
# "Profound **versatility** will only be achieved once we have an interface to the **brain**"

**Interview with Hugh Herr, Associate Professor of Media Arts and Sciences, Center for Extreme Bionics, Massachusetts Institute of Technology**

Professor Hugh Herr, Associate Professor of Media Arts and Sciences, Center for Extreme Bionics, Massachusetts Institute of Technology, had both legs below the knee removed after a climbing accident when he was just seventeen years old. But he refused to give up his hobby and developed 'home-made' prostheses which allowed him to continue climbing. In Prof. Herr's view, amputees have just as much right to run, dance and climb as everyone else in the world. With technology lagging far behind this objective, he sees his mission as bending technology and harnessing it in order to meet this laudable aim. Hugh Herr, who heads the Biomechatronics research group at the MIT Media Lab, has become one of the world's foremost researchers into bionic limbs and recently founded the Center for Extreme Bionics at MIT. After Adrianne Haslet-Davis, a passionate ballroom dancer, lost her left foot during the Boston Marathon bombing, Hugh Herr and his team painstakingly built her a bionic leg designed for dancing. At OTWorld in Leipzig in mid-May 2014, he gave one of the seven keynotes entitled 'The development of bionic legs: The science of extreme interfaces'. And while in Leipzig, he kindly spoke to the editorial team about his recent developments – and what the future holds in store for assistive technology.

*OT: What progress have you made in enhancing prosthetic systems and giving them similar characteristics to biological limbs?*

**Hugh Herr:** One challenge is to build a prosthetic limb that moves dynamically like a biological one. We've been working on this for decades. My company BiOM has developed the world's first bionic leg prosthesis – the BiOM® T2 system – which thanks to powered propulsion brings key metrics of gait in line with those of biological legs. For example, whereas walking speed with a commercial prosthesis is typically 40 percent slower than normal, with the BiOM® T2 there's no difference. All other prostheses make the wearer more tired at the end of the day because they require more food energy, but here, too, we've normalized metabolism. And thirdly, we've normalized some metrics of musculoskeletal stress by compensating to provide the right power and dynamics. This reduces and will ultimately eliminate the risk of osteoarthritis, which currently affects about 50 per cent of users over the age of sixty-five.

*OT: How many BiOM legs are already in use?*

**Herr:** Since becoming commercially available in 2010, we've fitted about 900 people with BiOM legs, including some 400 wounded soldiers. We've also developed computer-controlled bionic knees, some of which are linked to a bionic ankle.

*OT: After Adrianne Haslet-Davis had the lower part of her leg amputated following the Boston Marathon bombing, you built her a bionic leg equipped to dance. This involved analyzing another dancer's movements in order to develop a special algorithm for the rumba. Why is a separate code still required for different types of movement?*


*Hugh Herr and Urs Schneider preparing themselves for the interview*

**Herr:** The interaction between the brain and a biological limb is incredibly sophisticated. The problem is that today's commercial prostheses have no interface to the nervous system. As a result, there's a limit to the scope of current algorithms. For example, the algorithm in the BiOM® T2 enables me to walk at all speeds and to go up and down stairs – but it wouldn't do for ballroom dancing. It's not a question of increasing the amount of data in a bionic foot; the system would have to have the necessary intelligence to recognize when the wearer is transitioning. Profound versatility will only be achieved once we have an interface to the brain. With a smart interface, all that intelligence would be in place immediately. You'd decide to start dancing and the device would switch over accordingly since your nervous system would have direct control over it. An entire research team at MIT is devoted to developing a bidirectional interface to the peripheral nervous system. The findings will serve a wide range of areas, not just prosthetics. For example, an interface to the brain could solve problems like blindness.

*OT: Apart from the electronic interface, there's also the problem of the mechanical interface.*

**Herr:** Attaching prosthetics to the body is another very tough challenge. Mankind has been trying for centuries, but the solutions have never been satisfactory. For some reason, this is an area which doesn't get the attention or funding it deserves; neural interfaces evidently seem more exciting. You can build a perfect upper extremity bionic limb and even have it neutrally controlled, but if the attachment is uncomfortable and floppy, the owner won't want to wear it. And don't forget that with the motors they contain, bionic limbs can easily be heavier than biological ones. I think there's a fundamental theory of mechanical interfaces just waiting to be discovered. And when it has been, it'll affect what shoes look like, what bras look like – in fact anything that interfaces with the body. In just twenty years from now, the fact that shoes and bras only came in a small number of sizes will appear ridiculously crude. "What, you mean back in 2014 they didn't make personalized bras reflecting the wearer's exact size, health issues or breast symmetry?! Come on!" I think at some stage, we'll have sentient gloves that can be used to touch and scan parts of the human body in 3D. These gloves will rapidly capture your no-load shape and your tissue compliance in under a minute. In short, you'll be biomechanically mapped in next to no time. And that will allow personalized products – shoes, bras, even bionic limbs – to be quickly produced and delivered. What's more, with the advances being made in durable, breathing materials, this technology will result in shoes that last for – well, perhaps not a lifetime, but you get the idea!

*OT: The advances you've already made for amputees – not to mention those you predict – are incredible. Do you also work with non-amputees?*

**Herr:** For over a century, technologists have been trying unsuccessfully to build exoskeletons to improve walking. These devices are aimed at people carrying heavy loads over long distances, above all soldiers. They all failed because, although they were intended to reduce the energetic cost of loaded walking, they actually increased the food energy needed. To be honest, they were ultimately no more than fancy exercise machines! But two months ago, for the very first time in history, we finally succeeded in augmenting human walking. Our system uses fiberglass struts attached to boots which are alternately tensioned and released in sync with the wearer's speed. This multiplies the effect of muscular input and means less energy is required to walk. It's a thrilling breakthrough!

*OT: We're talking in Leipzig at OTWorld – the world's leading O&P trade show and congress. Why did you decide to come to OTWorld? What's special about it?*

**Herr:** First of all, I always love being in Europe, so that's one reason to come to OTWorld! Seriously, it's a great chance to check out the new technology on display, talk to my partners at the IPA Fraunhofer Institute for Manufacturing Engineering and Automation, and catch up with friends and colleagues in the O&P sector. Compared to shows in the US, OTWorld in Leipzig is more international – that's obvious! But another important difference is that the audience here is more scientific. After my keynote, I was struck by how many academics and other researchers approached me with questions – there clearly seems to be better integration between universities and industry in this field in Europe. I'd already been to OTWorld twice before and I must say that the congress and expo are always very well organized.

*Questions asked by Ruth Justen, freelance journalist in Leipzig.*

## PERSONAL FACTS:

Hugh Herr was born in Lancaster, Pennsylvania, in 1964 and has been an enthusiastic rock climber since his childhood. He took a degree in physics and a master's in mechanical engineering followed by a PhD in biophysics at Harvard University. He is the director of the Biomechatronics research group at the MIT Media Lab, where he also heads the Center for Extreme Bionics. In addition, he is the Chief Technology Officer of BiOM, the personal bionics company which he founded in 2007. He has ten patents and a string of awards to his name in the field of assistive technology, and has twice been included in TIME magazine's Top Ten Inventions.