Preface

"Maturity of mind is the capacity to endure uncertainty."
— John Finley (1935 – 2006)

"Information is the resolution of uncertainty."
— Claude Elwood Shannon (1916 – 2001)

Uncertain data is inherent in many important applications, such as environmental surveillance, market analysis, and quantitative economics research. Due to the importance of those applications and rapidly increasing amounts of uncertain data collected and accumulated, analyzing large collections of uncertain data has become an important task. Ranking queries (also known as top-k queries) are often natural and useful in analyzing uncertain data.

In this monograph, we study the problem of ranking queries on uncertain data. Specifically, we extend the basic uncertain data model in three directions, including uncertain data streams, probabilistic linkages, and probabilistic graphs, to meet various application needs. Moreover, we develop a series of novel ranking queries on uncertain data at different granularity levels, including selecting the most typical instances within an uncertain object, ranking instances and objects among a set of uncertain objects, and ranking the aggregate sets of uncertain objects.

To tackle the challenges on efficiency and scalability, we develop efficient and scalable query evaluation algorithms for the proposed ranking queries. First, we integrate statistical principles and scalable computational techniques to compute exact query results. Second, we develop efficient randomized algorithms to approximate the answers to ranking queries. Third, we propose efficient approximation methods based on the distribution characteristics of query results. A comprehensive empirical study using real and synthetic data sets verifies the effectiveness of the proposed ranking queries and the efficiency of our query evaluation methods.

This monograph can be a reference for academic researchers, graduate students, scientists, and engineers interested in techniques of uncertain data management and analysis, as well as ranking queries. Although the monograph focuses on ranking queries on uncertain data, it does introduce some general principles and models of

uncertain data management. Thus, the monograph can also serve as introductory reading approaching the general field of uncertain data management.

Uncertain data processing, management, and exploration in general remain an interesting and fast developing topic in the field of database systems and data analytics. Moreover, ranking queries on uncertain data as a specific topic keeps seeing new progress in both research and engineering development. We believe uncertain data management in general and ranking queries on uncertain data in specific are exciting directions, and still have a huge space for further research. This monograph can inspire some exciting opportunities.

This monograph records the major outcomes of Ming Hua's Ph.D. research at School of Computing Science, Simon Fraser University. This research was an interesting and rewarding journey. We started with several interesting problems concerning effective and efficient queries of massive data, where uncertainty, probability, and typicality play critical roles. It turned out that ranking queries provide a simple and nice way to bind those projects and ideas together. Moreover, we considered various application scenarios, including online analytic style exploration, continuously monitoring of streaming data, data integration, and road network analysis. Only after almost three years we realized that the whole bunch of work can be linked together and weave a nice picture under the theme of ranking queries on uncertain data, as presented in this monograph.

A Ph.D. thesis is never easy. Ming Hua's Ph.D. study is exciting and, at the same time, challenging, for both herself and Jian Pei, the senior supervisor (that is, the thesis advisor). We both remember the sleepless nights before the submission deadlines, the frustration when our submissions were rejected, the suffering moments before some new ideas came to our mind, and the excitement when we obtained breakthroughs afterall. This experience has been casted deeply in our memory forever. We are so lucky to be able to work as a team in those four years.

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