Boston University
Electrical & Computer Engineering
EC463 Capstone Senior Design Project

Problem Definition and Requirements Review

Home Enabled Holographic Devices

Submitted to

George Matthews
Microsoft New England Research and Development Center
1 Memorial Drive #1
Cambridge, MA
(617) 453 - 6000
george.matthews@microsoft.com

by

Team 13
Positional Tracking Group

Team Members

Allison Durkan azulad7@bu.edu
Edwin Fitzpatrick ejfitz@bu.edu
Johan Sebastian Ospina johanos@bu.edu
Tess Gauthier tgauth@bu.edu
Santiago Beltran sbeltran@bu.edu

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Customer Sign-Off

Home Enabled Holographic Devices

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Project Summary

Using Microsoft HoloLens we will be creating a platform to find, connect, track, and control existing internet-connected devices in the home. This will be split up into three facets: design the platform that allows these Internet of Things devices to speak to HoloLens, build a piece of hardware that can act as a marker to be tracked by HoloLens, and create an application for the HoloLens that allows it to control the interface of our platform.

1 Need for this Project

The average modern home supports 10 internet connected devices. This ranges from mobile phones, to routers, to internet connected TVs, to personal computers. According to Reuters, that number will jump to 50 by 2020. Many of the devices we use today have interactive displays that make it easy to control, but most of the 500 percent jump will be made up of devices that have a single purpose and small so they either need to have a very limited display, or none at all. This makes setting up, controlling, and maintaining these products less obvious and therefore more difficult.

This first step of creating an augmented reality interface will be for early adopters who already have dozens of internet connected devices in their home. Currently, the best solution for managing multiple devices is a mobile application. It shows a list of IoT devices on your network and you tap on each one to control it. That solution works well with 5 devices, but becomes overwhelming as you add more. Competitors suspect the solution to this problem is voice control, which initially sounds promising, but remembering the given name of each of your thirty devices and their supported functions becomes just as overwhelming.

Today, our solution will require a three-thousand-dollar headset, but tomorrow that headset will look like a pair a glasses and cost a few hundred dollars. Today, this is only a solution for people who dive into new technology early and easily, but soon the average consumer will be able to empathize with the problem of controlling the dozens of smart home devices. Allowing even the smallest device to display an uncompromised interface will make technology in the home easier to use for everyone.

2 Problem Statement and Deliverables

Technology in the home is hard to use. In modern homes, internet connected devices surround people, from smart TVs to wireless speakers and even technology like printers and smart locks. Controlling these different devices consists of multiple applications, either mobile or web, ranging even to clunky interfaces that are inconsistent between types of devices and not intuitive for the everyday user. This creates frustration and dissatisfaction with consumers who have purchased these smart devices with the belief that they are going to simplify and modernize their lives. People have to figure out how to install these devices, how to connect them to the internet to enable them to function properly and how to interact with each device through the device's separate interface.

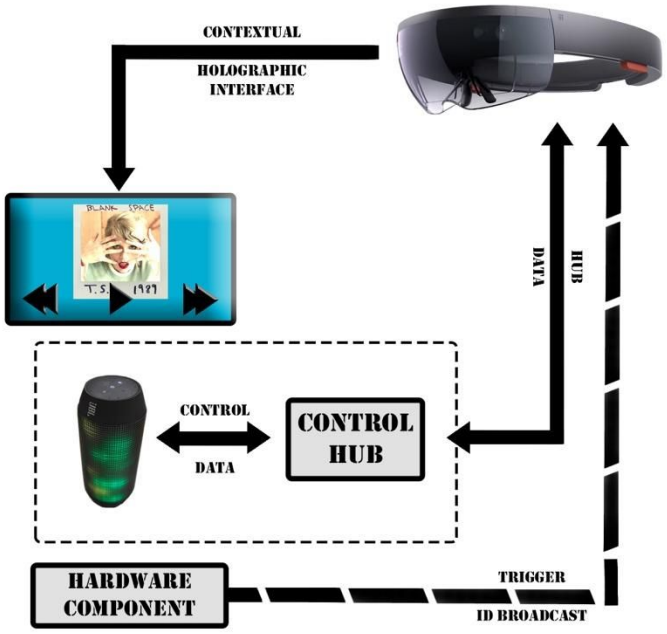
The first piece we will deliver is the platform that allows the HoloLens to interface with devices via an existing IoT hub. Manufacturers will enable its devices for holographic control by adding a uniquely identifiable constellation using the marker standard defined in our micro SDK. Within the SDK we will have pre-built, consistent, holographic items to build the interface within the device. This will allow for modular creation of holographic elements with triggers that connect via APIs to the device. An example of this would be an electronic door lock where a device maker would embed the constellation in the hardware and in our SDK establish the holographic interface based on our sandbox area and holographic elements. For the door lock, the interface would include a lock and unlock button, with button handlers that link via an API, to unlock the door or lock the door respectively.

