Humotech

Increasing mobility for people with lower-limb amputation with a robotic ankle-foot prosthesis emulator

speedgoat
real-time simulation and testing

Spin-off from Carnegie Mellon University uses MATLAB & Simulink with Speedgoat hardware to develop a robotic ankle-foot prosthesis to aid research into improving mobility and quality of life for individuals with below-knee amputation

Humotech (Human Motion Technologies LLC) is a spin-off from Carnegie Mellon University's Experimental Biomechatronics Laboratory, based on the PhD thesis work of Humotech founder and president, Josh Caputo. The company was founded in 2015 and is located in Pittsburgh, PA. They're a small team with a big vision to reimagine the way wearable machines, including prosthetics and exoskeletons, are developed and used. Humotech uses MATLAB & Simulink with Speedgoat real-time control hardware at the core of their Caplex™ platform. The Caplex system is modular and highly customizable to control various joints of the body in many different ways. One of the primary focuses of the company is the development of a test-drive strategy for people with lower-limb amputation utilizing Caplex configured as a ankle-foot prosthesis emulator

Below-knee amputation

Lower-limb amputation is a major and increasingly prevalent disability that reduces mobility and adversely affects quality of life for millions of individuals around the world. Individuals with amputation expend more energy to walk, and the intact limb experiences increased loading and injury. Individuals respond differently to different kinds of prosthetic foot & ankle devices, and there is currently a dearth of data to support the prescription of one kind of device over another. So, Humotech has developed a platform for patients to rapidly explore their options. The system emulates the different products, increasing the speed of trialing and reducing the cost relative to actually purchasing the various products that need to be tested. Humotech's first emulator devices included a single degree of freedom, plantarflexion/dorsiflexion, while the most recent also include inversion/eversion to assess quality of fit over uneven and cross-sloped terrain.

Ankle-foot prosthesis with off-board actuation

The prosthesis provides controllable torque about the ankle axis or axes. The keel(s) are controlled by an external actuator unit throughout the gait cycle, while a passive heel spring provides compliance in the early stance phase.The amount of applied torque is measured with a load cell, and the joint angle is measured with an optical encoder. The external actuator unit is an

The Humotech ankle-foot prosthesis in use

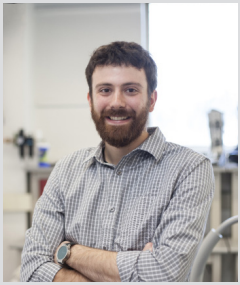
off-the-shelf Humotech subsystem consisting of a servo-motor, a servo-drive and a drive spindle. Torque is transmitted to the prosthesis via a bowden cable: a cable guided inside a flexible sheath, similar to bicycle brake cables. Off-board actuation enables the emulator to mimic a very wide variety of prosthetic foot & ankle types, while keeping the wearable end-effector very light weight.

The control signals for the high-performance torque control are determined using the actual torque applied at the ankle prosthesis together with the prosthesis joint angle and a pre-programmed profile of desired force & deflection that comes from mechanically testing actual prosthetic foot & ankle products. The Speedgoat Performance Real-Time Target Machine measures such torque and angle using real-time measurements from a load cell and an encoder, respectively, and computes motor commands to regulate ankle joint impedance. Humotech also has a portable version of the system, which utilizes the Speedgoat Unit. The interface and control code was developed in MATLAB & Simulink, with an external custom GUI. Simulink Coder was used to automatically generate the code to run on the target machine.arget machine.

Speedgoat's value contribution

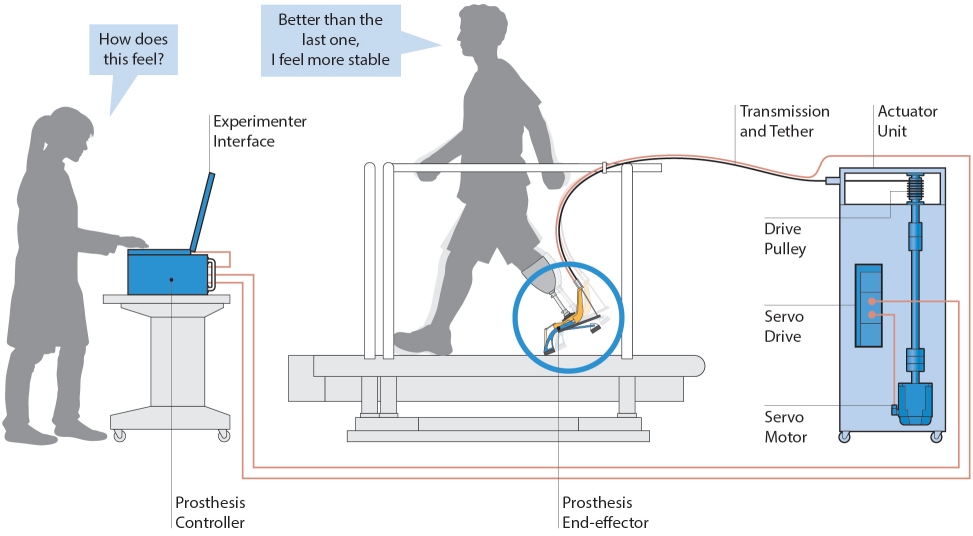
"For us Speedgoat offers a perfect combination of performance, customizability, modularity, a startup-friendly price point, seamless integration with MATLAB & Simulink, and excellent support."

- Josh Caputo, PhD
President & CEO, Humotech



Experiments and Future Endeavors

The prosthetic foot emulator is currently being evaluated for use as a clinical decision support tool at multiple VA and DoD sites around the US. In addition, researchers and developers at Universities, government labs, and commercial companies around the world are using Caplex to conduct research to better understand human biomechanics, explore new rehabilitation paradigms, and develop new assistive technologies.



A typical set-up for an experiment using the ankle-foot prosthesis and actuator

Humotech
Pittsburgh, PA, USA

www.humotech.com

Speedgoat products used
- Performance real-time target machine
- IO101: 16-bit Analog I/O module
- IO317: Configurable FPGA I/O module

MathWorks software used
- MATLAB®
- Simulink®
- MATLAB Coder™
- Simulink Coder™
- Simulink Real-Time™

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