CSE595 Spring 2009 Algorithms for Sensor Networks

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Due **March 10th** before class. Each problem, unless specified otherwise, has a maximum of 10 points. (i) You write down the solution clearly. If we can not recognize your writing then you may lose points. (ii) Avoid too many details. A succinct and clean proof is the best. You may use the algorithms we covered in class without referring to the details. (iii) No collaboration with fellow students is allowed. (iv) you may consult books or papers, but you must write down the solution on your own and cite the references.

Homework 1

1. **Least square estimation.** Assume an over-constrained linear system $Ax = b$, where A is a $m \times n$ matrix $\{a_{ij}\}$, x is a vector of n unknown variables $(x_1, x_2, \cdots, x_n)^T$, b is a vector of length m, $b = (b_1, b_2, \cdots, b_m)^T$. $m \geq n$. Show that the solution $x = (A^T A)^{-1} A^T b$ minimizes the least square error:
$$||b - Ax||^2 = \sum_{j=1}^{m} (b_j - \sum_{i=1}^{n} a_{ij} x_i)^2.$$

2. **Graph rigidity.**
   (a) In network localization, suppose that k nodes out of a total number of n nodes are anchor nodes. There are m edges in the graph. What is the minimum value for m such that there is no degree of freedom in the system?
   (b) For localization of sensor nodes in 3D, one may use *quadri-lateration* methods. That is, each node that measures distances to three or more anchor nodes can solve the unique location. Solve the same problem in (a).

3. **Geographical routing.** We covered in class geographical routing used for static sensor network. Describe for GPSR how to handle node movement, node insertion and deletion. Assume that the communication graph is a unit disk graph, the speed of communication is much faster than the speed of node movement. In particular, you need to
   (a) Discuss how one might maintain a planar graph (such as a Gabriel graph), in the case of changes.
   (b) Describe how message forwarding might be carried out.
   (c) (10 extra points) What properties does your algorithm guarantee?

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4. **Greedy routing.** Show that if the angles between adjacent edges of any vertex in a graph embedded in the plane are no greater than $2\pi/3$, greedy forwarding always works to find a path to the destination.