Solvability of Geometric Integrators for Multi-body Systems

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This work is concerned with the solvability of implicit time-stepping methods for simulating the dynamics of multi-body systems. The standard approach is to select a time-step based on desired level of accuracy and computational efficiency of integration. Implicit methods impose an additional but often overlooked requirement that the resulting nonlinear root-finding problem is solvable and has a unique solution. Motivated by empirically observed integrator failures when using large time-steps this work develops bounds on the chosen time-step which guarantee convergence of the root-finding problem solved with Newton's method. Second-order geometric variational integrators are used as a basis for the numerical scheme due to their favorable numerical behavior. In addition to developing solvability conditions for systems described by local coordinates, this work initiates a similar discussion for Lie group integrators which are a favored choice for floating-base systems such as robotic vehicles or molecular structures.