Strategy based on human reflexes may keep legged robots and prosthetic legs from tripping

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Trips and stumbles too often lead to falls for amputees using leg prosthetics, but a robotic leg prosthesis being developed at Carnegie Mellon University promises to help users recover their balance by using techniques based on the way human legs are controlled.

Hartmut Geyer, assistant professor of robotics, said a control strategy devised by studying human reflexes and other neuromuscular control systems has shown promise in simulation and in laboratory testing, producing stable walking gaits over uneven terrain and better recovery from trips and shoves.

Over the next three years, as part of a $900,000 National Robotics Initiative study funded through the National Science Foundation, this technology will be further developed and tested using volunteers with above-the-knee amputations. Joining Geyer on the research team are Steve Collins, associate professor of mechanical engineering and robotics, and Santiago Munoz, a certified prosthetist orthotist and instructor in the Department of Rehabilitation Science and Technology at the University of Pittsburgh.

"Powered prostheses can help compensate for missing leg muscles, but if amputees are afraid of falling down, they won't use them," Geyer said. "Today's prosthetics try to mimic natural leg motion, yet they can't respond like a healthy human leg would to trips, stumbles and pushes. Our work is motivated by the idea that if we understand how humans control their limbs, we can use those principles to control robotic limbs."

Those principles might aid not only leg prostheses, but also legged robots. Geyer's latest findings applying the neuromuscular control scheme to prosthetic legs and, in simulation, to full-size walking robots, were presented recently at the IEEE International Conference on Intelligent Robots and Systems in Hamburg, Germany. An upcoming paper in *IEEE Transactions on Biomedical Engineering* focuses specifically on how this control scheme can improve balance recovery.

Geyer has studied the dynamics of legged walking and motor control for the past decade. Among his observations is the role of the leg extensor muscles, which generally work to straighten joints. He says the force feedback from these muscles automatically responds to ground disturbances, quickly slowing leg movement or extending the leg further, as necessary.

Geyer's team has evaluated the neuromuscular model by using computer simulations and a cable-driven device about half the size of a human leg, called the Robotic Neuromuscular Leg 2. The leg test bed was funded by the Eunice Kennedy Shriver National Institute of Child Health & Human Development.

The researchers found that the neuromuscular control method can reproduce normal walking patterns and that it effectively responds to disturbances as the leg begins to swing forward as well as late in the swing. More work will be necessary, he noted, because the control scheme doesn't yet respond effectively to disturbances at mid-swing.

Powered prosthetics have motors that can adjust the angle of the knee and ankle during walking, allowing a more natural gait. These motors also generate force to compensate for missing muscles, making it less physically tasking for an amputee to walk and enabling them to move as fast as an able-bodied person.

More than a million Americans have had a leg amputation and that number is expected to quadruple by 2050, Geyer said. About half of the amputee population reports a fear of falling and large numbers say the inability to walk on uneven terrain limits their quality of life.

"Robotic prosthetics is an emerging field that provides an opportunity to address these problems with new prosthetic designs and control strategies," Geyer said.

Provided by Carnegie Mellon University