Referee reports on "Theory of semidefinite programming for sensor network localization" by A. M-C So and Y. Ye

February 6, 2005

Dear Yinyu,
Following are three referee reports. They are all positive and suggest minor changes in the paper. Therefore, we are happy to accept this paper.
I still expect one more report. However, I thought that it would help speed up the process if you had access to these three reports now.

Contents

1 Referee Report I

Referee's report on
"Theory of semidefinite programming for sensor network localization"
by
A. M-C So and Y. Ye

This paper presents a semidefinite programming model for sensor network localizations. This problem can be thought of as a special case of the graph realization problem where the coordinates of a subset of the nodes are known. The paper also discusses some related problems in distance geometry.
The sensor network localization problem is an important problem which has received a great deal of attention recently. The semidefinite approach to this problem is quite elegant and promising. The results obtained in this paper are new and interesting. The paper is well written and easy to read. Furthermore, the references are comprehensive.
Thus we recommend that this paper be accepted for publication. We would like to add one comment. The SDP problems in (3) and (4) seem complicated due to the notation used. We believe that these two problems might be simplified by using more appropriate notation.
Finally there is a typo on page 4. Replace well-known by well known in the line before (2).

2 Referee Report II

This paper is concerned with the "sensor network localization problem". Given a set of objects in $\Re^d$, some at known locations, and knowledge about some of the pairwise distances between objects, can we determine the location of all the objects? This is a variant of a problem that has been well studied by several communities. This particular variant is distinguished by the presence of some objects with known locations. Note that the data in a problem instance can be thought of as a graph.
The principle contribution of this paper is the identification of a class of graphs for which a semi-definite programming algorithm is guaranteed to find the unique solution. The graph class is interesting - it is graphs that have a solution in 2D, but no different solutions in higher dimensions. Although not remarked in the paper, I don't think this property is purely graph theoretic, but also depends upon the set of distances (or alternatively, on the locations of vertices in the solution). Perhaps there is some convexity property in the placement of vertices and anchors. It would be nice to have a graph and geometric understanding of strong localizability.
The authors draw connections to the rigidity literature, and to the results on unique realizability in particular. Although these prior results are closely related to the current paper, to my knowledge the current results are new. And I find them interesting and intriguing. I can't help but wonder if there are connections to Connelly's work on tensegrity frameworks ...
Although the paper is generally well written, I have a few suggestions for improving the presentation. Most are not substantive.

1. Page 2, Line 13: "there has been" should be "there have been".

2. P 2, L -16 (also P 7, L -6): "close to be" should be "close to being".

3. P 2, L -16 (also P 7, L -6): It's not clear to me why you can argue that your result is nearly the best possible. There could be a larger class of graphs that are solvable. The fact that the general problem is hard doesn't ensure that a particular solvable class is nearly the best possible.

4. P 8, L 16: "are couple ways" should be "are several ways".

5. Section 5: You mention early in this section that you assume the embeddings are generic. But this is an important assumption and should probably be included in some of the theorem statements.
6. P 10, L -5: ”an useful” should be ”a useful”.
7. Definition 5: Is it possible to reinterpret this condition in a manner that doesn’t depend on SDP duality?
8. P 12, L 4 and L 5: What is ”w.”?
9. P 13, L 8: I think you mean to reflect the subgraph induced by a_1, x_2 and a_3 (not a_2).

3 Referee Report III

In this paper the authors analyze the Sensor Network Localization problem, and study a SDP method for its solution. By using SDP duality they show that this method localizes in polynomial time any network that has unique sensor position to fit given distance measures. Moreover, they study the connections with rigidity theory, and give a simple condition for checking whether a graph G with anchors has a unique realization on the plane. Finally, they introduce the notion of strong realizability and show that the method identifies all strongly localizable sub-networks. The paper is interesting and well written and the results are sound.