

Who to query?

A two step querying technique for tracking real-time variant/unknown event distributions

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ABSTRACT

Some abstract sentences...

1. INTRODUCTION

Some introductory sentences...

2. RELATED WORK

- Spatial task distribution (maximizing task assignment)
- Applications: emergency scenarios, safety applications, etc.
- crowd sourcing and crowd sensing

3. RESEARCH QUESTION AND PROPOSED TECHNIQUE

In this paper, we envision a world where users can be probed to contribute to an unanswered question. An unanswered question can be related to a phenomenon that needs to be tracked under constraints of N resources. Examples include disastrous and safety applications. In particular, we have a two-dimensional grid and a number of objects that can sense the environment around them. These objects can be humans, artificial sensors, mobile phones or even robotic sensors. If we are interested in answering the question "How are things going in this grid?", we can basically ask or query all the objects in the two-dimensional space and aggregate their findings. In this paper, we assume that to answer this question, you can only query N objects. Hence, the question becomes: *Given N resources, who should you select to track a real-time phenomenon?* . Answering this question becomes essential in the case of a limited bandwidth of resources. This is particularly important in emergency scenarios when a network's performance degrades and preserving energy and other resources become important.

If we attempt to tackle this question from a probabilistic point of view, then the straightforward answer would be to try to select objects/users with the same probabilistic distribution as the phenomenon. For instance, if we know that

a certain phenomenon occurs at different places in the two-dimensional grid uniformly, then we would have no bias in selecting the users to query i.e. each user/object would have the same distribution of being selected to be queried. On the other hand, if we know the phenomenon we are interested in querying is more prevalent in certain areas of the grid as opposed to other areas, we would take that into consideration when we are selecting the users and select more users to query in this area and fewer users in other areas where there is a smaller probability of occurrence.

But what if you do not know the distribution or what if the distribution of the phenomenon is time variant? The aforementioned question becomes more interesting in this case and we can then inquire if there is a systematic algorithm that can be used for querying/selecting users to track a phenomenon regardless of the probabilistic distribution or time variations.

In this paper, we introduce a two-stage technique that can be used to select N users to track a real-time phenomenon with no prior information about the event distribution. The technique outperforms the random user selection by a percentage of 20 – 63% on average in terms of number of users chosen that were close in the events and outperforms the dispersion maximization technique by a percentage of 20 – 68% on average.

3.1 Technique Description

We assume that we have M users in our two-dimensional grid and that the system that selects a user to query is bounded by N resources where $N < M$. Each of the M users has a specific location in the grid determined by a two-dimensional system e.g. (x, y) or a $(lat, long)$. We also assume that the users selected will participate in answering the question of interest to the system and fully co-operate. A pre-selection phase can be used to eliminate users that aren't likely to co-operate or users who can provide false information using a system of building trust over time. The ways to rule out users based on trust or refusal to co-operate is not the main focus of this paper. Instead, we focus on how to select N out of M users to where $N < M$ to keep track of events occurring in the two-dimensional grid.

Our technique combines K nearest neighbor (KNN) queries with querying users to maximize the dispersion of their location in the grid as depicted in Algorithm 1. We devise the

selection of users into two stages. In the first stage, our goal is selecting users with the aim of maximizing the dispersion of their locations. Based on the crowd feedback in the first stage, we go into a more fine grained selection. The users that provides a positive feedback (i.e. they witness an event/emergency in their location) are called the pivot users. In the second stage, we aim to get the K nearest neighbors for the pivot users. We assume that because the pivot users witness an event, the K nearest neighbors will witness another event of the same type in a neighboring area.

The aforementioned technique assumes full trust in the first stage users to respond and provide unfalsified responses. To remedy that, we can explore dividing the selection of the second phase users into two groups: a group comprising of the KNN of the pivot users and another group that aims to maximize the dispersion. In this section, we will focus on studying our two-stage querying technique with the assumption of having full trust in the crowd and discuss the remedy in subsequent sections.

