Sensor Network Localization, Euclidean Distance Matrix Completions, and Graph Realization

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Abstract

The sensor network localization, ***SNL*** , problem consists of locating the positions of ad hoc wireless sensors, given only the distances between sensors that are within radio range and the positions of a subset of the sensors (called anchors). One main point is to view ***SNL*** as a (nearest) Euclidean Distance Matrix, ***EDM*** , completion problem that does not distinguish between the anchors and the sensors. We show that there are advantages for using the well-studied ***EDM*** model. This problem can be relaxed to a weighted, nearest, (positive) semidefinite programming, ***SDP*** , completion problem. This relaxation is ill-conditioned in two ways. First, it is, implicitly, highly degenerate in the sense that the feasble set is restricted to a low dimensional face of the ***SDP*** cone. This means that the Slater constraint qualification fails. Second, nonuniqueness of the optimal solution results in large sensitivity to small perturbations in the data.

The degeneracy in the ***SDP*** arises from cliques in the graph of the ***SNL*** problem. In this paper, we take advantage of the absence of the Slater constraint qualification and derive a preprocessing technique that solves the ***SNL*** problem, with exact data, by explicitly solving the corresponding ***SDP*** problem. We do this by finding explicit representations of the faces of the ***SDP*** cone corresponding to intersections of cliques of the ***SNL*** problem.