

Million-Dollar Legs

The robot will start here, a supervisor says. "Here" is a strip of white tape on the floor of the Honda Wako Research and Development Laboratory, the highly secret robotics facility outside Tokyo run by the Honda Motor Company. For ten years, the research team operated in complete secrecy; outside the lab, only the very top brass at Honda knew that the company was spending millions of dollars to create a life-sized humanoid robot that could walk on two legs, like a human being.

When Honda researchers revealed their first prototype in 1996, the announcement stunned the robotics world, not only because the project was so successful, but because it was so successfully kept a secret. Even today the company is reluctant to allow outsiders into the research lab, but Peter is persistent and Honda finally agrees to let us see the latest version of their robot walk in the laboratory.

We are escorted to a large, windowless robot laboratory where there are half a dozen shrouded figures hanging from the rafters at various workstations. After the current version, Honda P3 (for prototype three), is activated, the supervisor explains that the robot will walk to a door and open it, pass through the doorway, close the door, and walk to the bottom of a staircase. This will be the end of Program One. After technicians snap on a safety chain, Honda P3 will tackle Program Two. Snugly tethered, the machine will attempt the difficult—and, given the possibility of a fall, potentially costly—process of going up and down a flight of stairs.

"Can the robot stop anywhere, if I want it to stop?" Peter asks. "No, no," says the supervisor. "Once it starts the first stage, it cannot stop until the end of its program." The robot is not controlled by operators but does follow preprogrammed routines.

Looking more than a little like a short, white-suited spaceman, P3 hangs just above the floor from a chain attached to its head. The robot's hands are in glovelike casings. "Humanoid Robot" is written out, in English, on its chest. The chain moves forward on a pulley and lowers the robot to the floor—knees bent, feet ready to be planted flat on the ground. A hard-hatted technician steps behind it to position the robot at the tape mark as it touches down. The chain moves away and the robot stands independently—in itself an impressive feat.

As the robot straightens, it begins to move, emitting faint grinding sounds. It moves toward the door, and its footsteps sound surprisingly wet, like the slapping of rubber soles on a linoleum floor. As a human might, the robot twists slightly at its torso to maintain the correct walking gait. When the

robot reaches the door, it turns the knob and pushes the door open; the action seems perfectly natural. So natural, in fact, that when P3 turns to avoid the door before closing it, I can't help wondering aloud whether I'm watching a person inside a white plastic suit. I'm quickly assured by our hosts that I'm not.

A crowd of 15 or 20 white-uniformed lab technicians and engineers is watching the robot go through its paces. Their work has come to a standstill as they're not allowed to work when visitors are present. They have draped the robot bodies on their workstations with cloth to guard against prying eyes. Ours.

Program One ends without a hitch and the safety chain is attached for Program Two. The robot does truly keep its balance as it moves up the stairs. It turns at the top, bends slightly at the knees, then steps down until it reaches the bottom. It comes to a halt at the program's end.

We thank the technicians, who are huddled around a nearby computer monitor, grinning widely. I realize why and wave into the face of the robot. The technicians quickly look away. They're watching what the robot is seeing through its visor—Peter and me working in front of the robot—and they're a bit embarrassed at being caught. I'm embarrassed because I didn't realize earlier what they were doing. Peter wants to hang out with the robot some more but we have already overstayed our allotted five minutes by a half-hour. A few months later, we catch up with the Honda robot program's senior engineer, Masato Hirose:

Faith: How would you explain the Honda P3 robot to someone who has never seen it before and has no experience with robots?

Masato Hirose: When we began working, people at Waseda University had already built a humanoid robot that walked. So we asked ourselves, what could we do? And we thought, if we could develop a robot that walks at a speed equivalent to that of a human, it would be unprecedented. And if we could develop a robot that walks on two feet and is actually useful, that would be better.

Useful in what way?

For example, we may be able to make this robot walk on a flat surface in a large area, like a gymnasium. The robot could be operated, like playing a game.

You mean, for entertainment?

Yes.

