-foot orthosis with series elastic actuator [3], Gordon et al. studied on the active ankle-foot orthosis with pneumatic muscles [4]. This research activity deals with design of an elastic mechanism which can be utilized as an active ankle and knee joint actuator.

METHODS

In order to contribute to the developments of new kinds of prosthetic system and to remove the insufficient properties of the passive prostheses, a force controlled elastic prosthesis mechanism that can be utilized as artificial ankle and knee joints for active lower extremity prostheses was designed as a mechanism consisting of brushless dc-servomotor, ball-nut and screw, elastic component, measuring elements, guide columns, ball bearings and bushes.



Figure 1: General view of the below-knee prosthesis.

The spring displacement was measured with the linear potentiometer, and the force output was calculated. In addition, an ankle simulator consisting of this elastic mechanism was designed. General views of the prosthesis and the simulator are shown in Figures 1 and 2, respectively.

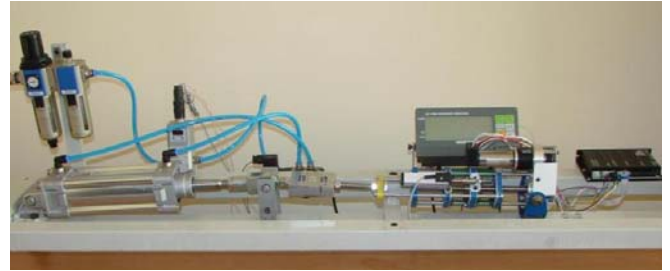


Figure 2: General view of the ankle simulator.

RESULTS AND DISCUSSION

A combination of an elastic prosthesis mechanism with a dc-servomotor, pneumatic actuating system and measuring elements was utilized. The controlled inputs in the simulator were the time-histories of the dorsal and plantar flexion angle, angular velocity and torque of the ankle joint. Control of the prosthesis in the imitating manner of the walking gait pattern was performed. Obtained force output of prosthesis mechanism is shown in Figure 3.

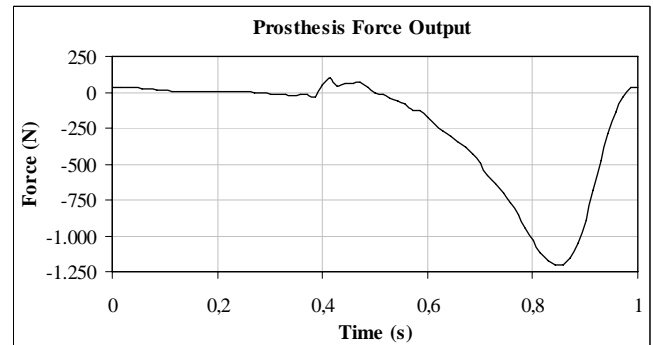


Figure 3: Prosthesis force output.

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