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Mobile crowd sensing of human-like intelligence using social sensors: A survey☆

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ABSTRACT

Recently, with the fast proliferation of smart phones, mobile phone has the powerful ability of not only communication but also computation. Human beings are not only data consumers, but data producer with their objective or subjective sensing needs. Mobile crowd sensing is an emerging computing paradigm that tasks everyday mobile devices to form participatory sensor networks. It allows the increasing number of mobile phone users to share local knowledge acquired by their sensor-enhanced devices. Social sensors, social sensor receiver platform, and mobile crowd sensing paradigm compose a process by which physical sensors present in mobile devices such as GPS are used to infer social relationships and human activities. In this survey, we review the mobile crowd sensing applications on social sensors based on social sensor receiver platform (e.g., Weibo and Twitter) from three categories: public security, smart city, and location based services. Most applications adopted in current works fit in one of these categories. Existing works on applications of mobile crowd sensing on social sensors are collected and studied. Some possible future directions of potential new application category are proposed and analyzed.
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1. Introduction

WITH the development of mobile devices especially mobile phones, we have been engaged in an internet of thing era. In our daily life, mobile phone has become more and more important. Recently, with the fast proliferation of smart phones, mobile phone has the powerful ability of not only communication but also computation. Different types of sensors are added in the smart phones such as accelerometer, gyroscope, compass, microphone, camera, GPS, and wireless network interfaces. The smart phones with advanced interface and functions make human beings to have ability to sensing the environment. Human beings are not only data consumers, but data producer with their objective or subjective sensing needs. These advances have provided unprecedented opportunities for both sensing coverage and computation ability. Thus, recently mobile crowd sensing (MCS) has catch more and more attention for its ability of sensing social and cyber environment.

Mobile crowd sensing is defined as [1] *a new sensing paradigm that empowers ordinary citizens to contribute data sensed or generated from their mobile devices and aggregates and fuses the data in the cloud for crowd intelligence extraction and human centric service delivery*. Different from traditional physical sensors based sensing paradigm, mobile crowd sensing [2] needs large number of users with smart phones to sense the surrounding environment. The smart phone can collect the useful information about the user such as location or GPS. Users can use the smart phone to collect the useful information of the environment such as images. Through using and analyzing the multi-modal sensing information, it is possible to update the development of public security, smart cities, location based services, etc. Overall, mobile crowd sensing is an emerging computing paradigm that tasks everyday mobile devices to form participatory sensor networks. It allows the increasing number of mobile phone users to share local knowledge acquired by their sensor-enhanced devices [3].

Different from physical sensors, mobile crowd sensing participants have the ability of analyzing data other than only

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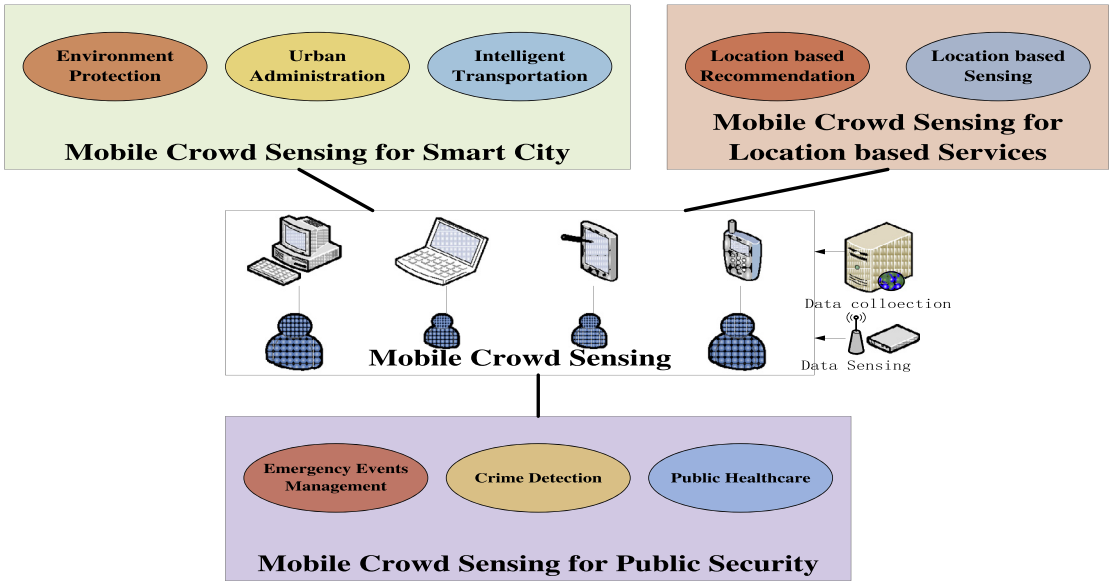

