

Smoothness of eigenvalues and eigenvectors of a matrix depending on parameters

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The study of eigenvalues and corresponding eigenvectors is very important; these eigensolutions characterize the normal modes of vibration for structures modelled by finite element methods. Based on the derivatives of these modes, an engineer is able to optimize a structure's design. Repeated eigenvalues, or nearly equal eigenvalues can exist in structures due to structural symmetries, but can also occur as parameters change, for instance, as the length of a beam varies, the torsion and bending mode frequencies may cross. We shall discuss the smoothness of eigenvalues and eigenvectors with respect to structural parameters, with focus on the situation where two eigenvalues cross. Special attention will be given to the labelling, or ordering, of eigenvalues. An algorithm will be presented which "restores" smoothness by relabelling eigenvalues. Also, analytical formulas for computing the derivatives of the eigensolutions will be discussed.