Linking Mechanics and Learning

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1 Abstract

We are interested in how to combine mechanical design and controller design to achieve agile and efficient locomotion. A key concept is to *exploit the natural dynamics*, as first pioneered by McGeer's completely passive walker[4] and subsequently by other robots[2][1]. Proper mechanical design can not only enable better performance, but also simplify controller design, for example by providing large regions of attraction which allow for robust open-loop control[5], or by decoupling different control tasks[3]. Designing the natural dynamics around a specific behavior also allows automatic *learning* of the controller, for example through reinforcement learning[6], by providing a smoother slope in the cost-landscape for the learning algorithm to traverse. This is however still very challenging to do in hardware, especially for arbitrary mechanical designs, as exploratory policies often risk damaging the robot, and until a reasonable controller has been found, the number of trials required to effectively search the policy space tends to be very large. These challenges have been holding back progress of using this powerful tool on real hardware. We want to address this, and systematically test the effect of different leg designs (segmentation, pantograph-designs, amount of compliance etc.) on the convergence of reinforcement learning in both simulation and hardware. For this, we aim to develop a modular robot capable of dynamic motion, and progressively test it in 1D (see 1) and 2D test-stands, and eventually out in the field. The test-stands will be partially actuated in order to automate resetting etc., such that large numbers of iterations can be conducted.

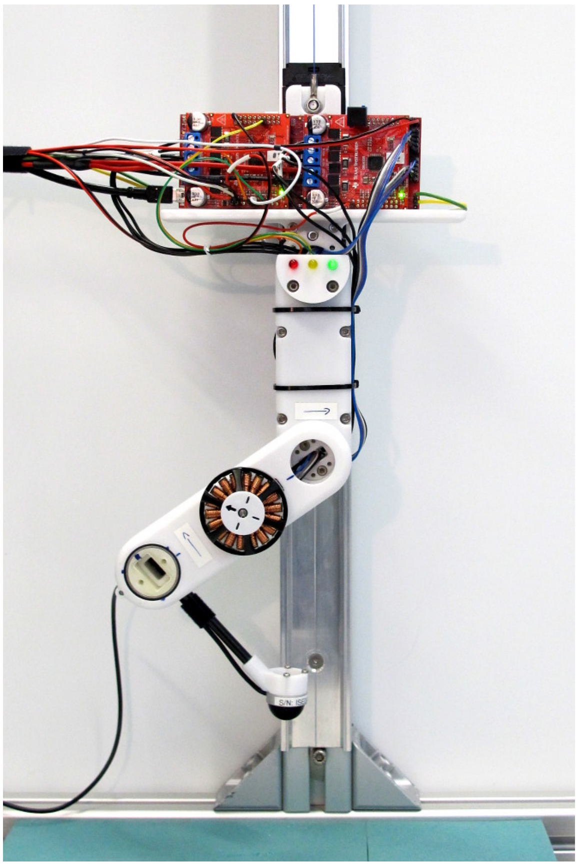

Figure 1: A first version of a segmented leg design in a 1D test-stand. In this case, the uppermost segment is blocked to the test-stand, resulting in a 2-segmented leg.

References

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