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Mobile Crowd Sensing: A Review

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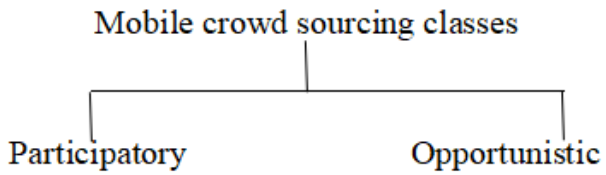
Abstract: *Mobile crowd sensing gives the facility of large scale sensing of the physical world at low cost using the sensors on the mobile phones. Modern smart phones are capable of sensing, computing data and communication capabilities which allows them to perform more complex tasks. Mobile crows sensing centers around human involvement so it comes with few challenges like privacy problems, reliability of the data. The solution to solve these challenges will add over head on smart phones but if we address the data reliability issues then mobile crowd sensing will become a strong method for collecting data from physical world. This paper provides a review of existing mobile crowd sensing work and in sensing applications.*

Keywords: *Internet of Things (IoT), Mobile Crowd sensing (MCS), Mobile phone sensing, participatory sensing.*

I. INTRODUCTION

The Recent developments in mobile Sensing and its technologies and an increase in smart phones, we are in the era of the Internet of Things (IoT). Internet of Things (IoT) aim is to interconnect objects and its surroundings[1, 2].
The previous traditional methods used for large scale sensing required a large number of sensor nodes. In previous methods a large number of sensor nodes were used to cover the large areas fro communication and economically it was undesirable. In a project names CitySee 100 sensor nodes and 1096 relay nodes are used for CO2 monitoring in an area of 1 km[3]. If we want to extend this this system to a larger area, we would need to use a large amount of sensor nodes and relay nodes so that full area coverage and connectivity can be maintained. Since Sensors cost high and along with that maintenance cost makes it a not so feasible solution and hard to implement. But the recent developments data from physical world can be collected using the sensors in various smart phones or wearable, smart vehicles etc.
This sensing technique is popularly called mobile crowd sensing (MCS) [4, 5] or *humancentric sensing* [6]. his technology can be applied to solve multiple problems. In internet of vehicles for example, mobile crowd sensing can be used for traffic prediction. Another field where mobile crowd sensing can be very beneficial is crowd sourcing during emergencies. Emergencies like flood or other earthquake have shown how citizens can be of great help for relief activities. So crowd souring for volunteer services in crisis management or emergencies can be done using mobile crowd sensing technology. The most important feature of mobile crowd sensing is human interaction or involvement. [4].



A. *Participatory sensing*: In participatory crowd sensing the user agrees to contribute information. The data that is collected or shared by the user is voluntarily I.e the participants consciously agrees to contribute.

B. *Opportunistic sensing*: In Opportunistic crowd sourcing the data is collected without human intervention or without permission or knowledge of the user. In this the participants unconsciously provides information. Here the data is collected by apps running in the background Services that are offered based on big data collection use the technique of crowd sensing. Services like social networking, cab services, search engines use crowd sensing technology. The human involvement in MCS (mobile crowd sensing) brings many challenges like privacy concerns.

In this Paper we will focus on opportunistic Sensing. Opportunistic sensing supports large scale developments[7].

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There are two classes of transmission in MCS:

• *Infrastructure-based transmission*: Here the users report data through the internet by using mobile phones.
• *Opportunistic transmission*: Here the users send data among users by using Bluetooth or Wi-Fi.

Most MCS applications uses the infrastructure- based transmission approach. But this method cannot be applied in the areas that have poor network or where network is costly. Therefore we will focus on the opportunistic transmission. Opportunistic transmission works well without centralized server.

