Analysis of Dynamics of Passive Walking from Energy Function and Eigenvalues

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1. Introduction

Passive walking robot could walk a gentle slope with no energy source other than gravity and no control[1]. Many researchers have interest in passive walking. However, the mechanisms of its dynamics are not well understood.

In this paper, we analyze dynamics of passive walking from the aspect of the robot's energy and eigenvalues. In addition, we focus the features of dynamics which the kneed and straight-legged walkers have in common.

2. Energy Function

One cycle is defined as the period from the state just after heel-strike to the next same state. In one cycle, the energy supplied by potential energy for walking down is expressed as ΔE_p. The energy lost by knee-lock and heel-strike are expressed as ΔE_{lk} and ΔE_{lh} respectively. The storage energy of the walker can be defined as $\Delta E_s = \Delta E_p - \Delta E_{lk} - \Delta E_{lh}$. The supply rate is defined as $\Delta E_{rs} = (|\Delta E_{s2}| - |\Delta E_{s1}|)/\Delta 1 cycle$. where ΔE_{s1} and ΔE_{s2} are two consecutive storage energies. As an example, figure 1 and 2 show storage energy ΔE_s and supply rate ΔE_r for kneed walker respectively.

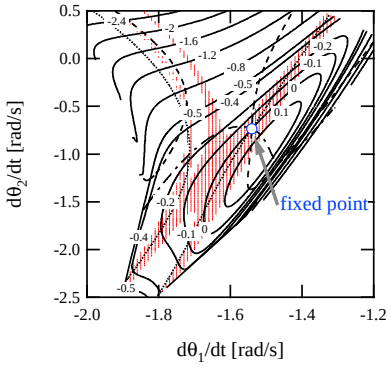

Figure 1: Storage energy before bifurcation

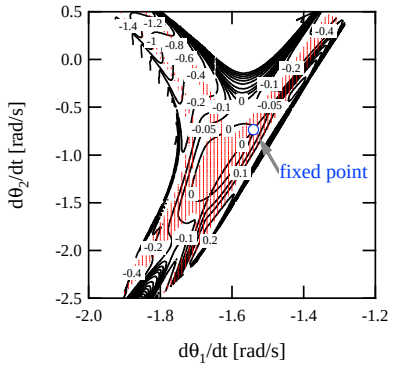

Figure 2: Supply rate before bifurcation

3. Analysis of Eigenvalues

Figure 3 shows loci of eigenvalues with slope angles for kneed walker. For large slope angle, one of the eigenvalues is outside the unit circle. This means that the fixed point is unstable. As a result, the periodic gait bifurcates.

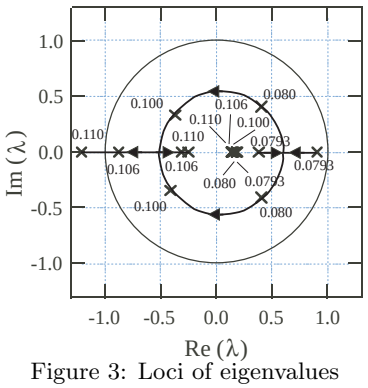

Figure 3: Loci of eigenvalues

4. Conclusion

We demonstrated the dynamics of passive walking before and after bifurcation and the behavior of local stability.

References

[1] T. McGeer: "Passive Dynamic Walking, " *The Int. J. of Robotics Research*, Vol.9, No.2 pp.62–82, 1990.