**Determining the New Product Option Maximizes Cover Ratio**

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ABSTRACT

Decision making problem is popular among these days. In rank aware processing, a user will choose the option that ranks tops for himself. Concretely, preferences of users are usually represented as weight vectors. Each attribute of weight vector means how important is that attribute to that user. The score of an option respecting to a user is the dot product between the user’s preference weight vector and the option. Only the options with top-k scores can attract the user. An option covers a user if and only if it can rank top-k for that user. Usually, a company has many products (options), each of which covers some of the users. A user covered by a company means at least one of its products covers this user. The company has to develop new product that satisfies a constrain and make its all products including this new product cover as more users as possible. In this problem we study how to determining which newly added option can maximize the cover ratio of the company. This problem is essential in developing new product, market decision, advertising, etc. We refer this problem as k-Cover Ratio Maximization (). In this paper, we begin from top-k problem’s computational geometric nature using tree to represented optio n spaces, and then from the relationship among constrain, options and user preference weight vectors to more efficiently solve this problem.

CCS CONCEPTS

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KEYWORDS

Cover ratio, Introduce new option, Top-k query

**1**  INTRODUCTION

Take smartphone market as an example, there are different models of smartphones（）. Each model （）has different prices, pixels, battery capacities, cooling capacities and etc. Now a company owns models () and a user data set . Different users prefer in different aspects, for example some of them may prefer smartphone that with large battery capacity but some prefer better quality of scree

n, so each presents the preference weight vector corresponding to a single user. The score of a model respecting to a user is the dot product . Usually a user will only make a choice from his own view of top-k, so a product ranks top- for the users is quite important. A product covers a user only when the score of it ranks top among all existing products (). With developing of company and market, company has to develop a new product to cover more user and make more profit. But with the limitation of technology, money and other factors, one can’t develop a perfect product to cover all users. It can only develop a product that covers as more user as possible under a constrain. For a company, some of its products have covered some users, so what it wants to do is how to make this new product cover more users that uncovered before.

In real life, k-Cover Ratio Maximization () can solve the problems that how to decide the next generation product for companies. In advertising industry, it can help merchants how to cover specific group such as students, pregnant women and children. Besides it can tell advertiser where to set up new advertising board and if do so it can cover which group of people. Data analysts can use it to discover which group of people is ignored by the market.

Generally speaking, it is not a product covers a user but a group of products covers a user. And for different users, there are different groups of products. Among these groups of products, there are uncertain number of identity products. In our problem, we are aim to find this new product in continuous product space, which means there are infinite candidate products, so it is difficult to tell which product covers the most users.

In this paper, we will from computational geometric nature of to explain how to find the exact optimal options (products) with the data structure mentioned in [1]. Besides, from some observations of this problem, we propose advance method that ignore irrelevant users and candidate products to save time. At last we sample products that satisfy the constrain and use their maximal cover count to prune the .

**2**  PROBLEM DEFINITION

**Definition 1.** A product’ s score respecting to a user is the dot product.

Without loss of generality, satisfies , satisfies and

**Definition 2.** A product covers a user when the score respecting to ranks top among .

**Problem 1.** The k-Cover Ratio Maximization takes product dataset , , user dataset and a positive integer k as inputs. It introduces how to determine a new product such that satisfies the constrain and maximizes the cover ratio of :

**3**  GEOMETRIC COMPUTATION NATURE

**3.1** Cover One User

Because the dataset is with limited number of products, for a user , it is easy to calculate its top-k score. Suppose is the score that ranks top-k for w, then if a new product p wants to rank top-k for this user, in other words, covers this user, p should follow . If we draw it when dimensionality d=2, it would be shown as Figure 1.

//TODO Figure 1

From Figure 1, we can see that divides the candidate product space into 2 half-space, one is marked as “+”, which represents ; the other is marked as “-”, which represents . If and only if the product in the region “+” can cover w.

**3.2**  From One User to Many Users

For the sake of simplicity, we use () to represent the space

; () to represent the space ; ()

to represent the space .

As shown in Figure 2(a), when it comes to multi users, such as 2 users {}, firstly divides product space into 2 half-space and ; then divides into and , divides into and .

Region covers , ; Region could only cover ; Region could only cover ; Region couldn’t cover any user.

//TODO Figure 2

**3.3**  Cell Tree Representation

The tree in Figure 2(b) is called , which firstly proposed by [1]. As shown in Figure 2(b), we use the root node represent the whole candidate space. After the insertion of , the root node (cell) generates 2 child cells and while the space is divided into 2 part; and represent and respectively. After the insertion of , the cell generates 2 child cells and ; the cell generates 2 child cells and . From root cell to cell , we can clearly see that is , which means covers and . Similarly, is , which means covers . Among all the cells, covers the largest number of users. If we change the root cell as and remove all those users that already covered by then we can use to solve .

**3.4**  Baseline solution

In the below paragraph, we will introduce our baseline approach to get the optimal solution for , which follows these steps:

1. Calculate the top k score for each
2. Find all the that covers, marked their set as

Below are steps to place alt-txt value in **MS Word 2013/2016**. To add alternative text to a picture in Word 2013/2016, follow these steps:

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