Could people use it for something other than amusement?

Well, when we were still envisioning the kind of robot we wanted to develop, we dreamed of a robot that would be useful at home. But that is still a dream for us, to be realized in the future—our cur-

Robo Specs

Name: Honda P3

Origin of name: Prototype 3

Purpose: To cultivate a new dimension in mobility as an automobile company.

Height: 1.6 m

Weight: 130 kg

Maximum walking speed: 2 km/h

Vision: Digital video cameras

Sensors: Gyrometer, G-sensors, 6-axis force sensors on wrists and feet

Frame composition: We are regretful that some [questions] cannot be answered due to our PR policy.

Batteries (type, duration): Ni-Zn batteries, 25 mins

External power: DC 136 V

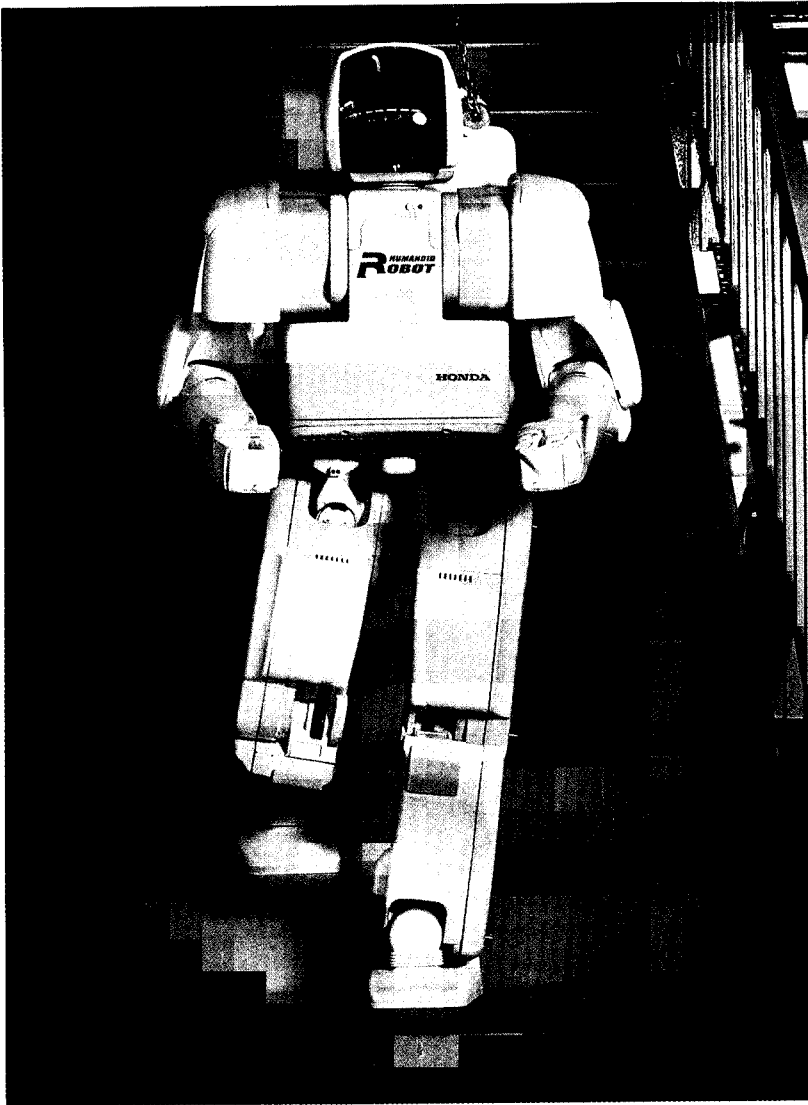
KLOC: We regret that some [questions] cannot be answered due to our PR policy.

Cost: We regret that some [questions] cannot be answered due to our PR policy.

