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Hybrid battery-friendly mobile solution for extracting users' visited places

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Abstract

Extracting and analyzing outdoor humans' activities represent a strong support for several applications fields, ranging from traffic management to marketing and social studies. Mobile users take their devices with them everywhere which leads to an increasing availability of persons' traces used to recognize their activities. However, mobile environment is distinguished from one to another by its resources limitations. In this paper, we present a novel hybrid approach that combines activity recognition and prediction algorithms in order to online recognize users' outdoor activities without draining the mobile resources. Our approach minimizes activity computations by wisely reducing the search frequency of activities, we demonstrate that our proposal is capable of reducing the battery consumption up to 60% while maintaining the same accuracy as its similar.

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Keywords: Activity recognition; Battery-awareness; Activity prediction; Trajectory analysis; Online clustering;

1. Introduction

Mobile wearable tracking devices, e.g., phones and navigation systems, sense the movement of persons represented by positioning records that capture geo-location, time, and a number of other attributes. Sensing is based on a collection of information related to the achieved activity from raw sensor data (GPS, Wi-Fi, RFID, Bluetooth signals,

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microphone, camera, accelerometers, magnetometers, etc.), these data are used to extract a pertinent information about the current activity and users' visited places[10]. As such, the mobile phone is no longer only a communication device, but also a powerful environmental sensing unit that can monitor a user's ambient context, both unobtrusively and in real time. This context awareness property makes this field a major piece that provides services to a range of application fields such as real-time traffic monitoring[8], social networking and cognitive assistance. However, the limited battery capacity of mobile devices represents a big hurdle for context detection. The embedded sensors in the mobile devices are major sources of power consumption. Hence, excessive power consumption may become a major obstacle to broader acceptance context-aware mobile applications, no matter how useful the service may be.

Activity recognition services that extract users visited places are supposed to operate 24 hours a day, 7 days a week. Searching for users visited places on every moment, like done in the majority of related works, leads to an excessive power consumption that drains mobile's battery rapidly. We will propose in this paper a novel approach that minimizes power consumption by reducing the calculation frequency of activities. The proposed algorithm learns users' habits and chooses an appropriate time to search for their performed activities. For instance, suppose that the user has the habit of going from home to work every morning, theoretically, there is no need to process the user movements on every time he goes from home to work since it represents useless calculations.

In this paper, we will demonstrate an innovative battery-friendly method that recognizes accurately users' activities without draining the battery of their phones, a method that succeed in detecting incrementally users‘ visited places without any previously fixed threshold, we will also prove that our proposal reduces outstandingly the battery consumption when keeping a same accuracy rate as its similar.

The following sections detail our contribution: Section 2 reviews related works; Section 3 presents our approach in terms of three major components, i.e. activity recognition, prediction and verification; Section 4 describes the experimentation by highlighting two dimensions: accuracy and power saving. Finally, conclusion as well as the expected contributions, are summarized in Section 5.

2. Related works

Research community's efforts are increasing day by day to carry out efficient mobile activity recognition systems. CityVoyager presented in[4] is a recommendation system designed for mobile devices, which recommends shops to users based on data analyzed from their past location history. Authors track the visited shops by the loss of the GPS signal, though, it is known that GPS signals frequently become lost in urban areas due to high buildings or due to some special weather conditions, these situations increase the possibilities of false detections. Furthermore, authors claim to propose an approach designed for mobile phones, however, there is no adaptation noted to support this demanding environment, for instance, finding frequented shops requires a heavy manipulation of the historical records of users' visited shops, authors seem to neglect the limited mobile's resources since there is no support for the limited battery life and there is no effort perceived to online detect and find the frequent shops.

In [3], an algorithm is proposed to associate each stop in a user's trajectory to a list of possible visited places and each of these places is associated to a probability, then, depending on the kinds of activities associated with the identified place, the trajectory is classified into a probable trajectory behaviour. This work uses numerous thresholds that are set manually like the minimum duration of an activity, nevertheless, since these parameters may depend on user profiles, this work may be ineffective on large datasets that contain several profiles.

While developing a rich body of work for managing moving objects, the research community has shown little interest to the limited resources of smartphones, for instance, nearly all approaches repeat the same activity research process for every daily activity which leads to an excessive consumption of phones' batteries.

Moreover, nearly all outdoor activity recognition approaches use a fixed activity's minimum duration threshold that represents the minimum time that the user has to spend in the POI (place of interest) to be declared as visited place. This threshold prevents false activity detection like traffic jams. However, previously fixing this threshold will increase error probability, because when set to a small value, it will increase the number of false activities like passing by a POI, and setting it to a high value, will miss detect some short-dwell activities like buying cigarettes at the convenience store. Consequently, we will be (to the best of our knowledge) the first to propose not only a dynamic approach that learns the activity's minimum duration threshold automatically, but to propose a specific threshold for each POI too. Our approach will assign to each POI a minimum duration threshold to be able to detect both the short