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ON THE NUMERICAL RESOLUTION OF THE DISCONTINUOUS MATERIAL BIFURCATION PROBLEM IN COMPUTATIONAL MATERIAL FAILURE MECHANICS

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Abstract. The work focuses on the numerical resolution of the discontinuous material bifurcation problem (DMVB) as a relevant ingredient in computational material failure mechanics. The problem consists of finding the conditions for the strain localization onset, in materials ruled by non linear hardening/softening constitutive models, in terms of the bifurcation properties of the so-called localization tensor; this providing the bifurcation time, the localization directions and the localization modes. Classically, the solution of that problem can only be found by analytical methods (for a much reduced number of constitutive models) or, in the most general case, by resorting to brute-force procedures based on sweep methods.

For the case of symmetric constitutive models (major symmetries of the tangent constitutive operator), and based on the conjugacy property of the Rayleigh's quotient of the localization tensor, the solution of the problem is associated to a coupled eigenvalue problem. Its solution consists of two unit vectors providing (in general, two) candidate solutions of the localization directions and the associated localization modes, at a typical time of the analysis, for the considered material point.

A numerical algorithm, based on the iterative resolution of that coupled eigenvalue problem in terms of the localization tensor, is proposed for such purpose

The algorithm is shown to be always convergent to the exact solution for the symmetric case (major and minor symmetries of the tangent constitutive operator). In the unsymmetric case (only minor symmetries), the solution is no longer exact, although it is shown that, using the symmetric part of the localization tensor in the proposed algorithm provides enough accurate solutions for most of cases (Oliver, Huespe et al. 2010).

The algorithm also provides the minimum (common) eigenvalue of the localization tensor along all possible localization directions. Thus, the first time that this eigenvalue becomes negative defines the bifurcation time.

Numerical examples illustrate the benefits of the proposed methodology in terms of accuracy and savings in the computational cost associated to the problem.The proposed algorithm provides exact, or very approximate, solutions of the DMBP at much reduced computational cost, thus emerging as a general procedure for its solution.