

## THE ROLLING MAN

**Jean-Paul Laumond** – Why am I interested in humanoid robotics? I always give a two-step answer. The first step is what I call the Fukushima syndrome: we were all stunned when no instrument was able to operate in the environment of the nuclear disaster, to shut a valve or maneuver anything. Humans had to go in themselves, in highly dangerous areas. How to build a machine that could do such things – walk on gravel, climb a ladder, break down a door? When you think out the features of such a machine, you find that if you put it on wheels, it will slide on gravel; if you put it on caterpillar tracks it can't climb a ladder. So an anthropomorphic structure comes to mind pretty naturally. The second step is to inquire “Hey, to make a robot walk, you have to know how we walk – how *do* we walk?” Well in fact, humans don't walk. They roll...

Let's go back in time, about five thousand years. Inventing the wheel. Logs were used to move heavy loads, but there was a basic problem: the weight they carried moved twice as fast as the log. Then, sometime around the year -3500 (nobody knows, really), the wheel axis was invented! You put an axis on the log, the speeds of the weight and the log are the same. That's the great discovery; the wheel is a technical device that Nature doesn't know, it's a human invention. And that wheel has a wonderful ability – converting a rotational motion into a translation.

To walk is to operate a linear translation; these are measured in meters or in kilometers... You've moved a kilometer. That's a mistake. You don't walk over a kilometer, you walk exactly 171 360 degrees! How do you walk? You move one foot after another, moving your leg; how does your leg move? It moves by rotating around the neck of your femur! So you have this swinging motion, a rotational motion that makes you bring one leg before the other! What I've just done is to translate kilometers into numbers of femur rotations, and the number of those – I calculated that – is 476 femur rotations per kilometer.

We actually went a bit further. With motion capture recording systems, we studied walking people and found their center of gravity. Then, we asked ourselves “What's the trajectory of the center of gravity, when we walk?” Well, we found that the trajectory is a trochoid, a trochoid is part of the cycloid family. A cycloid is the trajectory of a point moved by a disk. So simply put, what is a trochoid? It's the motion of your bicycle wheel valve. So that's incredible: the huge complexity of human walk – coordinating all the muscles, arms, legs, swinging, the head rocking, etc. – boils down to an extremely simple motion of the center of gravity, a trochoid motion. That's why I first said that we don't walk; we roll.

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