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**Fast Structured Jacobi-Jacobi Transform**

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In this talk, we will consider the fast structured algorithm for the computation involving finite expansions in Jacobi polynomials. The algorithm is based on two main ingredients. (i) Derive explicit formulas for connection matrices of two Jacobi expansions with arbitrary indices, and demonstrate that the connection matrices are relatively sparse if the indices have integer differences. (ii) Explore analytically or numerically a low-rank property hidden in the connection matrices, and construct rank structured approximations for them. Combining these two ingredients, we develop a fast structured Jacobi-Jacobi transform with nearly linear complexity (after a one-time precomputation step) between coefficients of two Jacobi expansions with arbitrary indices. An important byproduct of the fast Jacobi-Jacobi transform is the fast Jacobi transform between the function values at a set of Chebyshev-Gauss type points and coefficients of the Jacobi expansion with arbitrary indices. Ample numerical results are presented to illustrate the computational efficiency and accuracy of our algorithm.