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The balance of walking and bicycling

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Abstract

Our research on human walking and on walking robots has been largely inspired by the passive stability property of many bicycles. Similarly, perhaps the comparison with walking might shed light on the control of bicycles. What are the relations between the both the passive stability and controlled stability of walking and bicycling?

A bicycle is a complex mechanism that can balance itself. A human skeleton is a complex mechanism, maybe it can balance itself. And so, at least to some extent, it seems to be. In 1988 Tad McGeer discovered that walking robots need not be controlled (e.g. [1]), at least in two dimensions. Inspired by McGeer's results, and also by the analogy with bicycles, we have further explored the passive aspects of the stability of walking[**?**, **?**, **?**, **?**, **?**], extending the results to three dimensions. Similar research on walking has also been done here in Delft[].

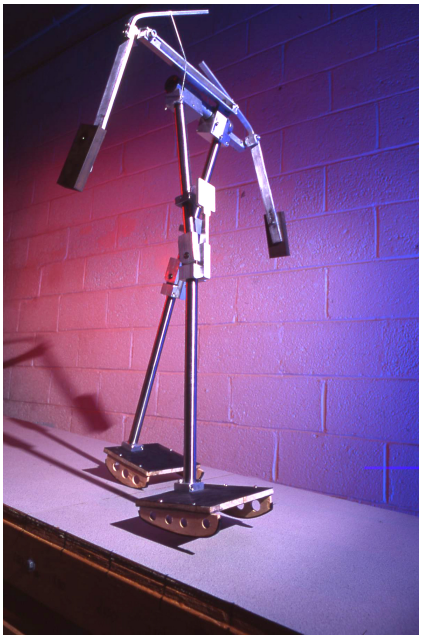

Figure 1. A passive walking robot made at Cornell. It walks and balances itself. No computers, no sensors, no motors. Power is from gravity. The inspiration came largely from the self-stability of bicycles. Videos of this and other passive walking machines will be shown. Photo by Hank Morgan.

That bicycles can be both conservative (neglecting air, rolling and bearing friction) and have asymptotic stability comes from the non-holonomic rolling constraint. Walking is also non-holonomic, but in an intermittent sense[**?**]. It is still not clear whether the asymptotic stability of passive walking robots depends on this non-holonomicity or on collisional dissipation, or both.

How do people balance bicycles? A plausible partial answer, based on the passive stability bicycle results, is that people learn to let the bicycle balance itself. And so it might be with human walkings. In one way of thinking a person is flesh that is riding on the bones. Perhaps, based on the passive robot results, people, at least in part, learn to let the skeleton balance itself.

But certainly their is an active aspect of balance, both for walking and bicycling. People balance bicycles that have no passive stability. And passive robots (and simulations) are not nearly robust enough, to explain why people don't fall very often. A typical passive robot will fall down if someone in the room merely imagines a disturbance.

References

[1] T. McGeer. Passive dynamic walking. *The International Journal of Robotics Research*, 9(2):62, 1990.