MIT Cheetah: New Design Paradigm for Mobile Robots

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Recent technological advances in legged robots are opening up a new era of mobile robotics. In particular, legged robots have a great potential to help disaster situations or elderly care services by providing excellent mobility. In this endeavor, biological inspirations play essential roles in developing machines capable of robust mobility. However, applying the inspirations from animals requires much more involved processes than simplify copying design features from the knowledge we obtain from biology. Since the evolution process is believed to be driven by multiple functions essential for survival in nature while the engineering need is limited to specific few according to the applications. More importantly, there are substantial differences between engineering systems and biological systems so that it is nearly impossible to copy nature or pointless to copy the features due to the differences. Often, the advantages in design feature in nature do not transfer to the engineering domain because of the different nature of the characteristics.

One way to effectively transfer the wisdom behind the designs by nature is to extract the governing principles of the targeted function of natural systems. Instead of taking design cues directly from the observation of animals, we can understand the scientific principles which can be applied regardless of the detail characteristics of each domain. Often, it takes observations across multiple species to fund the common principles of a certain function. It is critical not to prematurely connect the features to the functions that we can easily observe. For example, running capability is one of the most critical functions in animals. However, the design of the animals should satisfy more other functions. It is desirable to study multiple good running species to extract the design principles for running. Each species has their own special constraints and conditions that could have driven their evolution process. It is critical for engineers to collaborate with biologists from comparative biological studies.

In the Biomimetic Robotics Laboratory at MIT, we aim to develop bio-inspired machines capable of performing disaster response using the principles we learn from nature. One of the most important research components in designing bio-inspired legged machine is the actuation (motors and transmission). While many potential force transducer technologies were investigated, electromagnetic force generation seems to be most promising to emulate the functions of the muscle. In power density (power per unit weight), electric motors can exceed the power density of mammalian muscles by a factor of 100. Whereas manufacturing robots are designed for maximum stiffness, allowing for accurate and rapid position tracking without contact, mobile robots have a different set of hardware/software design requirements including dynamic physical interactions with environments. Events such as the Fukushima power plant explosion highlight the need for robots that can traverse various terrains and perform dynamic physical tasks in unpredictable environments, where robots need to possess compliance that allows for impact mitigation as well as high force capability. The talk will discuss the new mobile robot design paradigm focusing on the actuator characteristics and the impulse planning algorithms. As a successful embodiment of such paradigm, the talk will introduce the constituent technologies of the MIT Cheetah. Currently, the MIT cheetah is capable of running up to 13mph with an efficiency rivaling animals and capable of jumping over an 18-inch-high obstacle autonomously.