A Survey of Mobile Crowd Sensing Applications

Kai zhang, Xuemei Sun, Hua Su

***Abstract*—With the explosive popularity of wireless mobile terminal devices, the combination of mobile sensing and crowdsourcing ideas has created a new type of Internet of Things sensing model, namely, crowd sensing. As a new IOT awareness model, the mobile crowd sensing network collects individual, context, and context-aware data in a specific range through mobile-sensing devices, accomplishing complex social-aware tasks and providing enough sensing applications. This paper combines the development of mobile crowd sensing network, mainly introduces its basic concepts and the application of current mobile crowd sensing in all aspects of society, and summarizes the problems faced by mobile crowd sensing and future development.**

***Index Terms*—Mobile crowd sensing, Sensing Application**

I. MOBILE CROWD SENSING NETWORK OVERVIEW

1.1 Definition of mobile crowd sensing network

The crowd sensing network is a sensing network composed of mobile devices (such as mobile phones, tablets, etc.) that are widely used by ordinary users and integrated with a large number of sensors [1]. Since it is still in the early stages of research and development, there is no uniform and strict definition. Here is a basic definition of the crowd sensing network that is currently widely recognized by the academic community.

Ordinary users' mobile devices (such as mobile phones, tablets, etc.) are used as basic sensing units to conduct conscious or unconscious collaboration through mobile Internet (such as WiFi, cellular networks, and wired networks) to realize sensing task distribution and sensory data collection. A large-scale, complex social perception task is a crowd sensing network [2].

In the current computer field, the concept of crowd sensing is similar to participatory sensing [3], community sensing [4], and crowdsourcing [5]. They are all based on the participation of a large number of ordinary users, and their basic ideas are the same, that is, people are more powerful and play the wisdom of the group.

1.2 Mobile crowd sensing current key technology

The mobile crowd sensing network provides a new Internet of Things sensing model, and it also brings new technical challenges to researchers, which has become a hot research topic. The existing technical research in this field can be roughly divided into: data processing technology, incentive mechanism, crowd sensing platform and so on.

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1) Data processing technology. In the sense of crowd sensing, the core is to collect, analyzing, mine and utilize large-scale data. Data collected by a large number of untrained users has more prominent data quality problems (such as inaccurate data, incompleteness, inconsistency, and inconsistency). The sensing data is coarsely refined and de-authenticated, so that the refined data can reflect the sensing environment with high sensing, which is of great significance to the crowd sensing application. Many techniques and tools provide an effective means and approach for data processing. The Scaffidi et al. scheme provides an efficient string format conversion rules and interfaces for multi-source promiscuous data formats [6].

2) Incentives. In a mobile crowd sensing network, ordinary users are required to actively participate in and provide sensory data to complete social sensing tasks. However, users' participation in sensing requires a certain price (such as consuming resources, revealing privacy, etc.). Without a certain incentive compensation mechanism, it is difficult to attract a large number of users to actively participate in large-scale social tasks. Many studies have been proposed based on this incentive mechanism, such as the platform to use the game to explore the user's habit preferences [7], to evaluate and improve the relevance of the network search engine [8].

3) Crowd sensing platform. In the mobile crowd sensing network, the crowd sensing platform provides an information platform for task publishers and participants to publish, distribute, coordinate, and feedback tasks, and builds specific crowd sensing applications based on perceived tasks. Shahabi et al. [9] proposed a spatial crowd sensing platform based on trust mechanism, which solves the scalability and trust problems in space crowdsourcing applications.

The advantage of the mobile crowd sensing network is that the participants who complete the complex social-aware tasks do not need to be users with professional skills. A large number of ordinary users can work together to accomplish a single impossible through a reasonable and efficient task allocation mechanism and coordination mechanism. Large-scale social sensing tasks that are completed or take a long time to complete, forming a real-time dynamic, comprehensive and sensing ability that is closely related to people' s lives.

1.3 Mobile Crowd Sensitive Network Architecture

The general process of crowd sensing is shown in Figure 1. It consists of three parts: task publisher, perception platform and participants. When the task publisher needs some sensory data, he will send the corresponding task requirements and the budget for collecting data to the sensing platform. These requirements include the accuracy, granularity, time and quantity of the perceived data. Then the sensing platform recruits the participants according to actual needs. The data is collected and reported to the participants according to a certain scheme; afterwards, the participants pass the data to

the sensing platform, and the sensing platform finally transmits the data to the task publisher.

