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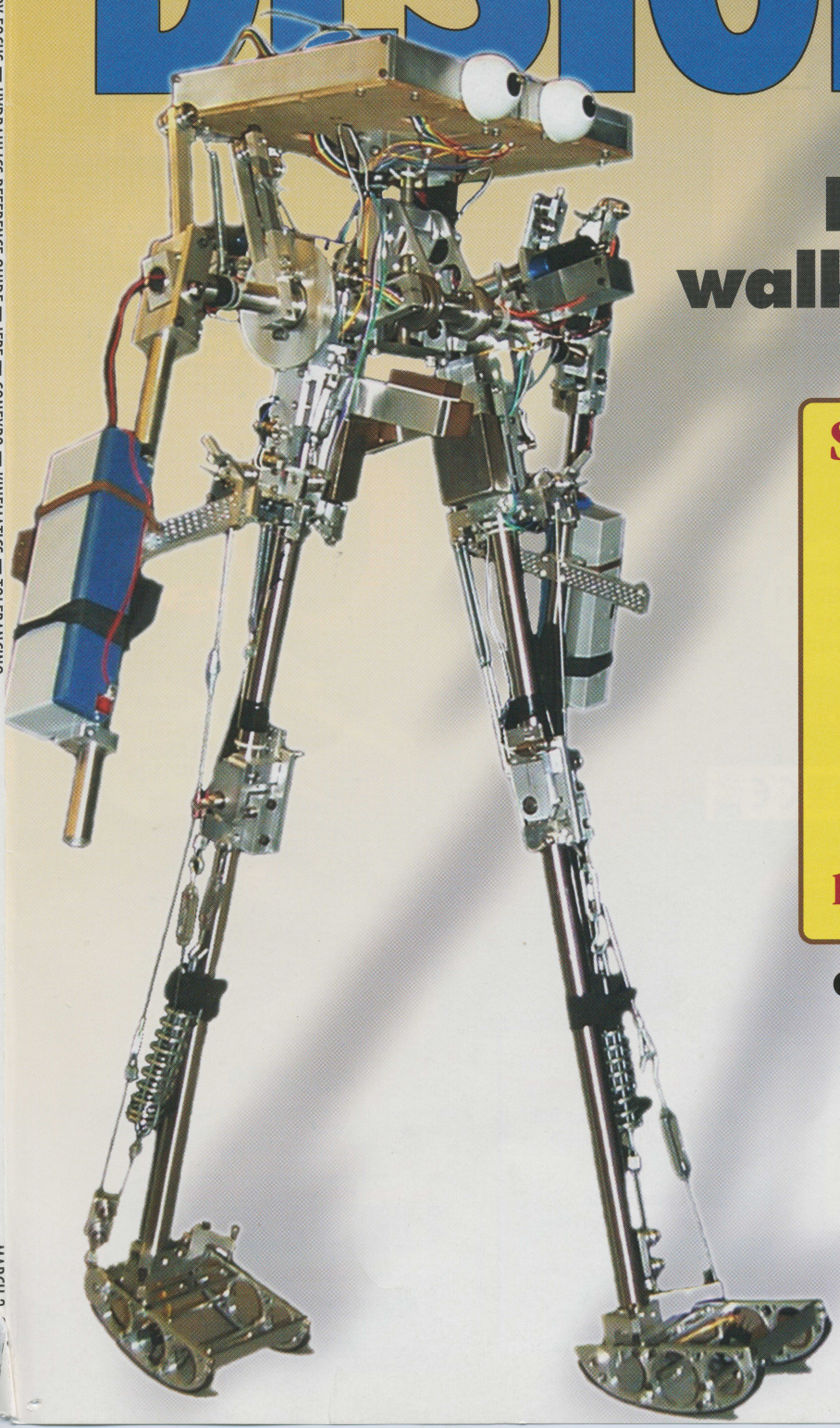

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They walk like men

Simple toys inspire researchers to devise bipedal robots that mimic the human gait.

