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Bagging the Peaks: Matrix and Tensor Factorization with Unimodal Constraints

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Abstract: We consider matrix and tensor factorization problems where there are both unimodal and rank constraints. Such methods find application in a variety of problems such as target localization, environmental monitoring, epidemic detection, and medical diagnosis. We presume that we have incomplete (sparse) and noisy samples of a particular field or image and that our objects of interest have spatial extent and can be modeled as low rank and unimodal: there is a single strong signal peak and this signal decays as one moves away from the strong signal peak. By exploiting modern signal processing techniques such as matrix completion and active search methods, we develop a high performance, moderate complexity algorithm for peak detection. This method is extended to the case of multiple targets via novel matrix factorization and isotonic projection methods. We further extend the approach to handle multimodal sensor data by exploiting tensor completion methods. Finally, we show how we can exploit our methods to solve a data clustering problem which is motivated by the application of radio map building. Radio signals in urban environments can be described by multiple propagation models. We can transform and compress location-labeled wireless channel measurements into a low-dimensional feature matrix. By analyzing the local peaks of the feature matrix, we can identify the regional propagation laws, which enable the clustering of the data. Theoretical performance bounds derived and properties of key matrices are proven. The methods are compared against the state of the art on both synthetic and real data sets and shown to offer superior performance with moderate complexity.