Mobile Big Data Meets Cyber-Physical System

Mobile Crowdsensing based Cyber-Physical System for Smart Urban Traffic Control

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The sheer number of user-companioned mobile devices (especially smartphones) and their inherent mobility and social interactions among devices enable a new and fast-growing mobile big data paradigm: the ability to acquire local knowledge through sensor-enhanced mobile devices (e.g., location, personal and surrounding context, noise level, traffic conditions and other information), and the possibility to share such knowledge within the global social sphere via mobile and online social networks. The information collected on the ground combined with data from online social media plus the support of the mobile cloud make the real-time analysis of the large amount of mobile sensing data a versatile platform that can possibly replace static sensing infrastructures in traditional cyber-physical systems (CPS), and enable a broad range of CPS applications. In this position paper, we introduce a new mobile crowdsensing based cyber-physical system where mobile big data from both sensor-enhanced smartphones and mobile social media is collected, analyzed, interpreted, and appropriately leveraged for smart and accurate control in a transportation cyber-physical system. Here, we use traffic control as a case study to illustrate the power of this new mobile crowdsensing approach for the design of cyber-physical systems.

Successful urban traffic management and control rely on efficient monitoring of urban traffic dynamics to provide essential information for decision making. Traffic monitoring systems deployed until now use data collected mainly from static roadside infrastructures, e.g., passive loop detectors, radars, and video cameras or even manually conducted surveys. However, survey data is often incomplete, inaccurate, and out-of-date, while static roadside infrastructure sensing data is incomplete and often difficult to analyze and aggregate in real time. In addition, the roadside infrastructure solution also suffers from insufficient node coverage, high installation/maintenance cost, and lack of scalability. Real time collection of dynamic, network-wide traffic information in urban environment is, therefore, likely to require alternative sensing techniques, and becomes one of key challenges in transportation cyber-physical systems.

Mobile crowdsensing takes the advances of new sensing and communication capability of smart phones and huge number of mobile users to enable massive mobile data collection in the urban environment. It has been widely used in many applications, such as urban dynamic mining, public safety, and environment monitoring. Compared with traditional static sensor networks, it leverages existing sensing and communication infrastructures without additional costs; provides unprecedented spatio-temporal coverage, especially for observing unpredictable events; and integrates human intelligence into the sensing and data processing. Combined with mobile social media services, mobile crowdsensing is generating massive, heterogeneous data and creating abundant opportunities for novel applications. In this paper, we treat both smartphones carried by mobile users and social media messages posted by them as the new types of traffic probes for a transportation CPS as shown in Figure 1. The major difference with existing transportation CPS is using mobile crowdsensing to replace or complement the pre-deployed static traffic sensors for obtaining more accurate real-time traffic information. One unique feature is the consideration of two types of crowdsensing data: traffic information generated from smartpones based on internal sensors and traffic events extracted from user-contributed messages on social media services.

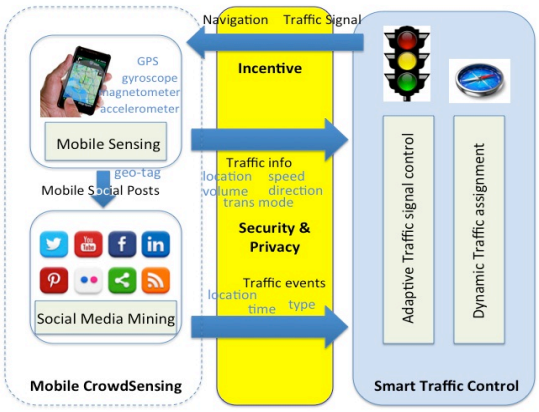

Figure 1. Mobile crowdsensing based traffic control system.

These crowdsensing data provide a new stream of traffic information that can be utilized for smart traffic control, and allow citizens to constantly interact with the urban transportation system. On the other hand, due to the massive, heterogeneous, or maybe noisy sensed data from mobile crowdsensing and the involvement of a large population of human users, new challenges are also faced by the proposed mobile crowdsensing CPS system, such as data quality, redundancy, inconsistency, cross-space mining, security, privacy, and incentive. We will discuss our detailed design of the proposed system with several unique challenges and additional complexities when mobile crowdsensing is used for traffic-related data collection.