An Overview of the Capabilities and Limitations of Smartphone Sensors

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ABSTRACT

Few technical details are available about the various sensors embedded in modern smartphones, and what details are available can be hard to assemble and interpret by the broader technical community that uses these devices. Since the physical and electromagnetic aspects of the sensors’ operation can significantly affect the analysis and use of their data, it is essential for those who rely on these data to understand these details. As such, the authors provide a simplified and yet technically precise explanation of some of the sensors found on the Motorola Droid, which are representative of sensors found in most smartphones. The authors specifically explain its proximity sensor, Hall effect magnetometer, capacitive accelerometer, orientation sensor, and light sensor. Each sensor is described using illustrations and experiments that are provided to demonstrate some unexpected behaviors.

Keywords: Android Operating System, Devices, Electromagnetic, Sensors, Smartphones

INTRODUCTION

Mobile phones have transformed so rapidly over the years that they have properly earned the modern moniker smartphones. Ten years ago, a cell phone typically only made phone calls and stored a user’s contacts, whereas, today, capabilities of cell phones seem boundless, from making phone calls, to checking email, to determining GPS coordinates, and even paying for parking. A cell phone has become a highly advanced technological necessity of modern day life.

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Sensor improvements and additions over the years have made a significant impact on cell phone advancements. Sensors have been steadily infiltrating all elements of our lives, such as light sensors used to detect obstacles to a closing garage door, or range sensors used to help park a car. It is only the recent applications of Microelectromechanical systems (MEMs) that have enabled the down-sizing of sensors to micrometer-order sizes that can be practically embedded, with reasonable power consumption, in handheld systems (Waldner, 2008). MEMs sensors are also used in many other applications, such as printers, which use a piezoelectric or thermal bubble ejection to deposit ink on paper, and gaming controllers, which use a MEMs accelerometer or gyroscope to capture a user’s movements.

Advancement in the mobile phone market has come much more rapidly than the accompanying documentation. This lack of information may partially stem from the desire of manufacturers to maintain a competitive advantage in the face of necessary patent disclosures. As a result, many users and developers, who set out to use these sensors, rely on vague or inadequate descriptions, and lack sufficient information to use the sensors correctly. The existing work crudely describes the sensors and how they might be utilized to capture or facilitate interactive activities (Essl & Rohs, 2009). However, this work seeks to address this dearth of information by clarifying some of the mechanisms and functionality of modern phone sensors.

In particular, we discuss the sensors found in the Motorola Droid (2012), providing a technical, user-centered understanding of its sensors, their capabilities, and especially their limitations. In some cases, the sensors found in the Droid are identical to those found in other smartphones. For instance, the Droid and the iPhone 4 both use the LIS331DLH accelerometer manufactured by STMicroelectronics (2009). Even when not identical, the sensors described in this paper typically work in the same fashion as the sensors found in other smartphones, but are simply provided by different manufacturers. Recently, smartphones such as the iPhone 4S, have incorporated gyroscopes to improve orientation sensing. However, this sensor is not discussed in this work.

In each case, we discuss a sensor’s specific characteristics and how its data is accessed. It should be stressed that this is not just an organized summary of data fact sheets about the Motorola Droid sensors, but rather explanations relating to real-world use scenarios of all smartphone sensors. In so doing, we also provide some simple experiments that demonstrate correct and incorrect data that may be provided by these sensors.

**SENSORS**

The Droid smartphone has five main sensors: a proximity sensor, a magnetometer, an accelerometer, an orientation sensor, and a light sensor, all of which enhance the phone’s functionality. Each sensor is embedded in the phone’s circuit board or placed strategically according to its function. In this section, we describe these sensors in greater detail using real world experiments to illustrate their capabilities and limitations.

**Proximity Sensor**

A proximity sensor is used to detect whether an object is located in the vicinity of the phone. Among other uses, this sensor permits the phone’s operating system to lock the keys of the touchscreen when the user makes a phone call. The proximity sensor identifies when the phone is close to the user’s ear and then locks the phone’s touchscreen so that the user’s face does not accidentally press any keys.

The Droid uses an infrared proximity sensor (ORSAM Opto Semiconductors, 2010), which functions through a Light-Emitting Diode (LED) that emits an infrared beam, detecting its own reflection from a proximate object. Infrared light is not typically visible to the naked eye and requires little power or complexity to generate. The detector uses two measurements of a current in a photo-transistor, one taken immediately prior the emitter pulse.
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