Correlation Tensor Decomposition and Its Application in Spatial Imaging Data

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Abstract: Most of existing statistical models in imaging analysis only focus on the first moment information of imaging pixels, while the important pixel-wise correlation structure is usually ignored. In this paper, motivated by the multimodal optical imaging data in a breast cancer study, we propose a new tensor learning approach to analyze spatial-correlated imaging data. Specifically, we construct a higher-order correlation tensor which effectively preserves the spatial information and captures the pixel-wise correlation structure. In addition, we propose a new semi-symmetric tensor decomposition method to model spatial correlations, which enables us to identify spatial structures associated with disease, and thus improves the diagnostic power. We also establish the theoretical properties for recovering the true spatial correlation structure, and develop scalable computational algorithm. We illustrate the performance of the proposed method in both simulation studies and the application to multi-photon breast cancer imaging data. The numerical results indicate that the proposed method outperforms other competing methods including the Convolutional Neural Network (CNN), especially when the sample size of imaging data is limited.