Humanoid Robot Fights Fires on Ships

Agility, speed, strength, and balance are all qualities needed to fight fires, especially when those fires are shipboard. Such feats are difficult for humans, let alone humanoid robots. But that’s just what the RoMeLa labs at Virginia Tech are working on.

“The SAFFiR [Shipboard Autonomous Firefighting Robot] will be able to carry and operate fire extinguishers, fire hoses, throw PEAT [propelled extinguishing agent technology] canisters, as well as interact with humans and find fires. We’ve already built the legs of the robot and are working on the rest of it,” said Derek Lahr, a PhD candidate and project manager.

The SAFFiR’s legs are a highly compact amalgamation of motors, pulleys, wire harnesses, and controllers that allow the robot not only to walk, but also to walk while on a ship as it pitches and rolls through waves. Key concerns while designing the SAFFiR included the need to control the robot’s locomotion from both a purely mechanical stance and a balance standpoint. For example, if the ship pitches forward, the robot might need to speed its leg movement and produce a longer stride length to keep itself from getting off balance.

Lahr said that by using maxon precision motors’ EPOS controls, the project engineers were able to interconnect all operations easily. “For six degrees of freedom in each leg, we use six motors. That’s 12 motors being used in just the legs section of the SAFFiR.” Both speed and torque were necessary, since at different parts of a stride, the leg will alternately move fast and free and then slow and more controlled.

Lahr and his team used multiple 30mm maxon motors for the legs. Wherever possible, they designed in 100W motors to help reduce the weight of the unit. The motors provide the largest amount of mass in the robot, so any reduction in weight was a plus. “maxon motors actually provide the highest power to weight ratio we could find in a brushless motor anywhere,” Lahr said. “And humanoid robots can be more sensitive to weight than an airplane.”

For certain critical joints like those in the knees, 200W motors were used. The knees of the robot, just like human knees, take the brunt of the load, especially when squatting or kneeling. They also have to move the fastest while walking. Those joints needed the additional torque and speed combination available with the larger wattage units.

At this point in the design testing phase, the robot is tethered much of the time, but the engineers have tested and confirmed the use of a pair of 10 amp/hour lithium polymer batteries (about the size of a small brick) will be able to power the robot for at least a half-hour with a 20A average current draw. This includes all the motors, sensors, and controls.

Because the robot operates off a closed-loop system and uses 12 motors just in the legs (there will be another 12 in the arms and hands, as well as two in the neck), Lahr and his team needed controllers that could handle the load. “We chose maxon’s EPOS 50/5 controllers for the joints, aside from two EPOS 24/5 controllers used for less demanding degrees of freedom,” he said.

One of the main reasons the team chose to use the EPOS (Easy Positioning System) series controllers was that they came equipped to use the CANopen bus system. “Several of us were familiar with CANopen from other applications, so we were attracted by the familiar operating and programming needs of the system software from the beginning,” Lahr said. This makes the EPOS embedded controllers well suited for multi-axis distributed controls that also feature electronic gearing, PVT, step and direction, and point-to-point positioning.

The EPOS controls are used in two different modes — position control mode and force control mode. Position control allows for higher-level controllers to read position data from the sensors and closely regulate the specific position of the leg, so that corrections can be incorporated while walking. Force control mode is the latest thing in locomotion, according to Lahr. “It combines current control circuitry with load cell feedback to create a ‘pure force’ actuator, which allows the leg to swing freely,” he said. “The EPOS controllers allow us to switch modes on-the-fly.”
This is important so that the leg impact doesn’t harm any of the actuators. “We can switch from position control to force control at the last millisecond, so that we can accurately control stride length and impact power,” he said. An additional benefit of using the maxon controllers is that they come with EPOS Studio (a GUI-based free software package provided by maxon), which provides a simple utility to program the controllers and helps the user to bug-check software before implementing it into the CANopen system.

In general, EPOS controllers have been designed using advanced 32-bit DSP technology, which provides users like Lahr and his team the extended functionality of a miniature embedded controller. The units were specifically developed to meet demanding size and performance requirements often found in robotic, medical, and semiconductor applications.

This media release is available on the internet at www.maxonmotor.com.au

Picture: Autonomous shipboard humanoid

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