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Title: Assisting locomotion with unpowered devices

Abstract: Wearable devices intended to assist human locomotion are usually powered by motors and batteries. Yet many locomotor tasks, such as walking on level ground at steady speed, require no energy input in theory. This helps to explain the unusually economical gaits of passive-dynamic walking robots. In humans, muscles often expend energy to perform tasks that machines can accomplish passively, such as producing force. In this talk we will describe unpowered approaches to reducing the energy lost through muscle activity during gait. The first device is an ankle exoskeleton that engages a spring to offload plantarflexor muscles when the foot is on the ground. Although this mechanism is passive, it reduces the metabolic energy consumed by the body during walking. Second, we will present a new type of actuator that uses ultra-low-power, lightweight, low-voltage electroadhesive clutches to expand the controllability of unpowered devices. We will describe an application to an ankle exoskeleton with selectable stiffness, intended to provide assistance over a range of speeds and gaits. Finally, we will discuss design methods for this class of device using versatile, exoskeleton emulator systems. The energetically-passive approach described here complements the established paradigm of active powering, and bodes well for the future of lightweight, highly-efficient, and relatively inexpensive exoskeletons that enhance or restore locomotor performance for humans.