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Calculating Non-Unique Sliding Modes for Switched Dynamical Systems

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Abstract : Ordinary differential equations with switching nonlinearities constitute a very useful tool in many applications. The solutions of such equations can usually be calculated analytically if they cross the discontinuities transversally. Otherwise, one has trajectories that slides along the discontinuity, and the calculations become less straightforward in this case. For instance, one of the problems one faces is non-uniqueness of the sliding modes. In the presentation, it is proposed to apply the theory of hybrid dynamical systems to calculate the solutions that are 'hidden' in the discontinuities. Roughly, one equips the underlying switched system with an explicitly designed discrete dynamical system ('automaton'), which governs the dynamics of the switched system. This construction 'splits' the dynamics, which, as it is shown in the presentation, gives uniqueness of the resulting hybrid trajectories and at the same time provides explicit formulae for them. Projecting the hybrid trajectories back onto the original continuous system explains non-uniqueness of its trajectories. The automaton is designed with the help of the attractors of the specially constructed adjoint dynamical system. Several examples are provided in the presentation, which supports the efficiency of the suggested scheme. The method can be of interest in control theory, gene regulatory networks, neural field models and other fields, where switched dynamics is a part of the analysis.

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