Cognitive Phone for Sensing Human Behavior

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INTRODUCTION

The *Cognitive Phone* is argued to be the next step in the evolution of the mobile phone. A Cognitive Phone has the abilities of analyzing, storing, extracting and processing information by using the phone platform, including both hardware configuration and intelligent software. It derives the capabilities of sensing and inferring human behavior and social context from the own platform, connected sensors, and/or linked servers. Prof. Campbell Andrew at the Dartmouth College and Associate Prof. Choudhury Tanzeem at Cornell University first introduced the Cognitive Phone concept in 2012. They are also the leading experts in this area.

OVERVIEW

In 2005, Nokia initialized a SensorPlanet Project to use a phone as a sensor in various applications, such as healthcare, traffic monitoring, etc. Eagle and Pentland (2006) introduced reality mining technology based on Bluetooth enabled phones in 2006. Campbell and Choudhury (2012) first introduced the Cognitive Phone concept in 2012.

CURRENT SCIENTIFIC KNOWLEDGE OF COGNITIVE PHONES

The evolution of mobile phones and built-in sensors increase the capability of a mobile phone to become a cognitive platform.

Evolution of Mobile Phone Network

Mobile phone also known as handheld phone or cell phone was first was demonstrated by Motorola in 1973. Mobile phone was designed for the wireless communication of telephones. The first generation (1G) mobile telecommunication using analog technology was produced during 1980s. In 1991, the second generation (2G) digital cellular technology was launched in Finland on the GSM standard. Both 1G and 2G mobile phones are focusing on the voice service. From the third generation of mobile telecommunication, increasing data stream services are demanded by mobile phone users. Besides, users require more computation and connection capabilities to support the diverse mobile applications running on a mobile phone. In the fourth generation of mobile phone network, high speed connection is demanded to support the pervasive applications

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including online movies, high-definition mobile TV, video conferencing, 3D television and cloud computing. The advanced mobile networks enable mobile phones online sensing capabilities in a rich context environment.

Mobile Phone Platform

With the high quality hardware platform configured into a mobile phone, the computing, sensing, and communication capabilities of a mobile phone are fast growing up. Leading hardware platforms enable cognitive phone ability with powerful CPU, featured sensors and several communication modules. The relevant hardware of the-state-of-the-art mobile phones are listed in the Table 1.

The most common mobile operating systems consist of Android, iOS, and Windows Phone. The operating systems provide APIs (Application programming interfaces) for accessing the internal resources of a mobile phone, which offers communication, computing, and sensing capabilities. The mobile phone communication modules consist of Cellular networks, e.g. LTE, 3G, short range wireless communication modules such as Wi-Fi, Bluetooth, and NFC. The state-of-the-art mobile phones are equipped with a quad-core CPU and a RAM more than 1 GB, which allow a mobile phone to run complex applications on-board.

The most important feature of all, a mobile phone contains varying built-in sensors, such as accelerometer, gyroscope, magnetometer, ba-

Table 1. Hardware configuration of mainstream mobile phones

	Samsung Galaxy S5	Apple iPhone 5S	Nokia Lumia 1520
Communication			
Cellular network(4G LTE)	Yes	Yes	Yes
Wi-Fi	Yes	Yes	Yes
Bluetooth(4.0)	Yes	Yes	Yes
NFC	Yes	No	Yes
Computing			
OS	Android 4.4	iOS 7	Windows phone 8.1
CPU	2.6GHz/4 cores/32bit	1.3GHz/2 cores/64bit	1.5GHz/2 cores/32bit
RAM	2G	1G	2G
Storage	16-64G	16-64G	32G
Battery	2600mAh	1560mAh	2000mAh
Sensing			
Camera	16MP	8MP	41MP
Navigation	GPS, A-GPS, GLONASS	GPS, A-GPS, GLONASS, Cell ID, Wi-Fi positioning	GPS, A-GPS, GLONASS, Cell ID, Wi-Fi positioning
Gyroscope	Yes	Yes	Yes
Accelerometer	Yes	Yes	Yes
Magnetometer	Yes	Yes	Yes
Barometer	Yes	No	No
Light sensor	Yes	Yes	Yes
Proximity sensor	Yes	Yes	Yes
Humidity	Yes	No	No
Thermometer	Yes	No	No
Hart rate monitor	Yes	No	No