

Distance geometry problems

Stage Master 2, 2018–2019

Thème: Programmation par contraintes, Analyse intervalle, Géométrie, Optimisation, Génération de code.

Laboratoire: U2IS, ENSTA ParisTech

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Durée: 6 mois

Rémunération: suivant la législation en vigueur (environ 550 euros).

Context. Some systems are sometimes defined only by distances, such as in chemistry, localization, sensor network, robotics.

Distance geometry problems are difficult to solve. From a complexity viewpoint, obtaining an approximate solution to a distance geometry is NP-hard. From an optimization viewpoint, distance geometry problems have many local minimizers which introduce doubts.

Some tools like DGSol (a software package for solving large distance geometry problems in macromolecular modeling proposed by Mor and Wu) solves distance geometry problems with a global continuation algorithm, with Gaussian smoothing of a merit function that only depends on the sparse distance data.

In particular, distance geometry problems are interesting mathematical problems with important applications in robotics for solving localization problems, UAV swarm organization, etc. If the distances given by sensors are always uncertain, in these special cases, the measures can be obtained with delay (conditioned by dynamics of UAVs and communication) or even completely wrong (due to outliers introduced by sensor fault). More than a distance solver able to manage with uncertainties, some more complicated issues can thus be addressed.

Objectives. We propose an internship in order to develop a more robust distance solver algorithm using the Interval Analysis in order to bound and certify the results. The Cayley-Menger distance matrix could be a good approach to fix the problem of lack of constraints. The relaxed intersection (or q-intersection) can also be used to counteract the effect of outliers. Finally, an introduction of dynamics of UAVs can be considered to minimize the effect of delay in distance getting.

The schedule can be:

- Make a state of the art;
- Develop a constraint generator;
- Define some contractors and optimizers to solve the distance problem;
- Improve the approach toward a robust tool against delay and outliers.

Candidate. The candidates should have solid basis in mathematics (numerical computation), in C++ programming and with motivation and autonomy skills. Submit your application by e-mail with:

- a cover letter;
- a curriculum vitæ;
- copies of diplomas and marks.

Bibliographie

- Jorge Moré and Zhijun Wu, "Global continuation for distance geometry problems", SIAM J. Optim. 7, no. 3 (August 1997), pp. 814-836.
- Dominique Michelucci and Sebti Foufou, "Using Cayley-Menger determinants for geometric constraint solving", 2004
- J. Porta, L. Ros, F. Thomas, "A Branch-and-Prune solver for distance constraints", Transactions on robotics, 2005
- Lavor, Carlile and Liberti, Leo and Mucherino, Antonio, "The interval Branch-and-Prune algorithm for the discretizable molecular distance geometry problem with inexact distances", Journal of Global Optimization, 2013
- Jaulin, L., "Robust set membership state estimation ; Application to Underwater Robotics", Automatica 45, 2009.