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COLFDE: A differential-difference equation BVP Solver

We describe a fortran collocation boundary value problem solver in the COLSYS family of codes, for state-dependent delay and advanced-delay differential equation BVPs. Advanced-delay problems arise in a number of applications, including as the defining equations for travelling waves on a lattice. At first sight, since we solve all the equations in one go, advanced terms create no more difficulty in coding a BVP solver than do delayed terms, and the presence of both will just create off diagonal terms in the Jacobian matrix for the Newton iteration. However, advanced-delay equations are ill-posed as initial value problems, and the existence of solutions of BVPs is delicate, and so the discretization needs to be handled carefully. We will describe a number of issues that arise including the need for and implementation of implicit boundary functions, the breakdown of the sparsity structure in the numerical linear algebra, small Newton convergence balls, and problems associated with state-dependency of solutions. Computations of lattice differential equations, a Neuronal network and a Bando traffic model will illustrate the issues.