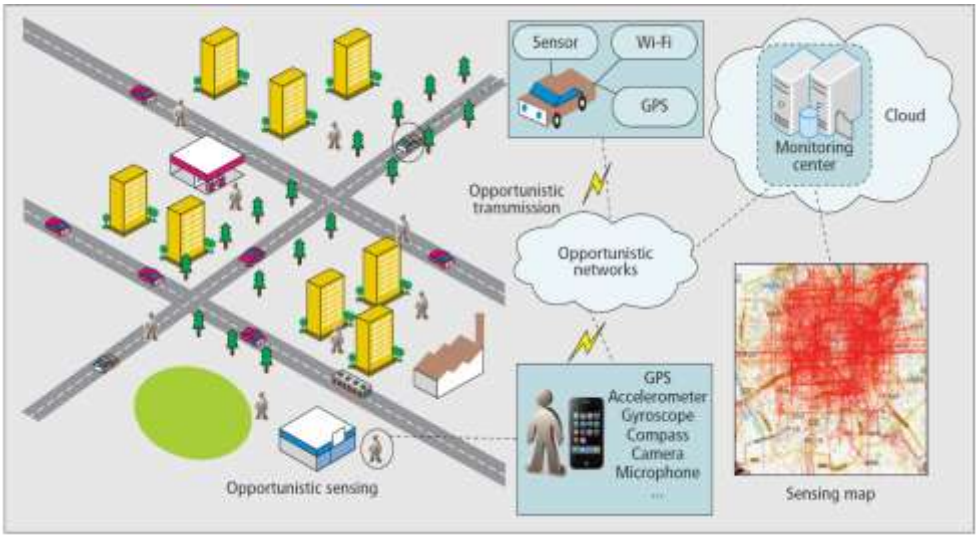

Figure 1. opportunistic urban sensing

II. HUMAN INVOLVEMENT

One of the most important feature of MCS is involvement of humans for sensing data, data transmission, analysis of data and decision making.

Since already millions of mobile devices and vehicles already exist therefore the cost of deploying network reduces Moreover, human mobility can be used to improve sensing and data trans-mission. Large Scale sensing can by done by this because where ever the mobile holder is the surrounding can easily be sensed by mobile nodes. Contacts among mobile users can be used to deliver data that has been sensed by the intermediate users using the store and forward method[8].
It is easier to maintain the network, Since mobile nodes have better power supply and large storage therefore it is easier to maintain. The responsibility of maintainence of mobile nodes is of their holders and they usually keep them in good condition.
For example, people will charge their mobile phones every day.
•Human Involvement brings some difficulties also. It does not always guarantee reliable sensing of data. Human might not want to share their data because it may contain private or sensitive information. Hence it also raises privacy concern issues. While participating in MCS, mobile users consume their own resources (e.g., battery and computing power) and have potential privacy threats. Thus it is required to provide sufficient incentive so that users agree to participate and share their data[9]. From the transmission point of view, users need to be benefited for sharing data among each other [10].

III. Existing works of MCS

Existing work of mobile crowd sensing can be classified into two categories: public infrastructure construction and personal daily life.

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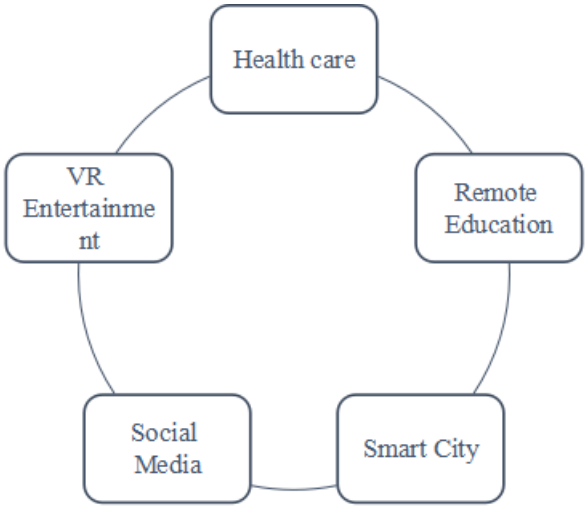
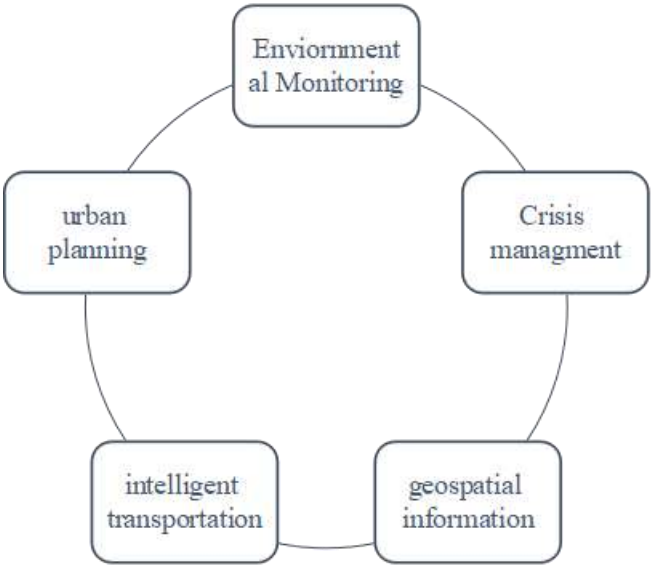


A. MCS in personal daily life

Mobile crowd sensing in personal life can be used for health monitoring or health care, construction of smart cities or remote education or social media. In case of an individual the data is collected using the movement patterns for example running, jogging, and the phenomena that is being monitored is restricted to individuals only. Mobile crowd sensing based games are also developed which collects data from the smart phone sensors and work on that data.
Mobile crowd sensing has three impressive properties which make MCS suitable to be used in industrial applications as well. These properties are: cost effectiveness, scalability, and mobility. This technology is cost effective, scale able and mobile which makes it suitable to be used in industry applications as well. Using MCS we can achieve enough coverage, and such coverage is scale able and cost effective.

