

A new ankle prosthetic allows amputees to pick up their foot and walk up slopes

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Credit: University of Bath

The human ankle and foot have 26 bones, 33 joints, and 100 tendons, ligaments and muscles between them, making the lower leg one of the most complex parts of the body. Creating a prosthetic that mimics the behavior of so many moving parts is no easy feat, and designing a robotic system that does so is even more complicated. But a new prototype developed in the U.K. is paving the way for some 40 million amputees worldwide.

The new prosthetic, developed by U.K. prosthetics maker Chas A. Blatchford & Sons, along with University of Bath researchers, combines an electric hydraulic system with an intricate pattern of sensors that give the model a level of intelligence not yet available on the market. These

components allow [amputees](#) to climb slopes effortlessly and plant one of their feet firmly on the ground without dragging it behind, a common problem for all lower-limb prosthetic wearers.

Integrating an EHA Unit

"The state-of-the-art lower limb prosthetics are sophisticated," said co-developer Andrew Plummer, who directs Bath's Centre for Power Transmission and Motion Control. "But they are passive. There's no energy input, and obviously, a normal human joint would not be passive. I think for a long time, there has been a desire to have intelligently controlled powered joints. But, this has had hardly any impact on the real products people can buy."

Plummer began collaborating with Blatchford five years ago to pursue a visionary approach: integrate the prosthetic with an electrohydraulic actuation (EHA) unit, the same technology found in the F-35 jet fighter.

Hydraulic systems use a pump to pressurize a working fluid, which in turn moves a cylinder or similar actuator. Done right, a hydraulic system multiplies forces efficiently over a broad range without using cumbersome gears, pulleys, or levers. Unlike electric motors, hydraulic systems apply constant force or torque without continuous motor operation, and reverse direction almost instantly.

The problem with conventional hydraulics is that the pump, fluid, and actuator are three separate systems. Not only are they heavy and bulky, but also prone to leaks and spills.

EHA units, on the other hand combine those three elements within the same device. This reduces size, weight, and the need for maintenance. Its ability to retain pressure enables the prosthetic to conserve power while shifting fluidly between active and passive modes. The 48 volt battery

can last essentially an entire day, or, about 5,000 steps, Plummer said.

This is the key reason why the researchers chose EHAs over electric servomotors. "Other electric motorized prosthetics have to run all the time," said Jawaad Bhatti, a mechatronic engineer at Blatchford who worked on the device. "The EHA unit allows our prosthetic to only operate on the battery when it is needed. With the electric ones, if the battery dies you can't walk at all. With ours, it just goes into passive mode and still functions quite well."

Making it Robotic

The researchers calibrate the sensors to the amputee's gait very precisely. Sensor data then goes to a computer equipped with a complex algorithm that allows it to respond rapidly to changes in stride and speed, powering up the EHA unit to help the amputee lift his or her foot off the ground.

"By studying the natural human walking gait, we've established that there are certain points within the gait cycle that are important for power input," said Plummer. "The key one is what we call 'toe off.' It's basically what's springing you forward at the end of the step. As you extend your ankle, you push forward. That being missing in a conventional prosthetic is quite a big drawback."

Without that push, amputees have to change the way they walk. This can lead to degrading damage in the leg, hips, and back, and even painful spasms or arthritis.

Engineers still have a few kinks to figure out. The most important involves fitting all the different components into a sleek, lightweight design. That starts with designing a smaller EHA unit to fit onto the joint of the ankle.

It also takes a lot of processing power to run the gait algorithm, so amputees currently carry the computer in a backpack. Ultimately, the researchers plan to incorporate it into the [prosthetic](#).

"It really is one step at a time," Plummer said. "We have to refine the prototype, come up with a new one, and then another one. It's not a simple matter of just manufacturing it now."

The team hasn't announced a release date for the first product, but they are conducting human trials.

"Powered prosthetics like ours will allow amputees to behave more like people who don't have an amputation, and that's the driving force behind our research," Plummer said.

Provided by University of Bath

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