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Solving Ill-Posed Initial Value Problems for Switched Differential Equations

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Abstract : To model gene regulatory networks one uses ordinary differential equations with switching nonlinearities, where the initial value problem is known to be well-posed if the trajectories cross the discontinuities transversally. Otherwise, the initial value problem is usually ill-posed, which lead to theoretical and numerical complications. In the presentation, it is proposed to apply the theory of hybrid dynamical systems, rather than switched ones, to regularize the problem. 'Hybridization' of the switched system means that one attaches a dynamic discrete component ('automaton'), which follows the trajectories of the original system and governs its dynamics at the points of ill-posedness of the initial value problem making it well-posed. The construction of the automaton is based on the classification of the attractors of the specially designed adjoint dynamical system. Several examples are provided in the presentation, which support the suggested analysis. The method can also be of interest in other applied fields, where differential equations contain switchings, e.g. in neural field models.

Keywords : hybrid dynamical systems, ill-posed problems, singular perturbation analysis, switching nonlinearities
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