Algorithm 1 Two-stage querying algorithm

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1: procedure USERS_SELECTUSERSFROMGRID (FIRST-STAGERATIO, N)
2:   selectedUsers = {}
3:   firstStageUsers = maximizeDisp( $\lfloor (firstStageRatio * N) \rfloor$ )
4:   usersFeedback = feedback(firstStageUsers)
5:   if (usersFeedback.size == 0)
6:     selectedUsers = maximizeDisp( $M - \lfloor (firstStagePercentage * N) \rfloor$ )
7:   else
8:     selectedUsers.append(firstStageUsers)
9:     secondStageUsersCount =  $M - \lfloor (firstStageRatio * N) \rfloor$ 
10:    Attempt ( $k = \text{secondStageUsersCount} / \text{firstStageUsers}$ )
11:    else calculateQuota(firstStageUsers)
12:    selectedUsers.append(KNN(firstStageUsers,  $k$ ))
13:    return selectedUsers
14: end procedure

```

[1]

4. EXPERIMENTS

In order to quantify the performance of our technique, we test it under different scenarios. We investigate the technique using three types of data spread: clustered, uniform and real datasets. In our experiments, we compare our algorithm in the selection of users to two policies as follows.

- Random user selection: For this policy, we select N users randomly based on a uniform distribution.
- Selection based on dispersion maximization: The selection of users in this policy depends on selecting N users from the crowd who maximize the dispersion of their locations.

4.1 Experiments Variables

There are multiple variables that can be controlled to test the behavior of the two-stage querying technique. Table 1 explains the most important variables.

col1	col2	col3
cell 4	cell5	cell6
cell 7	cell8	cell9

Table 1: Table to test captions and labels

4.2 Clustered data experminets

In this subsection, we aim to test our technique in a scenario where the events take a clustered form. Geographer Waldo R. Tobler's stated in the first law of geography: "Everything is related to everything else, but near things are more related than distant things." In this subsection, we assume that the incidents are related to each other and that they take a clustered form i.e. they form clusters across the 2D spatial matrix as seen in Fig 1.

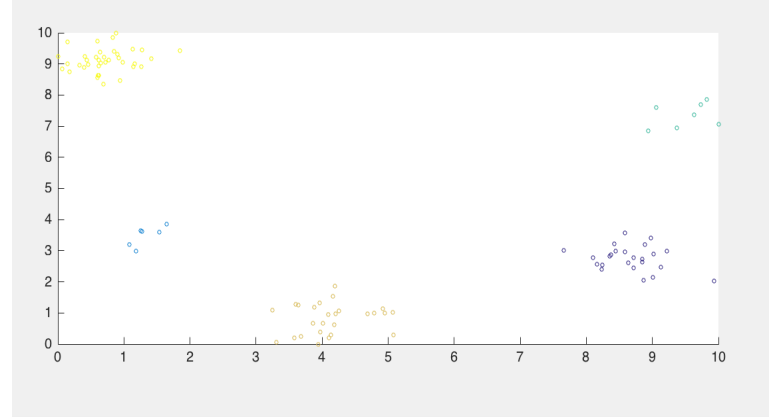


Figure 1: An example of a 2D spatial matrix with 5 clusters

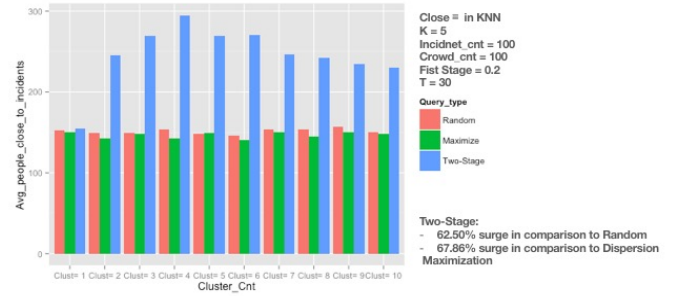


Figure 2: Average number of people close to the incidents when maximizing the dispersion with 20% of available resources.

4.3 Uniformly distributed data experminets

4.4 Case Study: Hollaback harassment data set

4.4.1 Data Overview

4.4.2 Analysis

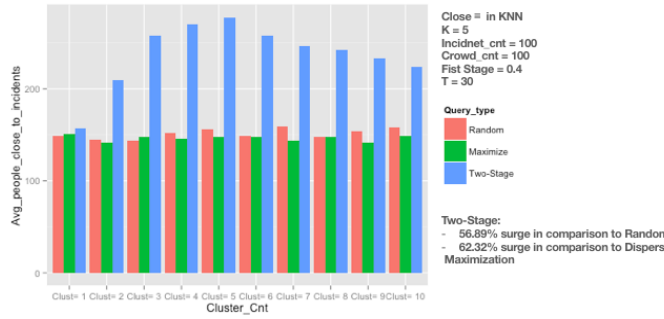


Figure 3: Average number of people close to the incidents when maximizing the dispersion with 40% of available resources.

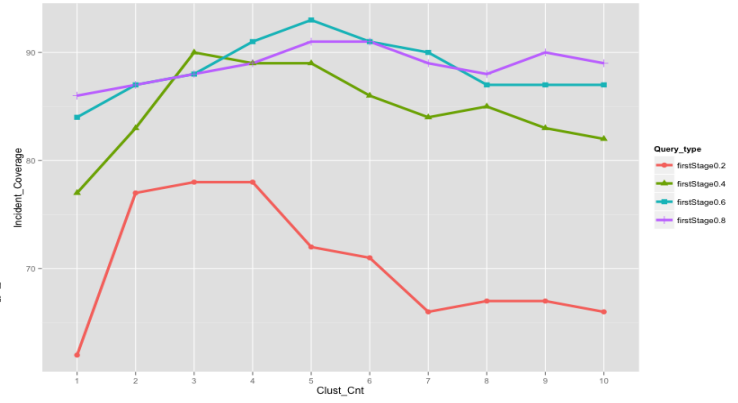


Figure 6: Number of incidents covered by variations of the two-stage querying technique.

5. DISCUSSION

- Our assumptions and limitations...

6. CONCLUSIONS

In this paper, we introduced...

7. ACKNOWLEDGMENTS

8. REFERENCES

- [1] D. Van Dyck, G. Cardon, B. Deforche, and I. De Bourdeaudhuij. Do adults like living in high-walkable neighborhoods? Associations of walkability parameters with neighborhood satisfaction and possible mediators. *Health & Place*, 17(4):971–977, 2011.



Figure 4: Average number of people close to the incidents when maximizing the dispersion with 60% of available resources.

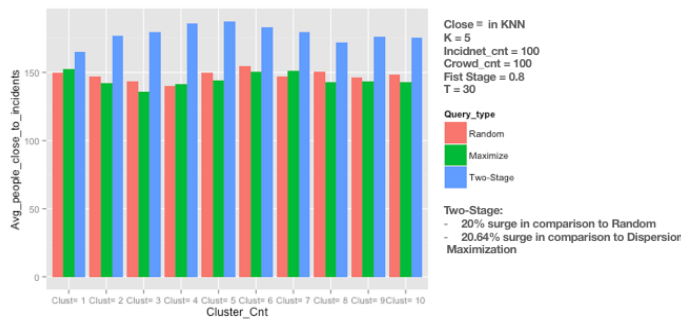


Figure 5: Average number of people close to the incidents when maximizing the dispersion with 80% of available resources.

4.5 Stressing the two stage querying technique (k=1)