

## SUMMARY OF Ph.D. DISSERTATION

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Title  <b>Advanced Approaches to Biped Walking Mechanism Based on Passive Dynamics</b>		
Abstract  <p>In this dissertation, level-ground walking methods based on passive dynamics and three-dimensional passive walking mechanisms are proposed. By exploiting the passive dynamics, stable bipedal locomotion can be achieved with simple mechanisms and controllers. To achieve level-ground walking based on passive dynamics, a torso is added to a planer biped and two control methods are investigated; one is using physical intuition of bipedal locomotion, and the other is using numerical optimization. Three-dimensional passive walking is difficult due to unstable roll and yaw motions. Flat feet with ankle springs are introduced to imitate the effects of arc-shaped feet while the friction with the ground is sufficient for yaw motion.</p> <p>The contents of this dissertation are summarized as follows.</p> <p>The first chapter describes the introduction of this study.</p> <p>In chapter 2, a brief survey of bipedal locomotion and the main technical tools of modeling and analysis of bipedal locomotion are described.</p> <p>In chapter 3, a torso is added to a biped and level-ground walking methods based on passive dynamics are presented. First, physical intuitive control methods are implemented. The torso is stabilized by PD control at a desired angle. Swing leg control is introduced to achieve the condition of contact with the ground before the biped falls forward. Numerical simulations show that the torso and swing leg control allows the biped with the torso to walk stably over a wide speed range. Next, optimization methods are used to investigate the more energy-efficient bipedal locomotion. Numerical optimizations are used to find the open-loop control trajectories. The optimization approach shows that adding springs at the hip joints enables highly energy-efficient locomotion.</p> <p>In chapter 4, three-dimensional passive walking with flat feet and ankle springs is presented. A three-dimensional rimless wheel, which is a simple model of three-dimensional passive walking, is used to show the effect of adding ankle springs to obtain a stable motion. Numerical simulations and experimental results show that a stable motion is obtained in the presence of the ankle springs. A physical three-dimensional passive walker is constructed to verify the proposed method. The torsional spring constant for the roll motion is determined by simple numerical simulations so that the roll and pitch motions are coordinated. Experimental results show that the flat feet with the ankle springs stabilize the yaw motion and enable the three-dimensional passive biped to take longer steps and walk faster than other simple three-dimensional passive walkers with arc-shaped feet.</p> <p>Finally, chapter 5 presents the conclusion of this study.</p>		