INdAM Workshop: Low-rank Structures and Numerical Methods in Matrix and Tensor Computations

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## A lifting approach to ParaTuck-2 tensor decompositions

Thursday, September 4, 2025 11:30 AM (30 minutes)

The ParaTuck-2 decomposition (PT2D) of is a two-layer generalization of the well-known canonical polyadic decomposition (CPD) of third-order tensors. It jointly factorizes a set of matrices  $T_k \in \mathbb{R}^{I \times J}$ ,  $k = 1, \ldots, K$ , as  $T_k = AD_G^{(k)}FD_H^{(k)}B^{\top}$ , with common factors  $F \in \mathbb{R}^{R \times S}$ ,  $A \in \mathbb{R}^{I \times S}$ ,  $B \in \mathbb{R}^{J \times S}$  and  $D_G^{(k)}$ ,  $D_H^{(k)}$  diagonal matrices that vary over k. The PT2D is motivated by several applications, including neural network compression and multivariate data analysis. Similarly to the CPD, the factors of the low-rank PT2D are identifiable (unique) under mild conditions. However, reliable numerical algorithms for the PT2D are lacking, unlike the case of the CPD.

In this talk , we show than under the best known uniqueness conditions [Harshman, Lundy, 1996], the exact PT2D can be computed by an algebraic algorithm (i.e., can the PT2D problems can be reduced to computing nullspaces and eigenvalues of certain matrices). We do so by lifting the slices of the tensor to higherdimensional space, which also allows for refining the existing uniqueness conditions. The algorithms are developed for general PT2D and its symmetric version (DEDICOM), which leads to an algebraic algorithm for another generalization of the CPD, the PARAFAC2 decomposition. Our methods are also applicable in the approximation scenario, as shown by the numerical experiments. Arxiv preprint: 2302.00922.

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