Sensory Networks Localisation Problem

Sensory Networks are being widely installed in the enviroment for purposes like target tracking, enviromental monitoring, healthcare monitoring. The information received from these sensors would be beneficial if we can accurately pin-point the relay location. For example, the central system might alert fire-accident from a sensor, not knowing its location would be unacceptable.

Sensory Networks Localisation Problem(SNLP) is about finding accurately the postion of the sensory devices installed over a d-dimensional space. For example if d=2, the space would be planar and we are to find out all (x,y) representing the location of the sensors.

One possible solution would be attach a GPS device to each of the sensory node. This will make the cost of the entire system go up (each GPS device costs about $100). Even if we use GPS devices it wouldnt be of any use in case of indoor sensory networks because the sensors would be in close range and the GPSpostions of sensors might overlap.

The next solution is to evaluate the positions based on the known sensor locations. The sensors whose location is known are called anchors and others non-anchors. Redifining the problem, we are to find out the accurate positions of non-anchors using the anchor positions.

To aid with the calculations we can use Time of Arrival (TOA), Time Difference of Arrival (TDOA), Received Signal Strength (RSS) and/or Angle of Arrival.

The first technique is Multi-Dimensional Scaling. Upon receiving the data from various sensors nodes the MDS system will plot it over a plane and represent it visually. MDS assumes that the data being recived is of known dimension. This isnt true always for example, Received Signals could be of un-known dimensions. The accuracy is compromised in this case.

Contemplating over the problem and applying the black box thinking strategy we can ask a question "We have a set of anchor points (known locations) and information regarding RSS or AoA or TOA can it be that these anchor points follow a pattern? Can we use inter-polation technique on the data at hand to get a function which can be used to get the postions of the non-anchor nodes?" Kernel Based Machine Learning is the technique which solves this problem in two stages. In stage one we design a classfier i.e train a suitable kernel function based upon the kernel alignment criterion and in stage two we develop a mapping function between the data and the physical location(real world positions).

Semi-Supervised Laplacian Regularised Least Squares(S2LapRLS) is an algorithm based on the kernel-based machine learning. It can use either Signal Strength or Pairwise distances between nodes as the data space(this forms the Gram Matrix). Received Signal Strength between nodes i,j is Sij =1 if i=j else x where 0<x<1. If the nodes are not within the communication range then Sij=0. We can also use pairwise distance Dij=Euclidean Distance , Dij=infinity if the nodes are not within the communication range.

We solve an optmization problem and find out the best kernel function, it can be solved in qudratic time without affecting the system's performance. Then we get a Laplacian Matrix and use it to get the coefficient matrix which is used to find the positions of the points.

The advantages of this alogorithm are that it is not affected even if the dimensions of the data space are unknown, and can optimally solve as compared to SDP.

References:

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