Demo Abstract - SIGAR: Sensor Integrated Gateway using Augmented Reality

Ishan Bansal, Nagarjun Bhat, Agrim Gupta, Harine Govindarajan, Dinesh Bharadia
University of California San Diego
La Jolla, United States
{isbansal,nbhat,agg003,hgovindarajan,dbharadia}@ucsd.edu

Abstract

We introduce SIGAR, a Sensor Integration Gateway using Augmented Reality, which combines RFID-based passive sensing with AR for real-time visualization. Using batteryless, wireless RFID sensors, SIGAR eliminates the need for power sources, enabling sustainable and cost-effective monitoring. A mobile app automatically detects sensors within the camera's field of view and overlays real-time sensory data onto the physical environment. Demonstrated through applications like force, soil moisture and light sensing, SIGAR provides intuitive, context-aware insights for environmental monitoring, inventory management, and more. This fusion of AR and passive sensing bridges digital and physical worlds, offering scalable, low-power IoT solutions.

CCS Concepts

• **Hardware** → **Sensor devices and platforms**; **Wireless integrated network sensors**; **Sensor applications and deployments**.

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Figure 1: Illustrative image showing the prowess of SIGAR in detecting sensors in the camera's field of view and displaying their real-time responses

1 Introduction

Remote sensing endeavors are fundamentally reliant on the acquisition of precise and spatially contextualized data. However, the practical implementation of dense sensor networks across diverse and often inaccessible environments presents significant logistical and economic hurdles. This demonstration introduces SIGAR: a Sensor Integrated Gateway using Augmented Reality, a novel mobile application poised to transform the paradigm of remote sensor data interaction and visualization. SIGAR leverages the intuitive power of augmented reality to seamlessly overlay real-time sensor readings directly onto the user's view of the physical environment, thereby enhancing data comprehension and interpretation.

A key innovation of SIGAR lies in its integration with batteryless, wireless RFID sensors such as force. This design choice eliminates the dependence on traditional power sources, enabling the deployment of sustainable, cost-effective, and broadly distributed sensor networks. Building upon the concept of sensor interfaces like ZenseTag [1], which utilize radio frequencies to directly transmit sensor data, SIGAR autonomously detects compatible RFID sensors within the mobile phone's camera's field of view or from a static image. The app then dynamically overlays the sensors' real-time values onto the screen, creating an augmented reality experience that connects the digital and physical realms.

This fusion of AR and passive sensing facilitates an intuitive and context-aware understanding of sensor data [2]. This capability is paramount for enabling ubiquitous sensing of a wide range of natural phenomena, including soil moisture levels, ambient light intensity, weights, and other environmental parameters as illustrated in Fig. 1. This paves the way for significant advancements in diverse fields such as precision agriculture [3], environmental conservation efforts, infrastructure monitoring, and a multitude of other remote sensing applications. SIGAR provides a scalable and accessible low-power IoT solution that offers a user-friendly interface, making it a compelling tool for researchers, practitioners, and citizen scientists alike. The simplicity and portability of SIGAR make it an ideal platform for collecting data in remote locations.

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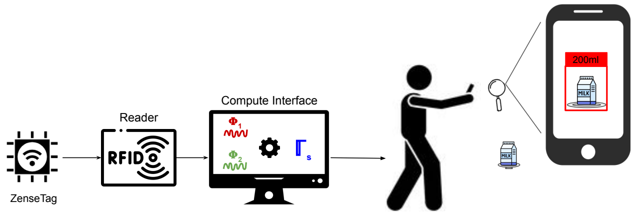

Figure 2: Illustration showing the end-to-end design of SIGAR where Γ_s represents the true sensory outcome.

2 Design Overview of SIGAR

The design of SIGAR comprises of three key components: ZenseTag [1] based sensors, an RFID interface software which is capable of retrieving data from an UHF RFID Reader like the Impinj R700 and the android application which can detect the sensors and overlay the viewfinder with their sensory response. The illustration of SIGAR can be seen in Fig. 2

2.1 Deployment of Sensors

We have built our sensors as proposed in ZenseTag [1] and deployed them in a similar fashion as mentioned in [4].

2.2 Reader - Compute Interface

We interface the RFID reader with a general-purpose compute device running Windows, Mac, or Linux. The software, built atop the Impinj Octane SDK, retrieves signal parameters and implements a signal processing algorithm to correctly interpret the differential phase. This phase is then mapped to sensory values in grams, lux, or relative moisture content for the corresponding sensors based on a preset calibration. These values, along with sensor keys, are transmitted over a socket for retrieval by the phone application. The software's versatility is demonstrated by its ability to automatically adjust calculations based on the specific sensor being read at any given moment, ensuring accurate and adaptive data interpretation across various sensing applications.

2.3 Android Application

Building upon the compute software package, we developed an augmented reality Android app that enhances the user experience. This app automatically detects sensors in the device's live camera feed or selected images, displaying real-time sensory stimuli which it retrieves from the data streamed over the HTTP socket. Leveraging Google's MLKit library, the app is compatible with Android 9 (API level 28) or newer devices. It requires an initial setup to link sensory tag identities with their specific purposes. Once configured, the app matches objects in the camera view with their corresponding sensors through object detection and optical character recognition, enabling seamless visualization of live sensory outcomes in an augmented reality environment.

3 Presentation of SIGAR

The demonstration will showcase the capability of SIGAR to detect sensor responses in real-time and display them on the phone's camera feed implicitly converting the phone into a sensor hub.

3.1 Experimental Setup:

The demonstration will require a PC to be connected to an Impinj RF reader which in turn is connected to a high-gain antenna that is kept within range of the sensors being trialed. We will setup a socket connection between the PC and our mobile device while having both devices connected over the same network through a mobile hotspot. The android app will have a live camera feed which can be pointed to the objects which will be recognized and augmented with the corresponding sensor response.

(a) Sensory output showing the weight of salt in the container.

(b) Sensory output showing the soil moisture content of potted soil.

Figure 3: SIGAR in action showing the sensory responses in the viewfinder of the mobile phone in the android application.

3.2 Demonstration:

In order to demonstrate the working of SIGAR for detecting soil-moisture and force, we will vary the soil moisture levels by pouring water in a pot of dry soil, and attach force sensors to kitchen containers to measure weights of food items to showcase the sensory response for each application which will be visible on the android application in real-time as shown in Fig. 3. This demonstration will also exhibit SIGAR's robustness to the presence of objects and the movement of people in and around the deployed sensors. We have evaluated these sensors: soil moisture (Fig. 3b), force (Fig. 3a).

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