Project status: Ongoing

Information from: Noriko Okamoto

Deftly opening a door, the Honda P3 (left) walks its assigned path at the Honda Research Center, outside Tokyo. The product of a costly decade-long effort, the Honda robotic project was only released from its shroud of corporate secrecy in 1996. In a carefully choreographed performance, P3 walks a line, opens a door, turns a corner, and, after a safety chain is attached, climbs a flight of stairs. Despite its mechanical sophistication, it can't respond to its environment. If people were to step in its way, the burly robot would knock them down without noticing them. Ultimately, of course, Honda researchers hope to change that. But, in what seems an attempt to hedge the company's bet, P3 senior engineer Masato Hirose is also working on sending the robot to places where it cannot possibly injure anyone. In the future, he hopes, the robot will be rocketed to distant planets, to remotely explore places human beings cannot yet visit.



Utterly ignoring the safety chain attached to the base of its "neck," the Honda P3 (above) confidently walks down a flight of steps in the company lab. More than a decade ago, at the beginning of the Honda project, the research team concluded that their robot would have to be able to walk, rather than simply roll on wheels. Wheeled robots, they decided, just couldn't function in a contemporary home full of stairs, toy-strewn floors, thick pile rugs, and other obstacles. Today P3 can walk with impressive smoothness. The only real sign of its robotic nature is the way it begins to walk with a little knee-dip, to compensate for the absence of a pelvis.

rent robot is not capable of that. We still need to reduce its weight, so it is equivalent to that of a human. There are also safety issues to be resolved. [P3 weighs 130 kg, and such a heavy object moving about a home could be dangerous.] But what we envisioned was—if we could develop a robot able to serve a human master, that would be very interesting. For example, when the master goes shopping, if the robot could accompany him or her, carrying the heavy bags, that would be very nice. In fact, this was the kind of thing that we envisioned at the initial stage [of development].

How far in the future is a shopping robot?

[Laughs]. It may take another ten years.

Only ten years! Japanese sidewalks are already so crowded, it's staggering to think what they would be like if everyone were accompanied by a robot. Maybe the robots could go shopping by themselves.

We're still at a stage where people have to develop their own sense about whether a robot could be useful to them. They could treat such a robot as a sort of mascot. I think whether these robots should come

into our daily lives or should remain in a special separate world [as in contemporary factories, where they are generally fenced off from human employees] still needs to be discussed further. We haven't reached any conclusions yet.

What about in a situation like taking care of the elderly? That's a concern in Japan, with the population getting steadily older.

Well, we're not at a stage yet where we can develop a robot that could be involved directly in taking care of people or nursing people. We haven't reached a stage yet where robots can treat or serve human beings.

Will that be P4?

No, not yet [laughs]. We still have a long way to go.

Maybe P10?

[Laughter].

What would you say to researchers who claim the Honda robot is old technology? Everyone in robotics is interested in it, but they also tell us that it's a lot of money for something built with old technology.

Well, actually we don't have any opinion about this. We just want to develop what we want to develop. I think that other people can say whatever they want about the technology.

When you look at the robot walk, after putting all this effort into it, what runs through your mind?

When I saw the robot walking for the first time, I had a deep sense of appreciation for my company. Because, first of all, the company allowed me to continue with this research and development. And as the saying goes, continuance is strength. I think that in our world today, very few profit-making companies would allow us to continue for twelve or thirteen years in the type of research where there's no guarantee that it's really going to work.

Why is a car company building a humanoid robot?

It's just something we view as another kind of mobility. An automobile gives you two-dimensional mobility. Three-dimensional mobility is an aircraft. And I believe four-dimensional mobility would be a robot that is a double of yourself.

When you think of ninjas, there is one technique that they supposedly have—where they can make an identical self appear. Several identical selves, even. It's something like that. You know, you might laugh when I say this but, for example, consider myself. I'm married. Let's say that because of work I was transferred somewhere away from my wife and my home. Maybe this robot could be with me, and my wife would remotely control this robot to monitor what I'm doing—whether I'm doing anything improper or whether I'm not cleaning up my room. *Robotically monitoring errant husbands? I like that!* So why did you decide, out of all the alternatives, to build one in human form? Bipedal walking, for instance, is much harder than getting something to move on wheels or tracks. And presumably, a shop-

ping robot could wheel along just as usefully as one that walked.

