Optimization of Step Length for the Least Balance Actuating

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1 Motivation

Walking robots usually have 4DOF or more on one leg. And to control all of the actuation to gait and balance its body posture simultaneously, algorithms embedded are complicated. To resolve this problem and make simply controlled fast biped robot, Jongwon Park[1,2] proposed the leg mechanism inspired by cats which retain 1 actuator on each leg. This leg mechanism let simplify gait pattern and is manufactured to experiment walking and running gait. The raptor robot was need to be upgraded to balance its posture while walking or running.

Based on the under-actuated leg mechanism, pitch and roll balance mechanism is implement to balance body posture by reaction torque of the spinning inertia. With this mechanism implementation, the robot system need to be optimized in gait pattern and balance actuation because required reaction torque for body posture balancing may large.

2 Method

Left leg crank and right leg crank are the only parameter that determine leg configuration or posture. The other factors that affect gait pattern are pitch and roll balance spinning inertia. In current study, pitch balancing is the only consideration as body posture.

With low speed walking gait, stance to swing phase transition can be modeled as **Figure 1**, which touch down impulse resemble the model Kuo showed [3]. To implement assigned leg configuration with fixed body pitch angle, pitch balance spinning inertia generate reaction torque to maintain consecutive inverted pendulum motion and not to fall down. With same gait speed or stance speed, the minimally optimized step length can be decided with calculation.

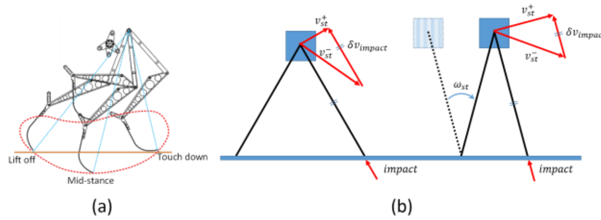

Figure 1. (a) The robot leg configuration according to crank angle. (b) Simplified schematic diagram of the raptor robot with different step length

3 Current work

We modeled the raptor robot and walking gait with different step length is simulated by Recurdyn dynamic model simulator in **Figure 2**. In simulator, it is assumed that body posture is maintained with well-tuned feedback controller and left and right gait pattern is symmetric.

The raptor robot has mechanical characteristics that it has dual swing phase at fast locomotion situation, but cannot have dual stance phase if compliance is disregarded. In current simulation, stance time and swing time is same and different step length is implemented with sinusoidal crank speed profile as shown in **Figure 3**.

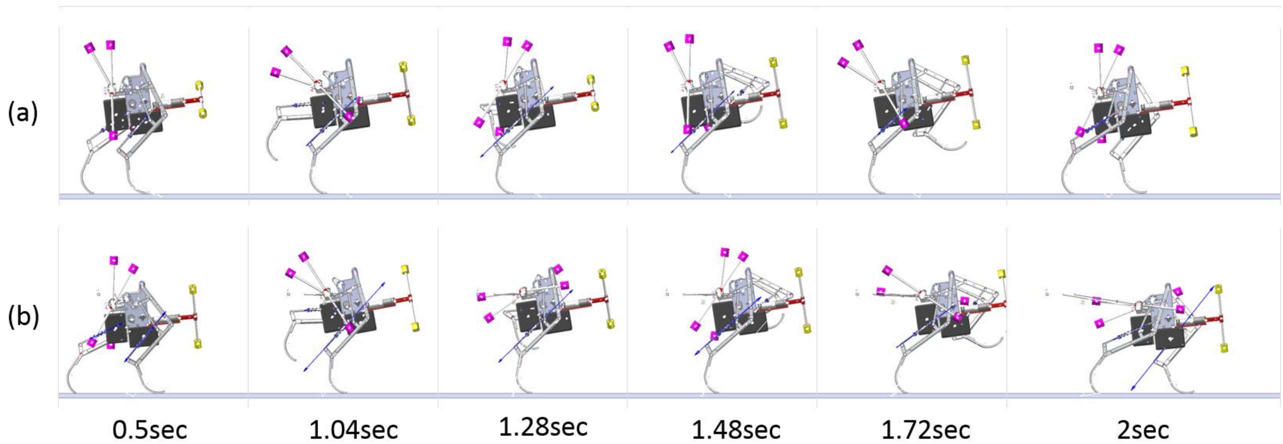

Figure 2. Snapshots of the walking simulation with (a) short step length and (b) long step length.

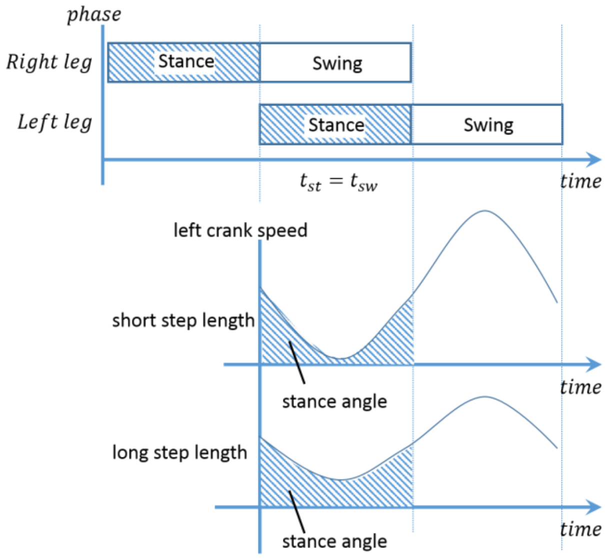

Figure 1. (a) Stance time and swing time is same and alternate the other leg simultaneously. (b) different step length is implemented with sinusoidal crank speed profile

4 Future work

The method that consider impulse and body velocity transition at touch down will be firmly implemented with low gait speed and high gait speed. If step length is narrow enough or speed of swing phase speed, swing leg inertia need to be considered.
Roll control is need to be considered. And to complement the proposed method, the pitch and roll reference may be profiled according to gait phase to minimize impulse that inherently aggravate body balancing.

References

[1] Park, Jongwon, et al. "Design of biped robot inspired by cats for fast running."*Electronics Letters* 50.10 (2014): 730-731.
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[3] Kuo, Arthur D. "Energetics of actively powered locomotion using the simplest walking model." *Journal of biomechanical engineering* 124.1 (2002): 113-120.