Mobile Phone Sensing in Scientific Research

Bo Liu
University of Missouri, USA

A. Bulent Koc
University of Missouri, USA

INTRODUCTION

About a decade ago, mobile phones were mainly used to make phone calls and send text messages. They usually had small screens and keyboards. With the advent of the first generation smartphones, all this has changed. Smartphones have operating systems installed and they are equipped with several sensors like a gyroscope, accelerometer, magnetic sensor, GPS, camera, microphone and wireless interfaces (Wi-Fi, Bluetooth, 2/3/4G). Mobile phones also come with more powerful CPU processors, larger memories, and high-resolution touch screens. Applications running on smartphones can utilize the sensors and provide enhanced user experience. Currently, the number of smartphone users has surpassed the number of personal computers. Mobile phones are common in several countries in the world. In 2003, 56% of American adults owned smartphones, which meant about 175.8 million smartphone users in the USA (Duggan & Smith, 2013). The number of smartphone users is expected to reach 1.75 billion in the world (eMarketer, 2014).

The rapid growing number of smartphones is due to the technological advances. First, the availability of cheaper and smaller embedded sensors installed in smartphones reduced the total cost, increased user experience, and provided more data available for application developers to create innovative programs. Second, smartphones are being manufactured with operating systems like Google's Android, Apple's iOS or Windows Phone. All of these platforms provide application stores for developers to upload applications that can be downloaded by smartphone users all over the world. This makes it possible to collect and analyze data that was not available before. Third, the mobile cloud computing technology enables convenient network access to a shared pool of data computing and storage. Both the data storage and its processing are carried outside the mobile phones where an application is launched. According to PewInternet (Duggan & Smith, 2013), 63% of adult mobile phone users use their phones to access internet related services, and this number has doubled since the first tracking of internet usage on mobile phones in 2009. In addition, about 21% of all adult mobile phone owners nowadays do most of their online browsing using their mobile phones instead of personal computers. More complicated and advanced tasks can be done by smartphones through cloud-based computing. Applications based on cloud technology can scale far beyond the capabilities of any smartphones. More importantly, these mobile phones usually are programmable and programmers have access to the sensor data captured by the phones. The computing and communication resources come with the mobile phones provide abundant opportunities for application developers.

Smartphones are equipped with various sensors and they are carried with people every day. Nowadays, several sensors are integrated into the smartphones. Sensors available on mobile phones can be classified as inertial, positioning,

DOI: 10.4018/978-1-4666-8239-9.ch035

and ambient sensors (Hoseini-Tabatabaei, Gluhak, & Tafazolli, 2013). Each of these types of sensors can be used to sense different aspects of environmental parameters. Figure 1 shows some of the built-in sensors in iPhone 5S. Among all the sensors, the most common sensors in smartphones are accelerometer, gyroscope, GPS, cameras and magnetic sensor in addition to the sensors for the basic phone functions.

Inertial Sensors

Inertial sensors, gyroscopes and accelerometers, were first developed for use in aerospace applications where high performance was needed and their higher prices were tolerated. The advancement of the microelectromechanical systems (MEMS) makes inertial sensors commonly used in several industries including communications, medical, and automotive (Shaeffer, 2013). Inertial sensors are used to measure or detect acceleration, tilt, shock, vibration, rotation, and multiple degrees-of-freedom motion. An important aspect is that accelerometers measure gravity and gyroscopes measure angular rate without external references. Accelerometers have been implemented to measure human physical activities (Fahim, Fatima, Lee, & Park, 2013; Kühnhausen, Leonhardt, Dirk, & Schmiedek, 2013; Pernek, Hummel, & Kokol, 2013), posture recognition (Yurur, Liu, & Moreno, 2013), and rehabilitation (Pfaeffli, Maddison, Jiang, Dalleck, & Löf, 2013). Gyroscopes also have been used in a number of research applications. developed a pedestrian navigation method aided with a visual gyroscope and a visual odometer. Wu, Dasgupta, Ramirez, Peterson

Figure 1. Built-in sensors in iPhone 5S