Decomposition, Potential-based Realization,
and Stabilization of Nonlinear Systems

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This contribution considers the problem of representing a sufficiently smooth nonlinear dynamical system as a structured potential-driven system and to exploit the obtained structure for the design of nonlinear state feedback stabilizing controllers. The problem has been studied in recent years for systems modeled as structured potential-driven systems, for example gradient systems, generalized Hamiltonian systems and systems given in Brayton--Moser form. To recover the advantages of those representations for the stabilization of general nonlinear systems, the present note proposes a geometric decomposition technique to re-express a given vector field into a desired potential-driven form. The decomposition method is based on the Hodge decomposition theorem, where a one-form associated to the given vector field is decomposed into its exact, co-exact, and harmonic parts. In particular, it is shown that the combination of the homotopy and the dual homotopy operators provides a general decomposition of the nonlinear system as a potential-driven system. Using the identified structure, it is then possible to design a stabilizing damping state feedback controller and ensure stability of desired isolated equilibria of the control system.