Giving Mobile Devices a SIXTH Sense: Introducing the SIXTH Middleware for Augmented Reality Applications

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ABSTRACT

With the increasing availability of sensors within smartphones and within the world at large, a question arises about how this sensor data can be leveraged by Augmented Reality (AR) devices. AR devices have traditionally been limited by the capability of a given device's unique set of sensors. Connecting sensors from multiple devices using a Sensor Web could address this problem. Through leveraging this Sensor Web existing AR environments could be improved and new scenarios made possible, with devices that previously could not have being used as part of an AR environment.

This paper proposes the use of SIXTH: a middleware designed to generate a Sensor Web, which allows a device to leverage heterogeneous external sensors within its environment to help facilitate the creation of richer AR experiences. This paper will present a worst case scenario, in which the device chosen will be a see-through, Android-based Head Mounted Display that has no access to sensors. This device is transformed into an AR device through the creation of a Sensor Web allowing it to sense its environment facilitated through the use of SIXTH.

Keywords: Android Augmented Reality, Sensor Web, OSGi

Index Terms: H.5.1 [Artificial, augmented, and virtual realities]: ;— [I.4.8]: Scene Analysis—Sensor fusion

1 INTRODUCTION AND RELATED WORK

With the increasing abundance of sensors in our environment and within modern smartphones, these sensors offer the crucial infrastructure to support the tantalising dream of ubiquitous computing. How to connect this infrastructure is on ongoing research question. One approach has been to leverage the abundance of sensors by creating a Sensor Web [6], where each sensor is a node capable of sensing and processing information. SIXTH middleware facilities the creation of a Sensor Web and offers the potential to use Augmented Reality (AR) as a visualisation tool for the Sensor Web. This simultaneously offers the possibility that a Sensor Web could be leveraged as a source of orientation and position information to create an AR experience.

The crucial problem with leveraging a Sensor Web to achieve this vision is that sensors are heterogeneous in nature. This problem has been addressed through the use of middleware platforms that allow for adaptors to be written for heterogeneous sensors to standardise their communication within a Sensor Web. This approach was first identified within the AR field with the development of the Ubitrack middleware [5, 7]. Other frameworks such as TREC [4] have prioritised the provision of a high level abstract layer that includes virtual sensors to allow for sensor fusion. Finally, a middleware in development by Ferreira [2] concentrates on providing the necessary tools to support large-scale sensor networks over 3G telecommunication networks to support AR gaming applications.

SIXTH differs from these previous approaches in numerous ways. Principally, it is designed to provide a heterogeneous Sensor Web that encompasses multiple types of physical sensors as well as support for virtual and cyber sensors. This paper will first outline SIXTH and its abilities. With that grounding, a case study based on several Android devices and a non-Android device will be described to illustrate the potential of SIXTH. This is followed by an outline of the future worked planned for exploring the use of SIXTH in the development of AR applications on Android-based devices such as Google Glass.

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2 SIXTH ARCHITECTURE

SIXTH is a Java-based Sensor Web middleware platform that provides an integration framework for gathering sensed data from any source. The SIXTH API allows the creation of new *adaptors* to facilitate connection with an external data source (e.g. a Wireless Sensor Network or a RESTful API). SIXTH is built on the Open Service Gateway Inititive framework (OSGi), which is a modular component-based framework. This basis allows for the creation of dynamic sensor applications in which new data sources can be added and removed at runtime. The SIXTH core is defined as a set of interfaces that model elements of a sensing network that are represented within the middleware. Examples include sensor nodes and their individual sensors and modalities. These interfaces also define the scaffolding for working with these core conceptual sensing device models, for example the query interface. To give an understanding to the overall functionality of the SIXTH middleware, an architecture diagram is shown in Figure 1. Given the nature of this short paper, a detailed treatment on SIXTH is available in [6].

3 CASE STUDY: AR IN SENSOR DEFICIENT DISPLAYS

The aim of this case study is to demonstrate the ability to send and receive data between multiple devices: one a sensor-rich Android smartphone (specifically a HTC Wildfire), a Shimmer sensor and a sensor-deficient Android Head Mounted Display (HMD) device (Epson Moverio BT-100). The Android HMD device was given access to the both the smartphone's sensors and Shimmer sensors allowing for a basic AR interaction similar to the popular Layar application where a blue circle representing a destination is placed in the correct position in front of the user seen through the HMD display. Data from the Shimmers's digital compass and accelerometer are used to calculate the orientation of the HMD as the Shimmer is placed directly on top of the HMD. The Shimmer thus tracks the head of the user while the smartphone sensors are used to track the user's body orientation and position. The smartphone also plays a second role in the Sensor Web as it uses its bluetooth capabilities to connect to the Shimmer, while the smartphone and HMD are connected through WiFi. Additional sensors within the smartphone allow for positioning information such as GPS to be utilised. In the future, additional sensors could be

