Technology in motion: Innovative exoskeleton helps paraplegics walk

A total of 66 teams from 25 countries took part in the first Cybathlon, hosted by the University of Science and Technology (ETH) in Zurich, Switzerland. Using the latest technologies in physical assistance systems, people with physical handicaps competed in six demanding disciplines. "Project March 1", a team of young scientists at Delft University of Technology (TU Delft), participated with its newly developed "March 1" exoskeleton. EtherCAT, the real-time communication system from Beckhoff, provides the necessary speed and reliability for the exoskeleton.

The Cybathlon is a remarkable contest in two major ways. On the one hand, all the athletes have physical handicaps. On the other, the event measures both the contestant and the machine, so all tasks require the incorporation of the latest technologies. One of the disciplines includes walking with the aid of an exoskeleton. These robotic suits enable paraplegics to walk instead of using a wheelchair. For the Cybathlon, a special course was laid out on which athletes had to master everyday, but nevertheless complex, situations such as getting up from a low chair, overcoming inclines and obstacles on the ground, and climbing stairs.

"The exoskeleton is an old idea that still needs a good deal of additional improvement," explains Nick Tsutsunava, the chief engineer of the Project March 1 development team at TU Delft, located in Delft, The Netherlands. Currently, existing exoskeletons provide users with relatively little direct control, meaning they are more like a passenger than a pilot. To enable users to control the robotic exoskeleton on their own, Nick Tsutsunava and a group of students established Project March 1 in the spring of 2015. Claudia Bosch-Commijs completes the Project March team as the exoskeleton pilot.

Perfect convergence of humans and robots

The team had a little more than a year to develop an innovative exoskeleton that would be able to compete in the Cybathlon. The project was based on an earlier development dubbed the 'Mindwalker', which coordinated walking mechanics with the user's brain waves. "The idea was not sufficiently perfected to translate it into a practical application, however," says Nick Tsutsunava. "That's why Project March 1 focuses on the fact that users walk with crutches to stabilize their upper body. Today, we operate with a so-called point-and-go system," he adds. "This means that the user points the crutch where they want to go, and operates it with buttons on the handle."

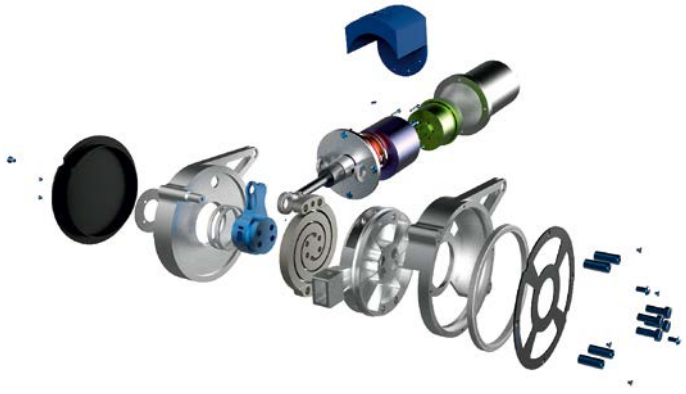
The team of developers around Nick Tsutsunava determined early on that the Mindwalker's mechanics would provide the foundation for their new "March 1" exoskeleton. "We changed the electronics a lot, and the drive system is completely different," according to the team leader. "What makes the upgraded March 1 mechanics so special is the addition of two hip joints that allow the user to not only walk straight ahead, but sideways as well. As a result, the pilot can shift weight from one leg to the other – just like during normal walking motions. This adds stability and makes it easier to climb stairs and walk on uneven ground."

Another major improvement is the use of serial-elastic actuators to control the joints. "We inserted a coil spring made of titanium between the skeleton structure and the motor," explains Nick Tsutsunava. "It functions as a shock absorber and allows us to measure spring deformation as an indication of the applied torque with an accuracy of 0.01 Nm. This level of accuracy makes it easier to stabilize the closed-loop control." This is an important feature, particularly since the backpack holding the electronics is quite heavy. The weight of the backpack must be balanced by the hip joints during each step. "With a position-control approach, the exoskeleton would be unable to move forward. However, controlling the torque while the exoskeleton knows that the user wants to move forward makes it possible to compensate for the weight in the back."

A backpack to hold the robotic brains

The March 1 exoskeleton has a backpack that holds the batteries and all electronics, which weighs over 10 kilograms. A powerful PC for SIMULINK® Real-Time™ provides the system intelligence. The PC communicates via the FB1111 EtherCAT piggyback controller board from Beckhoff with three data acquisition boards. The connection with the more than 100 actuators and sensors runs over an SPI bus via HDMI cables, and the boards run firmware written in C++. "Roughly two-thirds of the software is safety-related," says Nick Tsutsunava. "The system checks all incoming data and makes sure that no limit values are exceeded."

The new "March 1" exoskeleton developed by Project March 1 is able to step sideways, making it easier to walk on uneven ground or climb stairs.



A titanium coil spring between the skeletal structure and the motor absorbs bumps and makes it possible to determine the rate of torque with exceptional precision.

Further information:

www.projectmarch.nl/en

www.beckhoff.nl