SPECTRALLY EQUIVALENT MATRIX POLYNOMIALS:
NON-STANDARD REPRESENTATIONS AND
PRESERVATION OF STRUCTURE

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Eigenvalue problems of the form $P(\lambda)x = 0$, where $P(\lambda)$ is a matrix polynomial, arise in many applications: structural analysis of buildings and machines, stability analysis of dynamical systems, and model reduction, to name a few. The classical approach to solving such a problem is to reduce it to an eigenproblem associated with a matrix polynomial that is *spectrally equivalent* to $P(\lambda)$, and of lower degree. In this thesis we propose two new approaches to constructing and systematically analyzing matrix polynomials that are spectrally equivalent to $P(\lambda)$, when $P(\lambda)$ is expressed in a non-standard basis. Three main reasons that motivated this research are: the increasing use of non-standard bases in practice, the desirable numerical properties of some of these bases, and the absence of any systematic treatment of such matrix polynomials. A common feature in both of our approaches is that they avoid reformulating P into the standard basis, which is important as a change of basis can be poorly conditioned. We use these two approaches to show how to construct large new families of matrix polynomials that are spectrally equivalent to polynomials expressed in Newton, Bernstein, and Lagrange bases.

A related problem investigated in this thesis concerns T-palindromic matrix polynomials; these polynomials arise in applications such as the modeling of rail traffic noise caused by high speed trains and discrete-time optimal control. We provide an in-depth theoretical analysis of quadratic T-palindromic matrix polynomials, and show that every even grade T-palindromic matrix polynomial can be reduced to a spectrally equivalent *quadratic* T-palindromic matrix polynomial.