Stabilization of a 3D Simplest Walker by Using a Gyro

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Introduction and Method: The 2D simplest walking model was investigated by Garcia *et al.*[2] and Schwab & Wisse [1] as an approach in order to model dynamic walking patterns. In our contribution we start from the same approach. As a first step we integrate the simplest walking model into an ODE simulation in order to extend the inital 2D model to a 3D model. In dependence of the starting conditions we get a stable cyclic walking pattern. The left side of the figure below shows the number of steps as function of the starting conditions. The area in which the walker performs the maximum number of steps resembles the basin of attraction that was found for the 2D simplest walking model. Small differences are due to inevitable modifications that we had to introduce to the ODE simulation: (1) Finite size of the feet and non-vanishing leg masses. The ODE simulation requires a finite size of the contact planes and object masses in order to calculate the impact correctly. Also, the inertia tensor of the legs has to be non-singular. (2) Center of mass of the legs is in the middle of the legs.

In a second step, we add noise to our model and test the stabilizing effect of the gyro added to the walker. The noise is added in the form of an additive random gravitation perpendicular to the direction of the walking and the direction of the gravitational vector.

A 'gyro' is a device which sensors the tilt of the body and controls the posture to the desired state. The gyro is attached to the hip of the model to prevent the walker from falling to the lateral direction.

Results: Even under starting conditions that result in a stable cyclic motion in the noise free case the walker falls after a small number of steps, because the noise affects the system severly. In dependence of the speed of the rotor however the vulnerability of the walker against noise could be reduced. The right side of the figure below shows the result of our simulation. The higher the rotation speed, the higher the average number of steps. This result indicates that the high rotation speed of the gyro reduces the influence of the noise and prevents the walker from falling.

Discussion and Conclusion: Our results indicate that indeed the gyro has a stabilizing effect on the walking. We also got similar results in simulations of kneed walkers. Next steps are experiments with a prototype that is currently being built at Osaka University.

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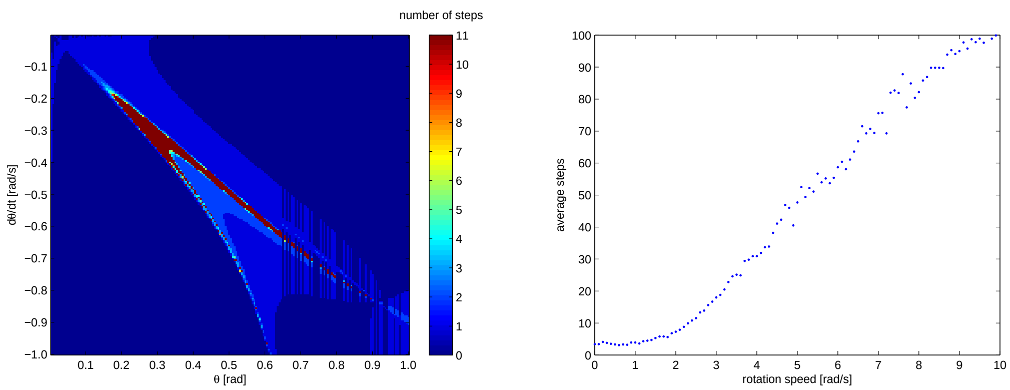
[1] L.Schwab and M.Wisse. Basin of attraction of the simplest walking model. *ASME 2001 Design Engineering Technical Comferences, DETG2001/VIB-21363*, 2001.

[2] A. Ruina M. Garcia, A. Chatterjee and M. J. Coleman. The simplest walking model: Stability, complexity, and scaling. *ASME J. Biomech. Eng.*, Vol. 120, pp. 281–288, 1998.



Left: Map of the number of steps as a function of the starting conditions. Right: The average number of steps vs. the rotation speed in the noise field.