Zeta: A general-purpose humanoid robot for science and industry

Zeta is designed for general-purpose applications in science and industry. Its humanoid construction allows it to complete any task a human is physically capable of doing. Zeta has twelve joints and a total of twenty degrees of freedom. The ankles, knees, hips and shoulders have two degrees of freedom each, while the elbow and finger joints have one degree of freedom. More motors are used for the more proximal joints (shoulders, hips) because they have to hold more weight than the more distal joints (ankles, elbows). Zeta has claw-like grasping hands and a segmented thorax that allows the top part of the body to bend. Zeta is not designed for social interactions with humans, so a head is superfluous to the robot's function.

The fact that Zeta is human-sized and designed to have a similar range of movement to a human allows it to be programmed to perform new human tasks without the need to design a new specific robot for the task. An example use of Zeta would be in hazardous environments, such as after chemical spills or nuclear radiation leaks, where work normally done by humans can be continued. Zeta's humanoid construction also allows it to carry out tasks when human-like behaviour is more important than efficiency. An example use would be testing whether certain environments were safe for humans, for example as a mobile crash test dummy. Zeta has also been carefully designed to ensure that it could feasibly be built in reality – hence the large numbers of motors to support realistic weights.

We began the process of creating Zeta by drawing sketches and deciding which joints and movements were important in order for a robot to be 'humanoid', and which ones could be left out for practical reasons. Since joints with multiple degrees of freedom had to be approximated by adjacent joints with one degree of freedom each, joints with three degrees of freedom were infeasible. This is why the knee can rotate around the leg's long axis while the hip cannot, even though in reality the hip has a larger range of motion around this axis than the knee. Once the sketch of the intended robot was finalised, each of the rigid links was created as a separate subassembly and then joined into the final robot.

One of the most helpful features of Inventor when assembling Zeta and taking screenshots was the ability to easily toggle the flexibility of subassemblies. This made it easy to have a robot with many moving parts while still being able to accurately move parts around relative to each other. Another useful feature was the ability to move parts manually and ground them so that moving dependent parts would not move parts higher up the chain. The quick constraint hotkeys were also a very helpful improvement over other CAD software we have used. Without this, creating an assembly with as many parts as Zeta has would have been much more difficult.

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