Synchro Motion: Design and Control of Lightweight Microprocessor Prosthetic Knees and Ankles

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I. Summary

Synchro Motion is a spin-out of Vanderbilt University that was founded in 2017 in order to commercialize lightweight mechatronic knee and ankle prostheses. Synchro Motion is a small R&D company funded through Small Business Innovative Research (SBIR) grants. The goal of the company is to bridge the gap between academic proof-of-concept devices and robust commercial devices that can improve the mobility of patients in the real world. The long-term vision of Synchro Motion is to establish a reputation of clinical translation in the field of orthotics and prosthetics.

Currently, Synchro Motion is developing both a microprocessor controlled low-power prosthetic ankle and a low-power prosthetic knee. Both of these devices utilize a novel power-asymmetric actuator as well as unique control approaches to deliver the desired biomechanical functionality to the patient. We hope to discuss the current status of this work as well as future directions of the company.

II. Introduction

Standard-of-care prosthetic knees and ankles typically leverage passive components such as carbon fiber leaf springs or hydraulic dampers to provide the desired biomechanical functionality to the user. These prosthetic designs are typically optimized for a single gait activity (typically walking) but lack the adaptability to accommodate other activities performed by the user. Members of both the academic and industrial communities have attempted to combat this limitation by developing fully powered prosthetic joints that are able to approach the performance capabilities of the healthy limb. Unfortunately, the high-power capabilities of these prosthetic joints is accompanied by an increase in size, mass, and control complexity relative to standard-of-care prosthetic devices.

The founders' prior experience with fully powered prosthesis design and control have motivated an alternative approach to prosthesis design in which passive components are leveraged in conjunction with small amounts of positive power at the joint to provide behavioral adaptability while maintaining a compact and lightweight design. This "semi-powered" approach has been utilized in a prosthetic ankle that is capable of variable damping, swing-phase repositioning, and stance phase energy storage/return. Similarly, this "semi-powered" approach has been used in the design of a knee capable of stance support as well as active swing phase control. Both designs utilize a novel power-asymmetric actuator that is capable of dissipating power an order of magnitude greater than the power it can generate.

III. Current Status and Future Directions

To date, Synchro Motion has created hardware prototypes of both the knee and ankle devices (Fig. 1) and has begun testing with amputee subjects.

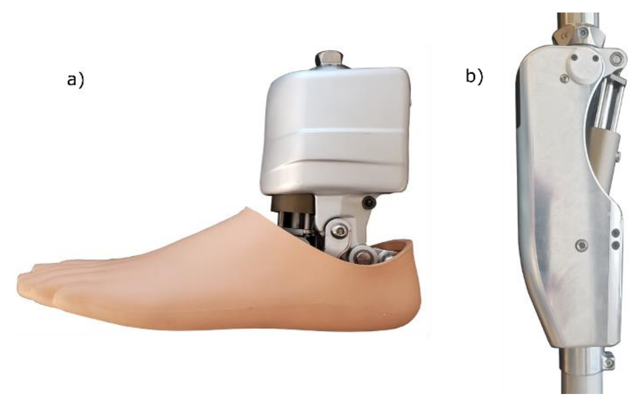

Fig. 1: a) Semi-powered prosthetic ankle prototype. b) Swing assist prosthetic knee prototype

Functional outcomes that will be prioritized for the ankle include improved stability across sloped and uneven terrain, improved ground clearance during swing, as well as energy storage and return during stance. Functional outcomes for the knee include robustness to stumble perturbations as well as increased range of walking speeds. Synchro Motion also plans to implement two-week take-home assessments of these prototypes to assess their real-world efficacy. Preliminary data from device assessments as well as future directions of the company will be discussed.

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