Demo: Ubiquitous Interaction with Smart Objects

Jan Rüth, Hanno Wirtz, Klaus Wehrle
Chair of Communication and Distributed Systems (COMSYS)
RWTH Aachen University
{rueth, wirtz, wehrle}@comsys.rwth-aachen.de

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1. INTRODUCTION

Increasingly, everyday physical objects become "smart" by making their functionality accessible, controllable, and extensible for Internet-based users and services via a connection to the digital world. Deployed in scenarios that range from private households over offices to public spaces, smart objects enable ubiquitous "smart spaces" that build on interaction with mobile users. However, ubiquitous interaction with smart objects is currently complicated by three factors. 1) Communication with objects requires Internet or local network access, a requirement that is not met under ground, abroad, or when lacking access credentials to 802.11 networks. 2) Identifying a specific object from the envisioned billions of objects requires a suitable discovery mechanism, introducing delays and mandating object owners to disclose object semantics. 3) Interacting with object functionalities mandates an a-priori installation of a specific app, that provides a human-usable interface, per object and use case, resulting in an abundance of (redundant) apps. We argue that smart object interaction is thereby restricted to pre-defined scenarios and objects, e.g., at home or in offices.

In this demonstration, we strive to make smart object interaction ubiquitous. Current approaches abstract from user locations and contexts via the Internet but lack support for spontaneous discovery and interaction with possibly unknown objects in the immediate vicinity of the user. In order to enable such interaction, we address the aforementioned factors by 1) enabling *direct* communication and interaction with objects over Bluetooth 4.0 Low Energy (BLE), removing the need for network access and reducing the discovery scope to the intuitive local interaction scope of the user and 2) enable smart objects to *unmediatedly* specify their functionality and interaction possibilities as well as their interface and its representation to users in a lightweight, generic, and extensible way, allowing for unrestricted, spontaneous interaction.

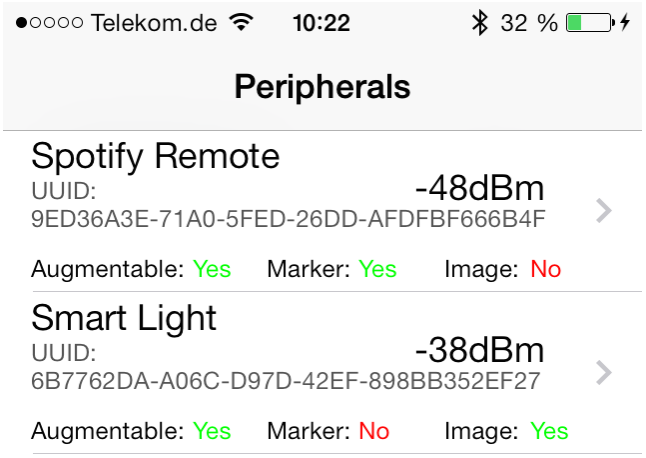

Figure 1: Discovery of nearby smart objects and their abilities. Objects can be recognized using a visual "Marker" or via computer vision ("Image").

2. SYSTEM OVERVIEW

Recent approaches [1] show the benefit of smart object interaction via a tactile virtual GUI that provides an intuitive interface to the object functionality. Specifically, the visually recognized object in the camera view is virtually augmented with the GUI. Especially in unknown scenarios, virtual interfaces greatly assist in understanding object functionalities and interfaces. Moreover, a virtually augmented GUI allows for more complex and versatile interaction mechanisms than a static, non-modifiable hardware interface. We thus enable smart objects to provide their GUI and underlying commands directly to mobile users, mitigating the requirement of pre-distributed GUI descriptions and network access as in [1]. Objects thus store and transmit a visual fingerprint of themselves as well as a generic definition of the GUI elements and their position relative to the object's visual appearance in the camera view.

We build on BLE as the communication channel for its energy efficiency, lightweight protocol stack, low cost factor, and proliferation in current smartphones. We offer two mech-

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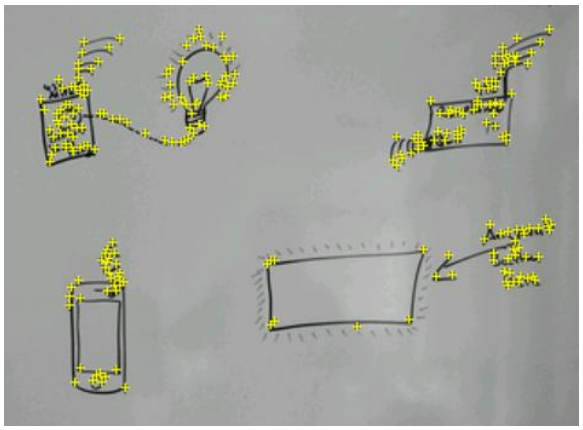

Figure 2: Artificial example of feature points (yellow plus signs) that the object transmits to the mobile device and that identify an object in computer vision recognition and subsequent GUI augmentation.

Figure 3: Visual marker attached to a computer screen. Augmented GUI elements relative to the marker provide an touch-based interface to interact with the underlying music player.

anisms for object discovery, cf. Figure 1, by mobile devices that present a tradeoff between obtrusiveness and communication overhead. First, objects can be visually recognized using a physically attached marker which is indicated to mobile devices using an marker ID and its dimensions. Alternatively, objects provide computer vision (CV) material, c.f. Figure 2, to enable CV-based recognition. CV recognition is physically less obtrusive at higher communication costs.

We utilize the Qualcomm Vuforia framework [2] to augment the camera view with 3D GUI elements as visible in Figure 3. The mobile user is able to interact with the GUI elements through the smartphone's touch screen. We then translate GUI actions into interaction commands transmitted to the object via BLE. Upon reception the smart object can trigger the requested functionality. Thereby the smartphone itself must not know the specific underlying technology of the smart objects thus enabling a generic and ubiquitous use.

3. DESCRIPTION OF DEMONSTRATION

We demonstrate our approach with iOS smartphones and a number of everyday objects to illustrate the design space of smart object interaction. The demonstration will allow discovery and selection of nearby objects and subsequent visual recognition and GUI interaction. We strive for a smart object setup that comprises "naturally" smart objects, such as a laptop, and objects whose physical functionality is extended using our approach. Conference participants will be able to interact with objects and change the interaction GUI of objects to show the flexibility and spontaneity of ubiquitous smart object interaction.

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4. REFERENCES

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