We had three alternatives. A robot with a maneuvering movement like [Shigeo] Hirose's snake robot [see page 89]. The second alternative was a robot that would move on legs, like a horse, and the third alternative was something that moves on wheels, like a car. As you know, Honda was already involved in machines with four wheels, so we eliminated that alternative. Then we thought that a robot that would walk on feet with legs would be the most interesting. And this kind of robot would also have the capability to walk in the mountains.

You want the robot to be able to navigate rough terrain?

Yes, but we still don't fully understand, technically, how far this robot can walk like a human. When a human being climbs a mountain, he doesn't use only his feet or legs. Of course not—he needs to use his hands, his arms. It's a synchronized movement of feet, legs, hands, and arms.

The current P3 can move its hands and arms and feet and legs together—we call this synchronized control—but the movement is limited. For example, let's say there's something heavy in front of a table and the robot is supposed to lift it onto the table. When it carries or lifts the object, its hips go backward automatically, to counterbalance the load. And when the hips are moved backward, in order to keep its balance, the robot has to use its hands and arms and legs so that the center of gravity will remain at the soles of its feet. That's all that this current model can do.

Is the upper body tele-operated? When we saw the robot walking, was its upper body controlled by operators at the computer console?

Not everything is tele-operated. For example, as I explained to you, when the robot lifts something, it tries to maintain its balance by itself. In the same way, when the robot tries to open a door by using the doorknob, it can sense the reaction coming back from the doorknob. And there's also the force that is applied when pushing the door open. So in that sense, it's not tele-operated. It's maintaining its balance by itself.

Clearly, that requires some computer power. How would you characterize P3's intelligence?

Well first of all, this P3 does not have the type of brain function that a human being has. It doesn't have the capability to think, to plan, to develop strategies, like a human being can. Rather, it's more focused on movement. Like moving its feet and moving its legs, and trying to maintain its balance when lifting objects. It's focused on the equivalent of a human being's spinal cord. So I don't really know whether you can call this intelligence.

Different roboticists have different definitions for

machine intelligence. An industrial robot that's painting a car has a certain limited amount of intelligence. It has only one task. It does its task and does it very well generally.

I agree. I don't know whether there is such a term but I think it's more like movement intelligence.

Why do you call the robot Prototype 3 instead of giving it a more personal name, as many robot builders do?

The reason we just call this P3, for Prototype Three, is that I personally don't like the idea that a robot can reflect the will or personality associated with a name. Often we are asked, "Is P3 a male or female?" But I always say it's neither. For me, a robot is a machine. It's an object and we are still in the process of research and development. And so I do not like to



regard this robot as being comparable to a human being and needing a name.

For many years, the Honda robot project was unknown to anybody outside the robot team here. It's really hard to keep a secret, even for a little while.

How did you keep this project a secret for so long?

Well, yes, you're right. This project was maintained as a secret for over ten years within our company. Even within our company only the top management knew about this. We did not issue any papers during this time, but I think that we were able to keep it a secret because we were working in a room without windows [laughter].

Was your wife in on the secret?

Well, actually, I wasn't supposed to tell her but I did [laughs sheepishly]. During the first years, I wasn't supposed to tell anyone about this. But I was undergoing so much struggle and difficulty, so many obstacles, and nothing was working. So, I had to talk to someone. I talked to my wife because I really needed to let things out. I think my company will forgive me.

Lights from futuristic concept cars reflecting in the shiny column behind his head, Honda P3 chief engineer Masato Hirose (above) has been entrusted with the transportation company's hopes of getting beyond wheels. Honda began its humanoid-robot program in 1986, intending to develop not the static, special-purpose robot common in automobile factories but a mobile, general-purpose robot that could be useful in the household. Hirose and his co-workers won't talk about it, but it seems clear they had no idea at the outset that it would take them more than a decade to create a robot that could walk. And they are still far from one that is ready for household use.