Consistent Initialization of Sensitivity Matrices in Direct Shooting Methods for DAE Optimal Control Problems

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A direct shooting method for the numerical solution of optimal control problems governed by differential-algebraic equation (DAE) systems of higher index is investigated. The infinite dimensional optimal control problem is transformed into a finite dimensional optimization problem by discretization of the control on a suitably chosen grid and by application of a discretization scheme to the DAE system. The discretized optimal control problem is solved numerically by sequential quadratic programming (SQP) methods. These methods need information about the gradient of the objective and the Jacobian of the constraints. This information is provided by performing a parametric sensitivity analysis of the DAE system. For this purpose, sensitivity matrices as solutions of the corresponding sensitivity DAE system are computed. In this context, consistent initial values for the original DAE system as well as for the sensitivity DAE system are needed. Therefore, methods for the consistent initialization of higher index systems in the presence of free initial values of the optimal control problem are presented. Several illustrive examples are presented to show the capability of the proposed methods.