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Nearest correlation matrices with structure: a dynamical systems approach

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The nearest correlation matrix problem consists in finding the closest valid correlation matrix to a given symmetric matrix that may fail to be positive semi-definite. In other words, given a symmetric unit-diagonal matrix that is not a proper correlation matrix, one seeks the nearest positive semi-definite matrix with unit diagonal entries.

We address the problem of finding the nearest correlation matrix to a given symmetric unit-diagonal matrix under additional structural constraints such as sparsity, block, or band patterns. This task arises in applications where positive semi-definiteness must be restored without losing essential structure.

Our method combines a two-level iteration: a structured gradient flow computes feasible perturbations within the prescribed structure, while an outer Newton scheme adjusts their magnitude to meet accuracy requirements. To handle high-dimensional settings efficiently, we replace full eigenvalue decompositions with a Rayleigh quotient approximation, focusing only on the critical invariant subspace needed to restore positive semidefiniteness.

The resulting algorithm systematically incorporates structural constraints into the nearest correlation matrix problem. Numerical experiments highlight its robustness across diverse structured scenarios, with promising applications in finance, statistics, and network analysis.

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