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Geometry, Curvature, and Locomotion ROSS HATTON, HOWIE CHOSET, Carnegie Mellon University — Many animals and robots locomote by undulating their bodies in traveling waves. Together with the generally inextensible nature of such systems, the large deformations involved in these motions introduce significant nonlinearities into their analysis. As a result, the equations of motion for these systems are often treated as black boxes – the displacement resulting from a given input (e.g., wave amplitude) can be calculated, but the relationship between the inputs and the net displacement over a period of the wave is hidden inside the nonlinearities. Drawing on results from the geometric mechanics community, we have developed an analysis framework for high-deformation locomotion that looks inside this black box, based on three core principles: (1) Working in terms of body curvature provides a linear basis for describing nonlinear high-deformation shapes. (2) Lie bracket analysis (the exploitation of system nonlinearities through oscillatory inputs) captures the nonlinearity of the system interaction with the world. (3) Systematically optimizing the coordinate choice transforms the system nonlinearity into a form that can be geometrically analyzed over the space of body curvatures to characterize the system's ultimate locomotory capabilities.

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