Brief Survey of Participatory Sensing

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1 Introduction

The concept of participatory sensing was introduced by Burke et al. (2006), and Campbell et al. (2006) also presented the similar concept. Both of them aims at building a interactive and participatory sensor network via everyday mobile devices in order to enable public and professional users to gather, analyze and share local knowledge. Many other terminologies were used in related works focusing on particular monitoring subjects, such as urban sensing, participatory urbanism, citizen sensing, people-centric sensing, community sensing, etc. Christin et al. (2011b) provides a detailed survey of participatory sensing.

2 Applications

Roughly, most literatures are focus on either *people-centric* or *environment-centric* sensing applications. Usually, the sensor node is a everyday mobile phone, but could also be automobiles or specially designed sensor integrated with cellphone.

2.1 People-centric

- Personal health monitoring (Burke et al., 2007)
- Estimate environmental impact and exposure (Mun et al., 2009)
- Monitor and document sport experiences (Eisenman et al., 2009)
- Enhance social media (Jennifer, 2013)
- Price auditing (Deng and Cox, 2009)

2.2 Environment-centric

- Air quality monitoring (Paulos et al., 2007; Mendez et al., 2011)
- Monitor noise (Kanjo et al., 2009; Rana et al., 2010)
- Monitor road and traffic conditions (Mohan et al., 2008)
- Analyze commute times and metropolitan Wi-Fi deployments (Hull et al., 2006)
- Study thermal effects (Von Kaenel et al., 2011)
- Estimate the thermal comfort of a building (Erickson and Cerpa, 2012)

3 Hot Topics

3.1 Privacy and data integrity

Participatory sensing applications rely on individuals to share personal data to produce aggregated knowledge. In this setting, privacy issue can discourage widespread adoption of new applications. So, a plethora of works has been done to solving the privacy problem.

- **Privacy:** preserve private information of users (Agrawal and Srikant, 2000; Ganti et al., 2008; Krumm, 2009; Christin et al., 2011a; De Cristofaro and Soriente, 2013; Groat et al., 2013)
- **Integrity:** evaluate information quality provided by users (Lenders et al., 2008; Saroiu and Wolman, 2009; Huang et al., 2012; Christin et al., 2014)

3.2 Energy

Just like normal sensor network, energy efficiency is still an important issue for the participatory sensing. Since the limited control on hardware structure especially for a large-scale phone network, the main methods should lies in software solutions that can prolong battery life. However, only one related paper about this topic is found on line. Maybe this common topic of wireless sensor network has well researched on other subbranches.

This only paper is from Wang et al. (2009), who uses hierarchical sensor management strategy to recognize user states as well as to detect state transitions. It improves battery life by powering only a minimum set of sensors and using appropriate sensor duty cycles.

3.3 Aggregated analysis

For different applications, the methods of data aggregation may vary significantly. In practice, it is hard to get a chance of playing with a large-scale participatory sensing network since a lot of challenges are still impeding the collection of big real-life data.

- **Compressive sensing:** Rana et al. (2007) reconstructs temporal-spatial profiles from participatory sensing data by exploiting the theory of compressive sensing.
- **Trade-off between privacy and performance:** Shi et al. (2010) presents a solution to privacy-preserving data aggregation in people-centric urban sensing systems.
- **Pattern & model:** Ganti et al. (2011) provides an overall survey about mobile participatory sensing, in which *pattern and model* are discussed. The patterns may help to build models and make predictions about the physical or social phenomena being observed. The challenge in identifying patterns from large amounts of data is usually application-specific and involves certain data mining algorithms.

4 Challenges

- Understanding and interpreting the sensed data
- Optimizing data collection on mobile devices
- Motivating users and protecting their privacy
- Working with images and video
- Energy conservation
- Scalability - Big Data

- Large-scale user trials
- Ensuring quality of data
- Calibration of sensors
- Can the phone sense the emotional state of the person?

5 Conclusion

The key of large-scale participatory sensing is collecting data from a large-scale nodes (users). Each node is a powerful senor platform, and the network is dynamically deployed. These are significantly different from traditional sensor network. So, privacy-preserving data aggregation and big data mining should be the main research directions. For energy-saving issue, we may borrow ideas from previous work on wireless sensor network or develop new scheme according to specific applications.

Considering our condition, I think, only engaging in energy efficiency of phone sensing may be not enough to extant to large-scale participatory sensing. We should do some network stuff like fusing and mining data from different mobile devices. For example, if users' cellphones can estimate the weather by processing local pictures captured recently, we may know the real-time weather of certain location through collecting and fusing the weather estimations from a batch of users within the same area.

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