FIT5190 Assignment 3

Flexible Task Allocation in
Participatory Sensing with Smartphones

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Abstract

Participatory sensing is a novel paradigm which takes advantages of pervasive smart-phones to collect enormous data and form collective knowledge about a state or condition of interest，enabling numerous participatory-sensing based applications. There are two crucial requirements in participatory sensing, fair task allocation and energy efficiency, which are intrinsically contrary with each other. In this paper, we try to allocate flexible sensing tasks, events with flexible starting and ending time, for achieving a good balance between fairness and energy efficiency. Under an offline model, we will present a novel algorithm which includes a method of constructing directed graph according to the problem. Under an online model, we introduce a new strategy of allocating online flexible tasks which will promise an approximation ratio of no more than 6. To evaluate the performance of algorithms, we will perform simulation to test the energy efficiency. With both online and offline algorithms, our study will make great contributions to the improvement of participatory sensing.

Keywords: Participatory sensing; Task allocation; Smartphones

Introduction

Participatory sensing is a distributed problem-solving model in which a crowd of undefined size is scheduled by a platform to solve a complex problem. Recently, the proliferation of smart-phones has provided a unprecedented opportunity to extend traditional web-based application to a larger crowd. Furthermore, with a rich set of cheap powerfully embedded sensors, participatory sensing with smart-phones offer a variety of novel ways to collect enormous data, enabling numerous applications, such as localization, environmental monitoring and crowding counting. There have been a few works which are similar to participatory sensing. Zhao et al. [1] consider the problem of matching heterogeneous tasks to workers with different, unknown skill set. The objective is to maximize the total benefit of the requester who submitted tasks. In [2], the problem of selecting a service provider from a list of providers is considered, with the objective of maximizing the consumer's satisfaction. Ballesteros et al. [4] focus on how to apply participatory sensing with smart-phones to improve the safety of city. In particularly, the problem of allocating fixed tasks in participatory sensing has been considered in [1].

In the real world, most of tasks submitted by requester are not so urgent and usually have a flexible starting and ending time. What is more, study about flexible task allocation can also be used to consider other

similar problems in practice which motivate us to consider the problem. In this paper, we focus on the problem of allocating flexible tasks in participatory sensing with smartphones with considering both fairness and energy efficiency.

Objective

The paper presents a new participatory sensing framework which aims at allocating flexible sensing tasks in participatory sensing for achieving a good balance between fair task allocation and energy efficiency. To verify the performance of algorithms, we will consider two models: an offline model and an online model. For the offline model, we present a novel method of converting serial tasks into a special graph which will make offline problem easier. For the online model, we introduce a new approximation method according the features of flexible sensing tasks which arrive dynamically. Both offline and online algorithms are created based on important observation about flexible sensing tasks and they will be applicable for other homogeneous problems.

Methodology

A typical participatory sensing system includes three parts, system users, central platform and a collection of smartphones. System users requesting

sensing services can send queries to the central platform which then allocates the sensing tasks to the member smart-phones. After being assigned a sensing task, a smart-phone performs the required sensing service and returns the sensing data to the platform which forwards the data to the querying user. In this paper we focus on allocating flexible sensing tasks. Compared with fixed sensing tasks whose starting and ending time are predefined, flexible sensing tasks have flexible starting and ending time. In other words, a smartphone can decide when to start the task as long as the ending time is within an interval which is longer than the task span when assigned a flexible task. In this paper, we focus on allocating flexible tasks in participatory sensing with considering both offline and online models.

At first, we want to prove that flexible tasks allocating in participatory sensing is NP hardness by reducing from job scheduling problem, a classical NP problem, to our problem. To optimize the problem, we will construct a directed graph where every note denotes a possible ending or starting time of the corresponding task. Then we will use modified searching method to find the Hamilton path which can be regarded as the best solution on single mobile. Then a greedy algorithm will be applied to the Hamilton path so that the central platform can allocate tasks to every machine fairness. For the online problem, we will introduce a novel strategy which is a criterion to decide whether a new

flexible task should be performed immediately. The most important point for that strategy is the choice of threshold which is the key of that strategy. We will evaluate performances of both models by comparing with a random allocation algorithm which allocates a task to one of smartphones randomly. By test the consumption of energy we can come to the conclusion whether the two algorithms in this paper is effective or not.

With the development of mobile devices, participatory sensing with smartphones has enabled enormous application. Flexible task allocation is applicable to many problems directly and indirectly with modifying some features. However, there are some limitations in our study. To simply this problem, we assume that all smart-phones are cooperative which means that they are affiliated to the system and willing to take sensing tasks and provide sensing services to the system. What's more, we also make an assumption that all the task are homogeneous so that the platform can assign different tasks which can reuse some parts of other tasks on the same smartphone. All assumptions we make in the study is to help us focus on allocation and they will never affects the efficiency and application of algorithms.

Novelty

We argue that the problem and algorithms in our study include three novel elements even though task allocating in participatory sensing is not new.

Fist, this paper is the first work which focuses on flexible task allocation in participatory sensing. Many existing works have studied problems in participatory sensing, for example [2] and [3]. In particular, Zhao et al. [1] study fixed task allocation. However, flexible tasks can start at any time as long as it is within given interval which makes task allocation more complex combining the arrival of tasks is also dynamically.

Second, this paper presents a novel method of converting serial tasks into a directed graph. There are enormous famous graph which can be used to solve certain problems, such as tree, direct graph and indirect graph. To offline problems in this paper, no existing graph can be applied directly. We present a new method of constructing graph based on all the possible starting time of flexible tasks. To our best knowledge, no similar method has been used in other works.

Third, this paper introduces a novel strategy for online problems. Both arrival and starting time of flexible task in an online model are dynamical. Zhao et al. [1] introduce three rules for allocating fixed tasks with achieving an m-approximation where m is number of smartphones and can be very large. In our study, we define a threshold to decide when to start a flexible task which provides an approximation ration of no more than 6 for the online model.

Conclusion

This study focuses on allocating flexible tasks in participatory sensing with achieving a good balance between fairness and energy efficiency. To achieve the objective, we present two models, an offline model and an online model. For the offline model, we present a new method of constructing graph which convert serial problem into searching Hamilton problem. For the online problem, we introduce a novel online algorithm based on the special feature of flexible tasks to decide the best starting time which achieve a competitive approximation ration of less than 6.

Flexible task allocations are more applicable compared with previous studies and can be easily used to improve the performance of participatory applications with modifying certain features. By addressing flexible tasks in participatory sensing, we also provide the contribution to future study about task allocation in participatory sensing.

References

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