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Randomness and Hardness in Geometric Computing Problems

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Abstract

In this dissertation, geometric optimization problems ensuring a kind of randomness (such as uniformity, irregularity, or random generation) as its objective and designing practical strategies are widely studied. We mainly consider how to define a good uniformity in geometric dispersion to be as irregularly as possible, how to generate efficiently geometric structures (e.g., simple polygons, plane triangulations, etc.) at random, and how difficult to achieve randomness underlying uniformity criterion. For each question, the occasion of investigations has been derived from both of theoretical and engineering aspects.

With wide-ranging advances in discrete and computational geometry, geometric computing, especially, which manipulates spatial data being structured combinatorially and/or geometrically, has become a pervasive and increasingly critical aspect in every corner of science and engineering. A lot of applications have been requiring practical algorithms for geometric optimization problems. When we deal with geometric optimization problems which are NP-hard, we often prefer to efficiently pick a good solution instead of the optimal from a solution space spread by relaxing the objective function. It is important to present a better relaxation to provid an appropriate solution space, rather to analyze an approximative solution space to show that any cost of the relaxed objective function is not so inferior, no matter what we pick up any from the space.

There exist various approximated and randomized paradigms in a comprehensive manner, such as concepts of random sampling. However, sampling based approaches may not be applied to practical applications directly, since eventual approaches require impractical large sampling set. Therefore, we have to reconsider geometric configurations more carefully, so that we can present useful and helpful frameworks, getting insight into essential difficulties. In fact, we think it is worth noting that we investigate for good relaxation criteria and techniques for randomly generating geometric structures, in order to sophisticate sampling techniques. In addition, analytical study for the existence of equilibrium/disequilibrium configuration on spatial competitions is also important. Considering a game model for competitive facility location, we show a case that each player will be competing to locate his/her facilities at equilibrium positions, when there exists a winning strategy.