Fig. 1. The illustration of the mobile crowd sensing on social sensors.

collecting. The mobile crowd sensing participant can transfer the information into knowledge. Usually, the mobile crowd sensing participant can be as "social sensors [4]." A social sensor is defined as an agent that provides information about its environment on a social network after interaction with other agents [5]. For example, if a mobile crowd sensing participant collects the information about a fire or crash, then she/he can be seen as a "fire sensor" or "crash sensor". Besides the social sensors and mobile crowd sensing paradigm, it is also needed a sensor receiver platform which can collect data from social sensors. Social sensors, social sensor receiver platform, and mobile crowd sensing paradigm compose a process by which physical sensors present in mobile devices such as GPS are used to infer social relationships and human activities. Social media services such as Weibo[1] and Twitter[2] are the appropriate platform as the social sensor receiver. The user of social media concerns one question, "What's happening?" An important feature of social media service is its real time nature.

In this survey, we review the mobile crowd sensing applications on social sensors based on social sensor receiver platform (e.g., Weibo and Twitter) from three categories: public security, smart city, and location based services. Most applications adopted in current works fit in one of these categories. The brief descriptions of the three categories are as follows.

(1) Public security related applications. The data from social sensors is important for the public security. For example, the social media posts can be used for detecting real-time events such as fire, earthquake, and so on. The mobile crowd sensing can be used to process data from social sensors. The mobile crowd sensing for public security is reviewed including emergency events management, crime detection, and public healthcare.
(2) Smart city related applications. The mobile crowd sensing for smart city is reviewed including environment protection, urban administration, and intelligent transportation.
(3) Location based services related applications. The mobile crowd sensing for location based services is reviewed including recommendation and sensing.

We highlight the contributions of this paper as follows.

(1) To the best of our knowledge, this is the first survey concerning various applications on social sensors for *mobile crowd sensing*.
(2) Existing works on applications of mobile crowd sensing on social sensors are collected and studied. We have classified the applications into three categories: public security, smart city, and location based services. Each application is organized and illustrated according to its unique structure. The important features of each application category are summarized and compared.
(4) Some possible future directions of potential new application category are proposed and analyzed.

The rest of the paper is organized as follows: Section 2 gives the brief review of mobile crowd sensing and social sensors. The mobile crowd sensing for public security is given in Section 3. Section 4 presents the mobile crowd sensing for smart city. Section 5 presents the mobile crowd sensing for location based services. Finally, Section 6 discusses some possible future directions and Section 7 draws the conclusion.

2. Brief review

In this section, three aspects of the survey including mobile crowd sensing, social sensors, and the integration of two aspects are given. The brief review including basic concepts and features are introduced. In Fig. 1, the illustration of the proposed survey is given.

2.1. Mobile crowd sensing

Different from traditional physical sensors based sensing paradigm, mobile crowd sensing is a new sensing paradigm using the mobile devices especially smart phones. Guo et al. [6] thought that mobile crowd sensing is a new and fast-growing sensing paradigm: the ability to acquire local knowledge through sensor-enhanced mobile devices – e.g., location, personal and surrounding context, noise level, traffic conditions, and in the future more specialized information such as pollution – and the possibility to share this knowledge within the social sphere, healthcare providers, and utility providers. Since the information collected by mobile crowd

[1] www.weibo.com.
[2] www.twitter.com.

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