THE UNIVERSITY OF CHICAGO

Computational and Applied Mathematics & Statistics Student Seminar

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Symmetries in Computations

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ABSTRACT

Symmetry plays a fundamental role across the mathematical, physical, and computational sciences. This talk investigates two distinct aspects of how symmetry underlies numerical computation. First, to implement manifold optimization algorithms it is necessary to represent manifolds as matrices. By leveraging the representation theory of their symmetry groups, we obtain a classification of homogeneous spaces that admit such matrix embeddings, including various known examples. Furthermore, we prove the minimality of these embeddings and provide explicit formulas for their construction. Second, we examine matrix decompositions, such as EVD and SVD, which form the core of numerical linear algebra. Through the lens of Lie theory, we provide a classification of matrix decompositions into ten classes. This framework yields a variational characterization of these decompositions and naturally generalizes classical concepts and algorithms, including the Rayleigh quotient, Toda flow, and the Francis algorithm.