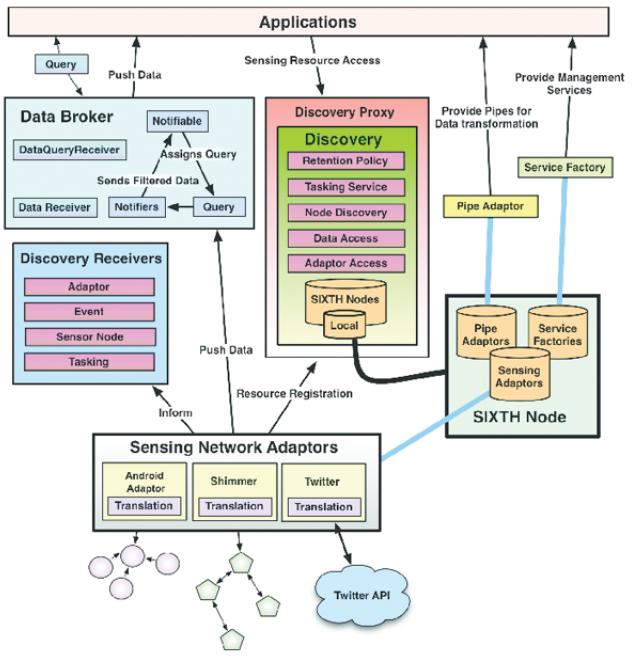

Figure 1: The SIXTH Middleware Architecture

added to this Sensor Web to allow for indoor tracking. To create a Sensor Web between these devices, a SIXTH Android Adaptor was developed that utilises a SIXTH-Android Common Interface Library. To achieve this, the Apache Felix OSGi implementation (`http://felix.apache.org`) was embedded into the Android environment. The Common Library allows the SIXTH Android Adaptor to communicate with Android's Sensor Manager and to access the actual embedded sensor within the smartphone itself. This Adaptor also uses the Common Library to notify the Android Application that it should update the GUI elements on the phone's screen. A discovery bundle then allows for the detection of other SIXTH deployments running on other devices, both Android and non-Android. SIXTH, which consists of both implementation and interface bundles, is run within the Felix OSGi environment on both Android devices. The SIXTH-Android Common Interface Library acts as a bridge between the OSGi environment and the Android Application. Specifically, 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 SIXTH Android Adaptor and RESTful Discovery bundles are implemented as OSGi bundles and run in this Android embedded Felix OSGi environment, as outlined in Figure 2.

4 Conclusion and Future Work

This introduction of the SIXTH middleware aims to explain how a Sensor Web can be generated by multiple sensors on numerous devices and can allow for AR applications to be implemented on sensor-deficient devices. This middleware is the first to our knowledge that allows for Android-based devices to become part of a Sensor Web and shows its potential to be used for future embedded AR interaction [3]. To help facilitate research in this area, SIXTH middleware and the SIXTH Android adaptor are to be released under a non-commercial licence (`http://sixth.ucd.ie`). We believe that the concept of a Sensor Web will become an increasingly crucial underlying technology to facilitate the visualisation of the Internet of Things.

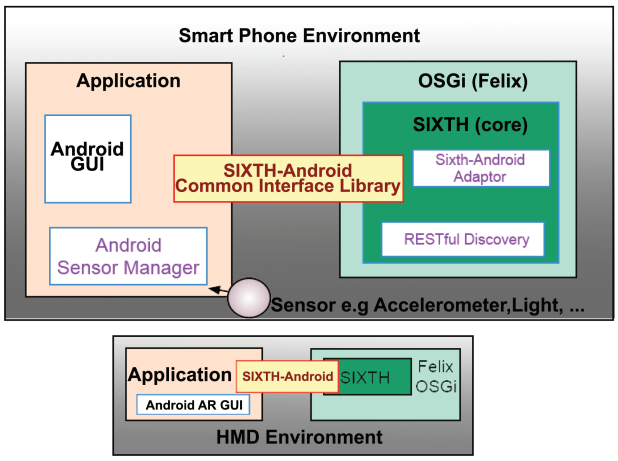

Figure 2: Outline of the Case study applications in both the Smart phone and HMD environments

To explore the functionality of the SIXTH Android adaptor, future work includes examining its ability to share sensors from multiple devices and to undertake a comparison between using smartphones, see-though AR platforms like GoogLe Glass and VR HMDs such as the Oculus Rift. Other future demonstrators include developing a prototype AR navigation application that can use both indoor tracking networks as well as rely on mobile phone sensors (e.g. for a maintenance technician exploring a building to test sensors throughout the network). These new applications also generate new research questions on how best to interact with their users. To answer this question it is intended to explore new interface paradigms such as intelligent AR agents [1].

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