1 The positive side of damping

Damping, specifically viscous friction, is always present in the real world, making machines less energetically efficient and causing hysteresis. Engineers go to great lengths to minimize damping in joints when building robots. This is despite the fact that, from a controls perspective, damping has important stabilizing effects. Indeed, studies have shown that physical damping is critical in achieving impedance control [1]. Though not well understood, the damping in muscles is also known to alleviate the effect of delays and noise in neural control [2].

While these studies on the stabilizing effect of damping are well acknowledged in the community, they are generally limited to isolated components rather than entire systems. This is due to the lack of a proper method to quantify stability and robustness for the overall system, which makes it difficult to appreciate the overall benefit of deliberately designing damping into the system. The negative effects are, on the other hand, easy to measure and thus given more importance.

We have recently developed a method to quantify the robustness inherent to a system’s natural dynamics CITATION. This method, based on viability theory [3], allows robustness to be quantified prior to designing the control system, and is valid for all possible robust controllers. In other words, the effects on robustness of physical properties such as damping can be quantified for the first time.

We will use this new quantification on a modified version of the classical spring-loaded inverted pendulum (SLIP) model for running, in the context of unforeseen ground-level perturbations [4], [5]. We are currently evaluating modifications with damping and actuation at different levels of abstraction. We expect our results to reveal to what degree damping affects overall robustness, in the presence of noise, perturbations as well as delays in sensing. We thus hope to shed new light on how animals manage to cope with robustness requirements, and also to inform how to design better robots, in particular how a small cost in efficiency can lead to markedly better robustness.

References


