Analysis and Applied Mathematics Seminar

Role of mechanical stability in animal morphology and neural control

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Abstract: Mechanical stability is vital for the fitness and survival of animals and is a crucial aspect of robot design and control. Mechanisms that impart stability to animal bodies can be broadly classified into the innate mechanical response of the body or open loop control and feedback control. I will discuss two examples, finger contact and overall body stability, to show how the innate mechanical response of the body is tuned for stability by shaping the neural control and evolution of animal form. By studying the linearized dynamics of a finger's internal degrees of freedom pushing on a hard surface, we show that human fingers and other musculoskeletal linkages are intrinsically prone to buckling-type postural instabilities. Humans rely on a family of convex neural activation strategies of muscles so that the elastic response of our muscles can suppress the intrinsic instability, but by limiting maximal fingertip forces. In the study on whole-body lateral stability during locomotion in terrestrial animals, we find that the scaling of body aspect ratio with size is likely driven by the scale-dependent unevenness of the natural terrain. Thus, we identify morphological and control features that allow animals to perform stably and robustly in noisy environments by investigating their unstable and marginally stable behaviors.

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