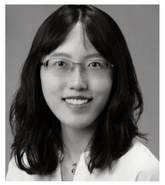
EXPLORING THE HUMAN FACTOR IN PROSTHETIC ADAPTATION

MOTION CAPTURE COULD HELP IMPROVE STABILITY IN AMPUTEE MOVEMENT



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Amazing work is being done using Vicon systems to understand how to build better prosthetics and wearable robots, but Dr. Hui-Ting Shih is working on the less explored side of the equation: the human wearing the limb.

Shih, a Doctor of Interdisciplinary Health Sciences and Rehabilitation Sciences at the University of Nevada, Las Vegas (UNLV) has recently completed the first phase of her research into how prosthetic users recover from trips. Exploring how people move with prosthetics is very much part of her department's DNA.

"When it comes to rehabilitation, most people think about the prosthetic leg and the need to make it better so people can walk more easily," explains Dr. Szu-Ping Lee, an associate professor in Shih's department and her PhD. adviser. "Our approach is slightly different. We believe that the prosthesis is only part of the equation. The other part is the human factor.

"If I give a patient with an amputation the best leg that's available on the market, does it really guarantee that they will be able to utilize the leg and function properly with that device? We think that it deserves more study. That's why the focus of the research in our lab is on rehabilitation or the human factor."

Shih's primary research tool is a system of 12 Vicon Bonita cameras running with Nexus. In addition to its Vicon cameras, the lab is set up with a Bertec instrumented treadmill. "We put them all together to try to develop a protocol that would simulate tripping scenarios during a walk," Shih explains.

The ultimate goal is to develop balance-training regimes that can help subjects to improve their responses to trips, with the aim of reducing falls. To do the work, Shih first had to develop a protocol with which to observe subjects stumbling and understand how they recover.

"We decided to take ground reaction force as the reference, and then we used MATLAB as the interface," says Shih. "So once the person is walking on the treadmill and one side of the force plate detects that the ground reaction force meets that criteria that we set, it will automatically deliver the perturbation. We pre-programed a change of the treadmill velocity to simulate the perturbation."

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LO-FI SOLUTIONS

Syncing the different technologies proved a challenge. Specifically, it was difficult to know when the perturbation had been initiated in relation to the Vicon data. Shih tried attaching markers to the treadmill belt, but the belt's vibrations were a problem. The solution Shih ultimately landed on was a DIY approach.

"Eventually, we got some reflective tape and attached that to the treadmill belt. We put two pieces on each belt, so we could easily tell the direction of movement and also the change of velocity, so that we could establish the initial reliability and validity of our protocol," says Shih.

With that technical problem solved, Shih initially worked with young adults and elderly subjects with no mobility impairments to test her protocols. Once it had been established that the protocol would provoke different responses in each population, Shih was able to move on to testing individuals with a below-the-knee amputation on one of their lower limbs.

"We put them on the treadmill for two main purposes," Shih says. "The first one is we wanted to see if they responded differently to a tripping perturbation delivered to their prosthetic side versus their non-prosthetic side. Then we're trying to see what intervention we can make to change their recovery responses."

SURPRISING RESULTS

The results were a little unexpected. "The first surprise we found was among the healthy participants, comparing tripping with slipping. We assumed, based on the literature, that the trip recovery responses would be mostly across the sagittal plane. But if we deliver it unilaterally, that's actually not necessarily true, because we also have some rotation from their responses."

There were surprises in the lower limb amputee population, too. "Originally we thought that there would be two components that would influence their responses," explains Shih. "One is the perception of the perturbation. We thought that when the prosthesis got perturbed, they might perceive and respond to the perturbation much more slowly than on the other side because of the lack of sensory organs.

"Then there's another component, and that's the motor one. After they detected the perturbation, how fast could they respond? How quickly can they complete and clear their responses?

"Surprisingly, we found that the detection component is not that different from side to side. Perhaps that's related to the protocol, and we might have put a pretty brutal protocol in place so that the perturbation is quite big, making it easy for them to detect.

"But from what we can see, that side-to-side difference in their responses is mainly down to the motor component."

The finding could have implications for any training programs that come out of the research. "This is just our initial thought, but perhaps for the intervention the key component to determine whether their trip recovery is successful or not is whether they have to use their prosthetic to make the movement or not."

In the future, Shih would like to extend the research by looking at different populations, studying different pathologies to discover what different mechanisms might be at play in their responses. She would also like to change the triggering criteria, as some research has already suggested that perturbing a subject's walk at a different phase of movement might yield different results.

Looking further ahead, Shih hopes that one day she might be able to combine the accuracy of an optical Vicon system with real-time analytics for patients. "I do see some potential if the processing could be fast enough for us to deliver some real-time feedback to the person who's doing the movement," she says, "so that it could be not only an assessment tool, but also an intervention, or it could be used directly in a basic training paradigm."