Title:

Imprecise (uncertain) Data: Modeling, Handling, applications and Algorithms

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Scientific Summary:

Many applications of computational geometry come from real world problems such as planning and robotics, mechanical designing, facility location and geographic information systems. Due to limit precision of observing and measuring devices, it is inevitable that the input data in such real applications is free from error, and we face with uncertain and imprecision data. So, despite the advantages and the power of computational geometry, there exists a weak point in the algorithms designed in this field which lies in the fact that the algorithmic solutions proposed for such problems are based on the unrealistic assumption that the input data and computations involved are precise [1, 2]. Therefore, these algorithms fail to work in presence of real world imprecision, which is inevitable in observing, measuring, modeling or computing errors. To overcome this problem and handle imprecision, several models have been proposed [3, 4]. Region-based models are of the most well-known ones. Generally, these models assume a predefined region as all possible locations of an imprecise point. Problems in presence of imprecision may seem different from their classical versions in computational geometry. For example, the problem of finding the axis-aligned bounding box of a set of precise points has a unique answer and it can be obtained simply in linear time, while there are several definitions of this problem where the points are imprecise, such as the largest/smallest area/perimeter axis-aligned bounding box [3].

The general goals of this project are as follows:

- How to model imprecision or uncertainty. Focusing on general-purpose or specific-purpose, efficient modeling (low complexity and easy to implement).
- Design algorithms for applications planning and robotics, mechanical designing, facility location and geographic information systems with imprecise input data.

Note that, in addition to geometry approach for modeling the imprecision and uncertainty, other approaches such as Fuzzy set theory [5], rough set theory [6] and neutrosophic set theory [7] are considered as well.

Keywords:

Imprecise Data; Uncertainty; Designing Robust and stable Algorithms; Modeling and handling imprecision.

Instruction: This project can be done as a team work.

NOTE THAT, there is no particular problem or theses' topic in this project, and we will define them exactly after some work and studying the papers and thesis in imprecision context. But **just** for clarifying some of such particular problems, I listed some of them in the following (However they are general):

1. Finding the worst and the best case of shortest path amidst a set of imprecise obstacles.
   Assume you are given a work space without knowing the exact position of the obstacles' vertices. How can we define and find the shortest path from a pair of given start and goal configuration?
2. Introducing and Computing metrics (such as Hausdorff and Frechet distance) for imprecise input.
3. Finding the complexity and algorithm for geometry objects with imprecise data.
   If you are given *n* regions as the *n* imprecision point, what are the complexity and/or algorithm for finding the convex hull, Voronoi diagram, Proximity problems, Covering problems and so on.
4. Facility Location- Applications:
   We are given *n* imprecise demand points. What is the minimum covering circle?
   Note that in this type of problem we can focus in both terms of imprecisions: imprecise position for demand set or imprecise demand weights. Also, there is an excellent potential for joining fuzzy idea and region-based models in facility location problems. To this end, we can use fuzzy definition for metrics or fuzzy definition for the position or demand weight of point.
5. Investigating the stability and robustness of geometric algorithms under the imprecision [8].
   There are many algorithms which is solving for a particular problem but they are not stable under the imprecision. So, a topic is investigating such algorithms in terms of robustness and/or stability and finally proposing more robust and/or stable algorithms.
6. Studying the problem of range searching concentrating on its applications in uncertain data base.
   Consider a large data base containing vague or uncertain record information (e.g. the exact salary or number of hours of employee does not available). So, how can we response to a query while query can also be exact or uncertain?

And now take a look to your around and remember your environmental information such as position, color, volume or any property of objects. Can you tell me how you can store this uncertain, vague and imprecise information (just mathematical modeling) and how you can restore them (just algorithm)?

References

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