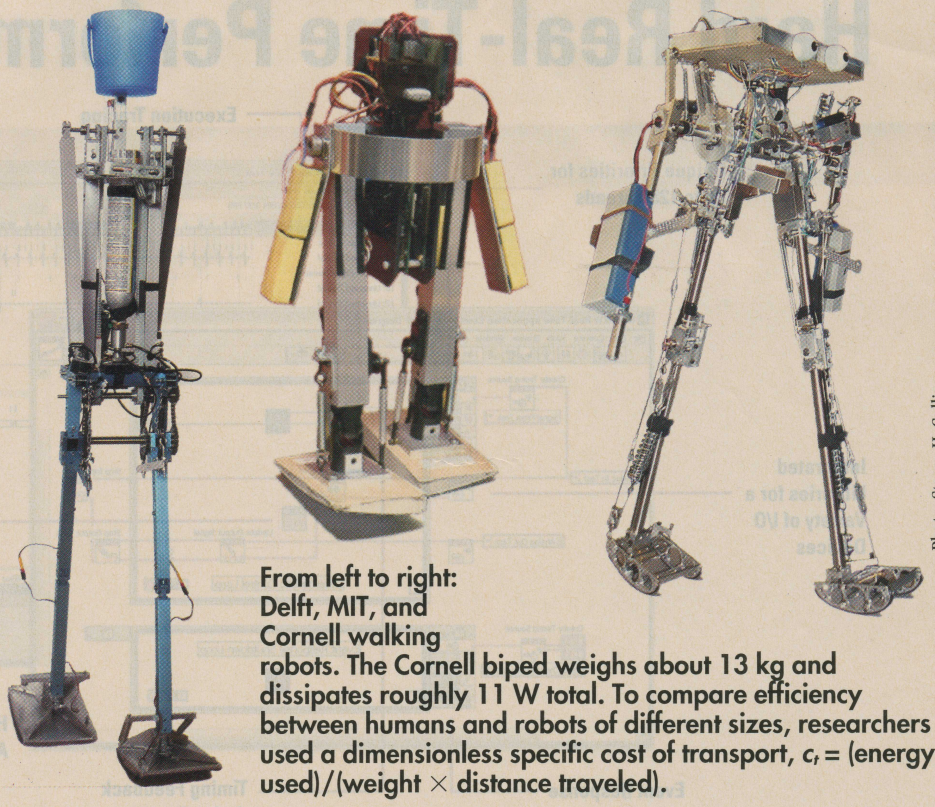

Photo: Steven H. Collins

From left to right: Delft, MIT, and Cornell walking robots. The Cornell biped weighs about 13 kg and dissipates roughly 11 W total. To compare efficiency between humans and robots of different sizes, researchers used a dimensionless specific cost of transport, c_t = (energy used)/(weight × distance traveled).

Researchers at Cornell University, the Massachusetts Institute of Technology (MIT), and Holland's Delft University of Technology have built robots that mimic the human gait — and the Cornell robot matches human efficiency. The researchers' inspiration: simple walking toys that fascinated children in the 19th century.

"Already our robot seems to be at least 10 times more efficient than anybody else's," says Andy Ruina, Cornell professor of theoretical and applied mechanics. The Cornell robot consumes an amount of energy per unit weight and distance comparable to a human walker. In contrast, Cornell researchers estimate the Honda Asimo uses at least 10 times as much energy as a human. The reason: Asimo is based on the mainstream control paradigm, precise joint-angle control. This scheme demands actuators with high precision and a frequency response exceeding that of human muscles. It actively controls every joint angle at all times.

The MIT and Delft robots, though not built deliberately to be energy efficient, also use much less energy than the Asimo. More important, the researchers say, is that their robots provide a more realistic model of how humans walk.

Ruina, his former student Steven Collins, MIT postdoctoral researcher Russ Tedrake, and Delft postdoctoral researcher Martijn Wisse recently described their new robots in the journal *Science* (Feb. 18, 2005) and at the annual meeting of the American Association for the Advancement of Science in Washington, D.C.

Cornell's robot rivals human efficiency, Ruina explains, because it uses energy only to push off, while other robots needlessly use energy to absorb work; for example, in moving the limbs forward more slowly than they would naturally swing under gravity power. "In other robots, the motors are fighting themselves," he says.

Researchers at each of the three universities have built walking robots, differing slightly but based on the same principle. They are an extension of several years of research into "passive-dynamic walkers" that walk down a shallow slope, very much like simple walking toys that have been around since the 1800s and developed more scientifically starting in 1988. These downhill walkers were developed further in Ruina's lab, leading to a two-legged version with articulated knees built by Wisse during a visit to Cornell.

For current robot studies, the researchers simply substituted small motors for gravity power. Ruina says the research followed the example of the Wright Brothers, who carefully researched gliders, then simply added a motor to achieve powered flight.

The robot work was done primarily to study the biomechanics of human locomotion, but it could have applications in practical robotics. Collins, now at the University of Michigan, already is applying some of what he has learned to the design of a powered prosthetic foot for amputees. "It's not exactly the same thing, but certainly the mode of thought comes from thinking about robots," he says. Information gained from studying walking robots should be of use to the rehabilitation community, he adds.

The researchers note that gravity-powered walkers have been considered irrelevant to human walking by some

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