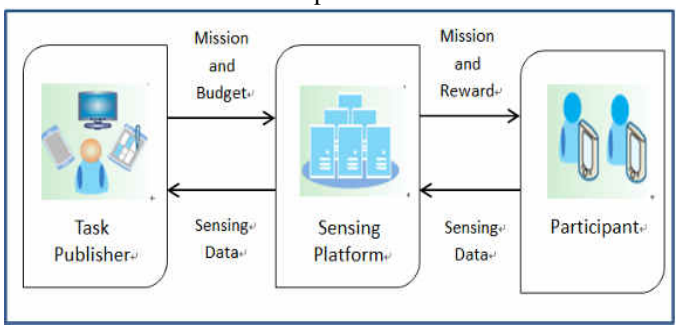

Fig 1 General flow of mobile crowd sensing system

This paper focuses on the application of current mobile crowd sensing in real life, and summarizes the current challenges and future development of crowd sensing. Among them, mobile crowd sensing mainly includes traffic, environment and society. Application Next, we will explain it.

II. MOBILE CROWD SENSING IN TRAFFIC APPLICATIONS

In the application of transportation, we give a typical example. Li Shu's article [10] proposes a method of using the smart phone to communicate with the onboard computer (OBD) to obtain traffic information and location information of the vehicle to identify traffic congestion. The onboard diagnostic system device monitors multiple systems and components of the vehicle, including the engine, fuel system, and the like. The OBD is coupled to an electronic control unit (ECU) through vehicle-related component information, and the ECU has a function of detecting and analyzing a vehicle-related failure. The data information acquired by the vehicle OBD can be accessed and processed through the OBD standard data interface.

The intelligent transportation system based on crowd sensing consists of three functional components, which are information data sensing unit, data processing center and local message application and sending unit. The information data sensing unit is mainly composed of an on-board diagnostic system (OBD) and an OBD adapter and a smart phone (as shown in FIG. 2).

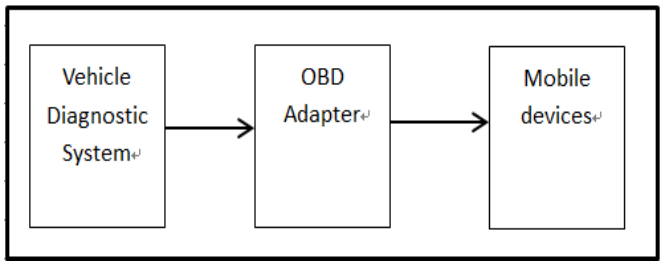

Fig 2 Sensing unit system structure

According to the map drawing of the vehicle speed data and the geographical location information of the same road segment, the map road is redrawn in different colors, and the drawn map information is returned to the registered user, so as to facilitate the driver to obtain near real-time congestion. Situations choose other routes to avoid congestion. Moreover, the traffic management department can also make a map through the map, such as controlling the traffic lights at the intersection to reduce the number of vehicles entering the congested section within a unit time.

III. THE APPLICATION OF MOBILE CROWD SENSING IN THE EVIRONMENT

3.1 Monitor the air quality of the environment with a crowd sensing network

The CommonSense system [11] uses a portable handheld air quality sensing device to connect to the user's mobile phone to build a city air quality monitoring system. Firstly, through the research of the participating ordinary users, experts and management departments, the design principles and framework of data collection and knowledge representation are proposed. Then, a user-centered system is designed to analyze the air quality sensing data. Unlike other traditional systems, the system decomposes data analysis tasks into specific small applications, making it easy to take advantage of individual sensing data.

The SensorMap system [12] builds a city air quality monitoring network using air quality sensing devices installed on each vehicle. The system focuses on system implementation, and the article [12] simply gives the implementation framework of the system.

The Peir system [13] makes full use of the distributed processing capabilities of the web network and the personal mobility awareness of the user's mobile phone to build a system that monitors the environment in which the user is located. It mainly solves and implements four key technologies, namely GPS data collection, user behavior classification based on hidden Markov model, automatic division of location data, and relationship model between environmental impact and human behavior. At the same time, the system was run for 6 months based on 30 volunteers in 2008. The article [13] analyzed and evaluated the performance of the system based on these experimental data.

