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Abstract

Yvonne Blum, Monica A. Daley

Perturbed bipedal running: Identifying control strategies used by guinea fowl

Key words: Avian running, swing leg control, spring mass model

Our goal is to identify control strategies used by birds to achieve stable and robust locomotion in uneven terrain. We want to investigate how touch down conditions, which are determined by swing leg control strategies, influence stance dynamics during steady state running and in the presence of a permanent drop and a pothole. We hypothesize that, regardless of the condition of the ground height disturbance, birds show a consistent swing leg behaviour during the drop step itself and adapt their kinematics and dynamics to the new ground height in the following, subsequent steps. To underpin our hypothesis, we want to test different swing leg control strategies based on a simple, actuated spring mass model (spring-loaded inverted pendulum (SLIP) model) and compare the simulation results with the observed experimental data.

Avian running trials were conducted on a runway, and dynamics and kinematics of eight birds (guinea fowl, *Numida meleagris*) were recorded. We had three experimental setups, consisting of a flat runway, a ramp with a 6 cm drop and a 6 cm pothole.

To test potential control strategy candidates, we use a simple planar spring mass model with a leg actuator. During flight, the leg angle and leg length are controlled as a function of time to choose an optimal trajectory such that the model's apex and touch down conditions correspond to the observed leg conditions in avian running. The resulting simulated dynamic parameters (e.g. peak force, impulse, work) are compared to the experimental parameters.

Previous results suggest that swing leg control, namely the time-dependent adjustment of leg angle and leg length in anticipation of ground contact, affects the initial conditions of the following stance phase, and therefore, controls the stance phase as well. While the flight phase might be controlled by a mainly feed-forward and time-dependant swing leg strategy with a triggered starting point, our previous results suggest that during stance phase the system's energy is regulated depending on the resulting leg conditions at the instant of touch down. Such a combination of control strategies, namely a "blind" flight control with a stance control that relies on its initial conditions, could work without feedback and might explain why running birds such as guinea fowl are such remarkable obstacle negotiators. Especially the experimentally observed swing leg retraction seems to be a strategy to minimize fluctuations in peak forces by allowing for deviations from equilibrium gait.