B. MCS in public infrastructure

Group sensing is used to monitor group phenomena that cannot be easily measured by a single individual for example, in virtual teaching, mobile phones of students are used to sense and share the physical information around them. Such virtual teaching, students can learn about the customs of different cities and countries. Community sensing is used for large-scale monitoring of community that cannot be easily measured by a special group of people (e.g., students); for example, intelligent transportation systems. Such systems can sense the congestion of different road segments through the mobile phones carried by drivers, and the cameras installed in the systems, to measure travel speed. Unlike group sensing, there are different groups in community sensing.



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IV. MCS APPLICATIONS

A. Smart Cities

It is difficult to manage a city with high population worldwide. Hence there is a need for smart cities. Hence many governments and research organizations are currently working on sensing data to improve efficiency. Around the world, the governments building a green low-carbon area that aims at becoming a smart city. All these methods are beneficial but are also costly at the same time. But the cost of sensing data can be reduced by using crowd sensing and will also provide some additional data.. For example, many projects proposes to leverage crowd sensing to directly engage humans in the management.

B. Road Transportation

Most of the modern vehicles are equipped with GPS sensors. These sensors can be used to sense data and analyze traffic patterns which can further be used for analyzing traffic behaviour, speed, construction of new roads according to the that. Drivers will be able to get real-time information based on the data sensed and collected from smart phones. Drivers can be benefited by getting real time information on parking data. This data can be collected from cars having ultrasonic sensors. Transportation agencies can collect pothole data using GPS and accelerometer sensors to quickly repair the roads. In countries having snow storm can be benefited by collecting data in the form of images taken by citizens so that snow cleaning and removal can be efficiently prioritized.

C. Health-care & Well being

Wireless sensors worn by people for heart rate monitoring and blood pressure monitoring can communicate their information to the owners' smart phones. Typically, this is done for both real-time and long-term health monitoring of individuals. Mobile sensing can leverage these existing data into large scale health care studies that seamlessly collect data from various groups of people, which can be selected based on location, age, etc. An example is to collect data from people who eat regularly fast food. The phones can perform activity recognition and determine the level of physical exercise done by people, which was proven to directly influence people's health. As a result of such a study in a city, the municipality may decide to create more bike lanes to encourage people to do more physical activities. Similarly, we can use phones to determine the level of social interaction among groups of people (e.g., using Bluetooth scanning, GPS, or audio sensor). For example, a university may discover that students (or students from certain departments) are not interacting with each other enough; consequently, it may decide to organize more social events on campus.. Marketing/Advertising: Real-time location or mobility traces/patterns can be used by vendors/advertisers to target certain categories of people. Similarly, they can run context-aware surveys (function of location, time, etc.). For example, one question in such a survey could ask people attending a concert what artists they would like to see in the future.

D. *Citizen-journalism*

Citizens can report real time data in the form of photos, video, and text from public events or disaster areas. In this way, real-time information from anywhere across the globe can be shared with the public as soon as the event happens. But, malicious users may try to earn easy money by claiming that an event is happening at a certain location while being somewhere else.

E. *Environment*

Environment protection agencies can use pollution sensors installed in the phones to map with high accuracy the pollution zones around the country. The participants may claim "fake" pollution to hurt business competitors by submitting the sensed pollution data associated with false locations. Ultimately, the validation of sensed data is important in a mobile crowd sensing system to provide confidence to its clients who use the sensed data. However, it is challenging to validate each and every sensed data point of each participant because sensing measurements are highly dependent on context. One approach to handle this issue is to validate the location associated with the sensed data point in order to achieve a certain degree of reliability on the sensed data. Still, we need to overcome a major challenge: how to validate the location of data points in a scalable and cost-effective way without help from the wireless carrier? Let us note that wireless carriers may not help with location validation for legal reasons related to user privacy or even commercial interests. To achieve reliability on participants' location data, there are a few traditional solutions such as using Trusted Platform Modules (TPM) on smart phones or duplicating the tasks among multiple participants. However, these solutions cannot be used directly for a variety of reasons.

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V. CONCLUSION

This chapter discusses the opportunities and challenges in mobile crowd sensing brought on by human involvement and its applications. In particular, we have studied the opportunistic characteristics of human mobility concept of mobile crowd sensing and its applications to everyday life. It described the design and implementation of McSense, a mobile crowd sensing platform, which was used to run a user study with over 50 users at the NJIT campus for a period of 2 months. We also discussed the data reliability issues in mobile crowd sensing by presenting several scenarios involving malicious behavior. Therefore, we conclude this chapter with our belief that mobile crowd sensing will become a widespread method for collecting sensing data from the physical world once the data reliability issues are properly addressed.

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