3.2 Using the crowd sensing network to perceive the degree of noise pollution in the city

The article [14, 15] uses the microphone and GPS sensor in the smartphone to sense and construct a city noise distribution map to monitor urban noise pollution in real time. Based on a noise calculation model, a ten-order digital filter is used to calculate the noise level based on the induced voltage value collected by the handset microphone. Due to the uncontrollability and unreliability of the perceived users, the sensing data is incomplete and most of the locations have no sensing data. To this end, the article [14] uses the spatial correlation of noise-aware data, based on the compressed sensing method, to restore the sparse sensory data into a complete noise map.

IV. THE APPLICATION OF MOBILE CROWD SENSING IN SOCIAL ASPECTS

Since mobile phones are often carried around people anytime and anywhere, this provides a good way to record people's

social behavior. Therefore, the crowd sensing network can provide a new and convenient way to study human social behavior. You can use the mobile phone that the user carries with you to sense the user's social behavior and other information, such as the time of exercise, the number of contacts and the number of times, etc. Then social behavior scientists analyze the sensory data of a large number of people to study the social characteristics of human beings, such as social relationships. , Activity, etc. [4]. This method based on crowd sensing network is more accurate, more objective and more human than traditional questionnaire survey and carrying device measurement.

4.1 SociableSens System

The SociableSens system [4] uses the Bluetooth device, accelerometer and microphone of the mobile phone to sense and record the interaction information between the user and others, and then quantitatively analyze the user' s social attributes and activity based on the sensing data to provide social suggestions for the user.

Firstly, the author proposes a sensor sampling method based on the reinforcement learning mechanism, which adaptively controls the sampling frequency of the acceleration sensor, Bluetooth and microphone to make a good compromise between energy consumption, perceptual precision and perceived time delay. .

Then, a computing task allocation method based on multi-criteria decision theory is proposed to dynamically determine where the computing task is executed (such as on a mobile phone or a cloud server) to consume energy, calculate latency, and transmit data on the network. There is a good compromise between the three.

Finally, a social attribute calculation method is proposed, which calculates the social attributes of the user and the strength of the relationship with friends based on the data perceived by the mobile phone, and feeds back to the user.

4.2 Other typical applications

Social aspects In addition to the SociableSens system mentioned above, crowd sensing has also been applied in social networking, travel, diet and travel.

For example, much social software recommends friends through a common friend between users. Use mobile devices to collect user outing habits and encourage users to go out environmentally [16]. By making a "location-photo" library, people can take advantage of the shooting

The picture queries its own geographic information [17]. By sharing their catering status in a circle of friends, they can not only improve themselves, but also give good opinions to others [18]. Through the GPS trajectory and environment-related information provided by bicycle users, the best bicycle riding route is obtained [19].

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V. CURRT CHALLENGES AND DUTURE DEVELOPMENT

Mobile crowd sensing can monitor large-scale phenomena through individual data [20], so it is necessary to collect a large amount of data from individuals. In order to make the calculation process more efficient, you usually need to consider the following issues:

1) Data collection must take into account user costs

2) The pressure on the network during the user's data transmission

3) Need to set up a back-end cloud computing server for receiving, computing, management and analysis

4) Users can be assured and voluntarily use the mobile phone as a user privacy protection mechanism for data collection detectors

The data credibility problem in the crowd sensing environment includes the system's verification of the individual collection end data and the system's accurate judgment of the event results. The reliability of data collection requires the use of credit specifications to limit client users, on the other hand, more precise algorithms to verify data reliability. The system's accurate judgment of the outcome of the event is a key basis for motivating users to continue using the system. Although the group environment provides an opportunity for uploading fake data, real data has the same opportunity. How to distinguish the authenticity of the data is a big challenge.

"People collect firewood and high flames". For modern human society, mobile group intelligence perception is the way in which group wisdom manifests itself in the information age. Wireless networks and smart devices are the basis of mobile crowd sensing, and the continuous expansion of mobile crowd sensing application requirements in turn puts higher demands on the development of the two. Individuals in the crowd sensing environment exist in the form of numbers. Privacy protection is the basis of individual mutual trust and cooperation. The imperfections of security norms and credit norms will inevitably affect the application of crowd sensing. In general, mobile crowd sensing is for human society. Development and the development of information technology will play a facilitating role, and more challenges are waiting for people to discover and solve it.

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