SIXTH: Cupid for the Sensor Web

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ABSTRACT

With the vast number of sensors on current and future mobile computing devices, as well as within our environment, a revolution in HCI is taking place. Devices with multiple sensors enable navigation applications, location-based searches, touch-based interfaces with haptic feedback and the promise of Augmented Reality, with devices such as Google Glass on the horizon. These new promising devices possess many sensors but may lack a specific sensor required for a given desired interaction. This paper proposes a solution using the SIXTH middleware platform to act as a matchmaker between devices to share sensor data by means of a sensor web. A brief exemplar case study is presented, where a device designed originally as a sensor-less optical see-through video player becomes self-adaptive by changing its display in response to ambient light data made accessible through a sensor web.

Categories and Subject Descriptors

H.5.1 [**Artificial, augmented, and virtual realities**]: Augmented Reality
; I.4.8 [**Scene Analysis**]: Sensor fusion—*Sensor Web*

Keywords

Android, Augmented Reality, Sensor Web, OSGi

1. INTRODUCTION

With the advent of rich sensor filled devices, new forms of HCI are being made possible. As innovative concepts of how these devices can be used emerge, a need to allow sensors to be shared between them has become apparent. The idea of sharing underpins the original concept of a *sensor web*, originally envisaged in the form of environmental pods that share and use sensor data between them [1]. SIXTH is a middleware for the sensor web that expands on this novel interaction to encompass not only physical sensors but also *cyber sensors*. A cyber sensor is a software-based sensor that enables real-time monitoring of non-physical environments (e.g. social networks, websites, etc.). Part of its function is to act as a matchmaker between applications that require particular data and the sensors that produce it.

A sensor web offers a potential solution to the problem of linking a sensor-rich environment to an Augmented Reality (AR) experience for visualisation and accessibility, so that users may gain greater insights into the myriad of data being generated. Such a technique has been explored before, for instance in the Ubitrack middleware, which shares position and orientation data between multiple devices to achieve a rich AR environment [2]. SIXTH fundamentally differs from this approach by encompassing a range of both physical and cyber sensors and thus is a far more flexible approach to sharing sensors between devices. To understand how this may be achieved, this paper first introduces the SIXTH middleware, and then presents a case study in how the creation of a simple sensor web between two Android devices allows for an improved HCI experience.

2. SIXTH

SIXTH is a Sensor Web Middleware platform targeted at J2SE-compliant platforms. SIXTH integrates sensed data from any source once an *adaptor* has been defined for it. Data sources include both physical sensing platforms such as Android smartphones and cyber sensing platforms such as Twitter, or indeed other middleware systems such as COSM or GSN. The middleware is built on the Open Services Gateway Initiative framework (OSGi), which provides a flexible component framework enabling the addition, removal and update of services at runtime (e.g. the addition of a new adaptor into an already running SIXTH deployment to introduce a new data source).

Functioning as a distributed system, each SIXTH deployment can communicate, via interchangeable communication modules, to share data and in future to spread the load of data processing and reassign sensing tasks. An additional feature is a query abstraction to filter sensor data, which enables end-applications to request data that is pertinent to their needs. Queries can be written using an SQL-like query language or directly as POJOs. Information about the middleware itself can also be requested (e.g. to receive notices of sensor status). Adaptors have been developed for a variety of physical sensing devices (e.g. Android devices, SunSPOT and Shimmer wireless sensors) and cyber data sources (e.g

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Twitter, COSM). These provide a stream of data to the middleware and also provide a means to alter the operation of the devices through retasking interfaces. The architecture and functionality of SIXTH is discussed in more detail in [3].

3. AMBIENT LIGHT SENSOR SHARING

A case study was developed whereby SIXTH was utilised to provide ambient light level sensor data from an Android Smartphone (Samsung Galaxy Nexus) to an Android Head Mounted Display (HMD) device (Epson Moverio BT-100), which contains no sensors. The HMD consists of a transparent display that facilitates AR experiences. The ambient light data from the smartphone allows the brightness of the AR glasses to be adjusted so that the image they display remains clear and undistorted due to ambient light levels.

Integrating SIXTH into an Android application poses a number of technical obstacles. The primary obstacle is that of conflicting classloaders (since SIXTH runs within OSGi and Android applications do not). To make use of the classes and systems within SIXTH, the Android application requires access to a library exposing the SIXTH functionality.

To solve this problem, we utilised an OSGi feature that facilitates a dependency on code from a specific package without actually identifying that package. This allowed for the creation of a code library on the OSGi side, and an identical application library on the Android side. Both the SIXTH Android Adaptor and the Android application were both then made dependent on this "SIXTH-Android Common Interface Library" (referred to as the "Common Library").

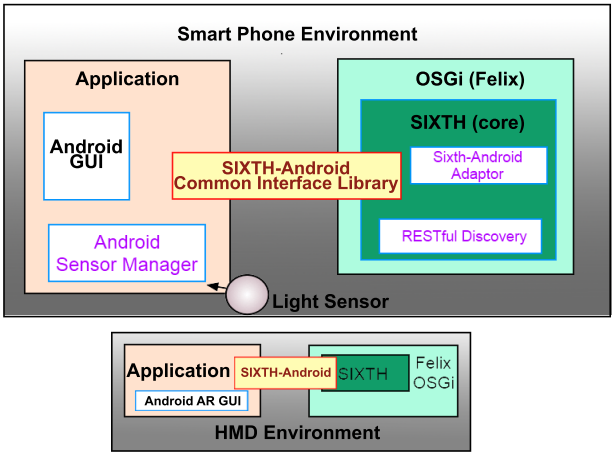

Figure 1: Outline of the case study applications in both the smartphone and HMD environments

An outline of how SIXTH works in both a smartphone and HMD device is given in Figure 1. Overall the system consists of 2 main components: the Android application and the OSGi framework. A SIXTH Android Adaptor was also developed, which uses the Common Library to gain control of any sensors on the Android application side with the help of Android's Sensor Manager. The Android application contains all the systems that manage and interact with the various subsystems (e.g. GUI, Sensor Manager and the WiFi Manager). The OSGi framework, within which SIXTH is run, is provided by embedding the Apache Felix OSGi framework implementation into the Android environment.

During run-time, the OSGi environment can be configured to expose the packages of the Common Library, which are actually loaded by the Android classloader. Exposing this Common Library to the OSGi environment allows its use by any OSGi plugin dependent on it. This allows both the Android and OSGi components to communicate with each other via Common Library classes.

The SIXTH-Android Adaptor exposes its functionality by implementing the interfaces present in the Common Library, thus allowing the actual Android application to access this exposed functionality from the OSGi runtime. The Android application can manage and notify the SIXTH-Android Adaptor about the sensors and systems present on the smartphone. This gives SIXTH access to the Android application's sensor manager and GUI elements, and the Android application access to the SIXTH Android Adaptor and RESTful Discovery bundles. The RESTful Discovery service provides remote discovery and communication services to SIXTH through a RESTful communication protocol. Discovery of remote instances of the SIXTH framework is achieved using the JmDNS library [4].

4. CONCLUSION

This paper has demonstrated the SIXTH middleware and a case study for its use in a HCI context. By matching a sensor-deficient device with one featuring an ambient light sensor, an improved AR experience can be created. This motivates further investigation into other types of available physical and cyber sensor data that could similarly improve user experience.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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