Passive Limbs for Dynamic Running and Climbing

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For most terrestrial and arboreal (or other scansorial) animals legs are the key to effective locomotion. Although their morphology varies greatly from animal to animal, for locomotion modes such as running most legs perform a similar, basic set of functional roles. Primarily we think of legs as actuators, but they also function as a strut, a spring, and/or a damper.

In this talk, I will look at passive legs and how they can be used in robots to achieve dynamic locomotion. I will begin with a review of some earlier work on running that used only active body degrees of freedom (body bending and twisting) to move its six entirely passive legs. The compliance of these cantilever beam structures proved critical to achieving fast motions and SLIP-like COM trajectories.

The second portion of the talk will discuss how similar passive appendages can be used in dynamic climbing of vertical walls to regulate body rotations. The DynoClimber/BOB family of climbing robots are based on the pendular model of climbing, initially proposed by Bob Full and Dan Goldman to explain similarities in the rapid vertical climbing motions of cockroaches and geckos. By encoding the pendular COM dynamics, these robots have been able to reach vertical speeds of up to 67 cm/s, or about 1.5 body lengths per second while only using a single motor per front leg. While modeling and analysis has shown that the pendular rocking in the plane of the wall (yaw) is beneficial to rapid vertical running, the planar model has not yet been extended to 3D and the effects of roll and pitch are not yet well understood. In fact, excessive roll causes significant attachment problems while climbing. The addition of passive rear legs, however, has helped stabilize these motions. The talk will describe recent investigations into how the compliance, orientation, and oscillation of these rear legs can enable dynamic maneuverability on walls.