Online Learning for Obstacle Avoidance with Powered Transfemoral Prostheses

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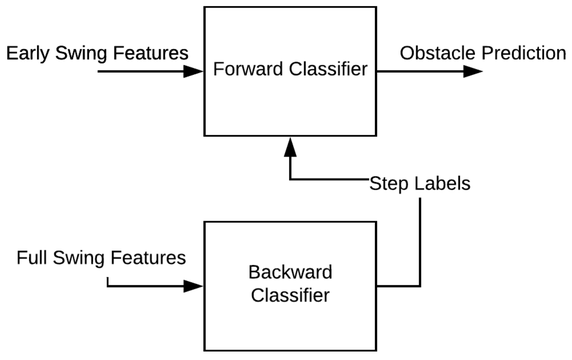
Introduction

• Falls are a significant risk for amputees, with an annual fall rate of 58% [1].

• Current transfemoral prosthesis swing controls can reproduce normal swing trajectories. [2]

• Previous work has been focused on stumble recovery rather than active avoidance [3].

Obstacle Classification



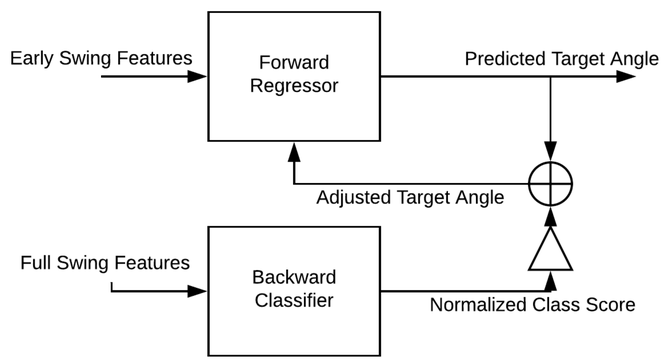
Forward-Backward Classifier

• A variety of features were extracted from the hip angle, hip velocity, and thigh accelerations of the user.

• Obstacle avoidance attempts were classified using features from early in the swing phase.

• This classifier was trained online using labels from a full-swing classifier.

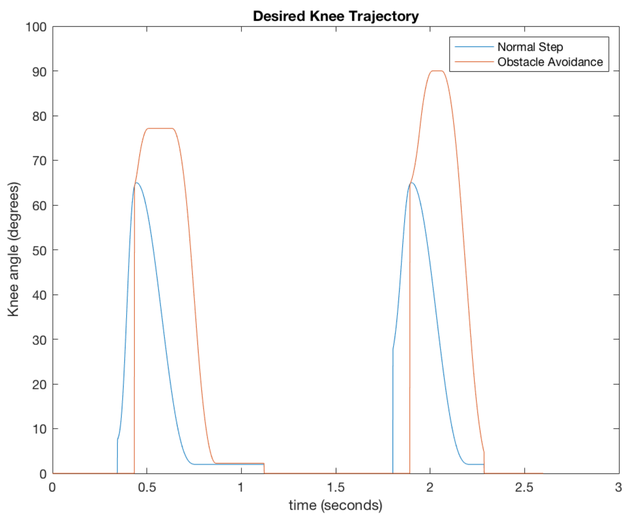
Knee Angle Regression



Knee Angle Regression System

•We used the backward classifier's normalized class scores to quantify obstacle difficulty and provide feedback for the knee angle regression.

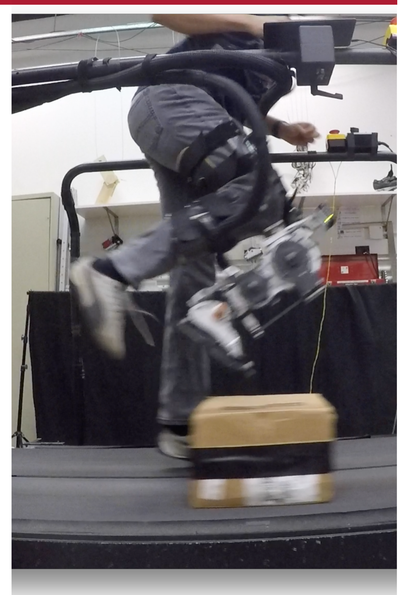
Avoidance Trajectory



Normal and Avoidance Trajectories for Moderate and Large Obstacles

• During detected avoidance steps, a maximum-clearance trajectory to the predicted target angle was used.

Results



Obstacle Avoidance with Normal Swing Control and with Obstacle Avoidance Trajectory

• The online learning system improved the obstacle avoidance success rate from 37% to 89%

• Modifications to the planned trajectory improve obstacle avoidance success rates and allow larger obstacles to be avoided.

References

[1] Kulkarni et al., "Falls in Patients with Lower Limb Amputations." *Physiotherapy* vol. 82, no. 2, p. 130-136. 1996.

[2] Lenzi, Tommaso, Levi Hargrove, and Jonathon Sensinger. "Speed-adaptation mechanism: Robotic prostheses can actively regulate joint torque." *IEEE Robotics & Automation Magazine* vol 21, no. 4, p. 94-107. 2014.

[3] Lawson, Brian E, H Atakan Varol, Frank Sup, and Michael Goldfarb. "Stumble Detection and Classification for an Intelligent Transfemoral Prosthesis," in *Proc. 32nd Annual International Conference of the IEEE EMBS,* Buenos Aires, Argentina, 2010. p. 511–14.

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