Speed and Slope Estimation on a Powered Prosthetic Leg

Background

A position-based virtual constraint controller on a powered prosthetic leg enforces human-normal kinematics on the prosthetic device, synchronized by a phase variable to the user's movement, in order to support and propel the amputee user. To change to a new task (*i.e.* walking at different speeds, inclines, stairs, running…) the desired kinematic trajectories must be updated to match that task. The state of the art method is to use switching rules and classifiers to detect large changes in task and then select the most appropriate desired trajectory from a finite number of predefined options.

The Locolab is developing an improvement to the state of the art, in which a continuous parameterization of human kinematics is utilized to provide human-normal kinematics for any arbitrary walking speed and incline. This method will help to provide more natural and appropriate kinematics over a continuum of tasks, but will require an accurate estimation of speed and walking incline. You can reference a paper on this topic from Dario and I here:

http://ieeexplore.ieee.org/abstract/document/7591161/

Project Description

The purpose of this project is to provide accurate speed and incline estimates of an amputee walking on either our Gen1 or Gen2 prosthetic leg prototypes. You will have a lot of freedom in terms of algorithm choice and instrumentation.

Objectives

The controller that will utilize these speed and slope measurements is in parallel development to this project, but I will provide an estimate to its requirements.

Accuracy	~0.1 m/s of speed, and ~1 ° of incline
Frequency of estimation	Once per stride, ~1 second
Non-intrusive	This generally means avoiding sensors that obstruct movement, or are mounted outside of the prosthetic leg or socket. Sensors on the sound leg may be considered if their benefits outweigh the cost of asking the user to wear additional instrumentation.
Cost-effectiveness and simplicity	Generally speaking, we want to use fewer and lower cost sensors. It may be worth investigating if our speed and slope measurement can be extracted from the IMU already used to measure the phase variable, as this would introduce minimal cost.

These requirements will adapt as the controller and hardware develop, but I believe the emphasis will be on accuracy of measurement rather than speed.

Resources & Contact Information

Chris Nesler has a low-cost IMU earmarked for this project, feel free to speak to him about this.

During previous incline experiments on able-bodied subjects, I used EMG sensors with built in accelerometers (http://www.delsys.com/products/wireless-emg/trigno-lab/). That accelerometer data, combined with motion capture data to provide global orientation, may give an estimate as to what kind of data could be recorded with an IMU at one of our EMG locations. That data is available in the locolab drive: Z:\Projects\Incline Experiment.

I'm also available any time you have questions:

Kyle Embry kyle.embry@utdallas.edu

Sanyukta Bihari sxb133030@utdallas.edu

Sanyukta has also put together a nice summary of her literature review on the topic along with her recommendations on what method to pursue, I'll pass that along. Sanyukta is graduating this semester, but feel free to contact her with questions.

Timeline

Email reports: I want to be conscience of your limited time, and I know you're currently having face-to-face weekly meetings with Chris Nesler. For now, let's do email updates of what you've been working on so I'm up to date, and any questions you have I might be able to help with. I can also meet with you and Chris in person if you want to update me that way.	~every two weeks at first, more frequently as the project progresses
Semester Goal: Proof of concept Prototype sensor/algorithm that can estimate speed and slope of able bodied or	May 8th (finals week or before)