Mechanical Design for Robot Locomotion

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Robotic limbs have been shown to enable mobility in unstructured, real-world terrain; they allow robots to step around cluttered environments, scramble up hills, carry heavy loads, and even perform acrobatics. However, mechanical limbs cannot operate as a means for such dynamic locomotion if they are simply treated as general articulated mechanisms. Mechanical design in the context of locomotion requires us to be aware of the control paradigm (sometimes even serving as a "part" of the controller) and how the robot relies on contact to generate motion. These two interfaces (software control, physical contact) direct the design of inherent hardware dynamics (passive dynamics), where mechanical design decisions are made specifically to serve the context. In this work, we create a practical definition of "locomotion" to lead us towards metrics for grading a design’s aptitude for real-world mobility and tracking progress toward better designs. Metrics such as weight, cost, and other engineering goals are commonly understood and not considered here. Instead, we are interested in the locomotion-specific metrics of floating-base manipulability, impact reduction, power quality, and compliance tuning. These metrics have intuitive, geometric representations for use in human-driven design processes, while their numerical representations can be evaluated in simulation. Multiple competing metrics require a multi-objective design process, which here is discussed as stochastic search. This structure is analogous to a human-driven design process, but is also amenable to future computer automation.

Abstract

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