By having a Holographic Interface SDK, all interactions would be clear, coherent, and consistent across devices. The SDK contains holographic interface elements built up of buttons, switches, sliders, image areas, input areas, text areas, and other primitive UI elements. The control interface that hovers over IoT devices would be built of the these elements into a panel and be written by the device manufacturer via a XML-standard file to layout the elements accordingly.

The second deliverable is a Universal Windows Platform (UWP) application to run on the Microsoft HoloLens. The Microsoft HoloLens is a fully untethered, augmented reality headset that runs Windows 10 and allows users to interact with holograms in the space around them. Because this device runs Windows 10, we can create a UWP application that will run on the HoloLens. This application will connect the device with smart technology in the home and present the consistent, intuitive interface to go with different types of devices provided by our platform. For example, speakers would have the same type of holographic display above them, even though they would be different brands of speakers. This would allow for a more consistent user experience across devices in the home and can be achieved with a UWP application for HoloLens.

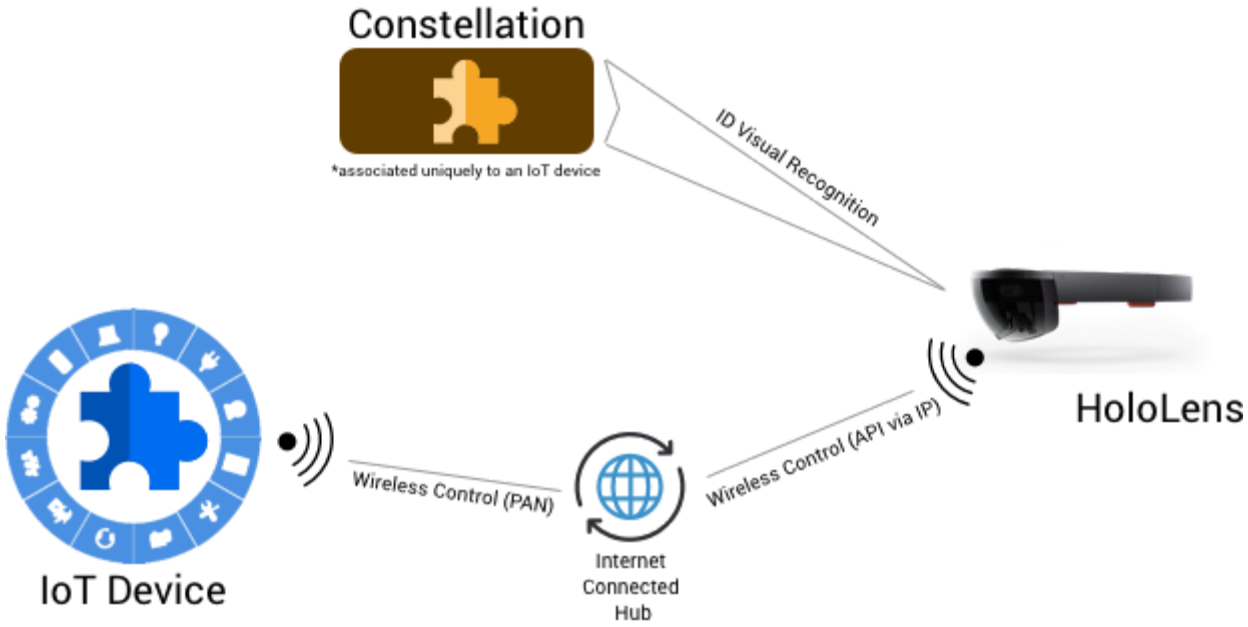
The third deliverable we will create is a hardware component that will allow the HoloLens to track objects that are moved in the space the user is in. Currently, the spatial mapping capabilities of the HoloLens limit the abilities to keep track of where devices rest in the room. For example, if a room was mapped, the HoloLens would be able to detect there was an object in it and create interactions around the space it occupies, but if that device was then moved to somewhere else in the room, it has no way to tell that the object in the new mapping is the same as the other object. We are going to make a hardware component that the HoloLens will be able to detect and recognize as smart devices move about the rooms in a home.

3 Visualization



System Architecture

The system architecture will consist of three main components, the first of which is the Microsoft HoloLens. This HoloLens will enable the holographic interaction between the user and their IoT devices. It will keep track of all the prefabricated holographic models for the devices it knows how to use, then it will display the appropriate user interface for that enabled device. When the HoloLens is surveying a room and encounters an enabled device, the hardware component will provide the HoloLens a signal and data about said device. The HoloLens will then at that point process the information it received and communicate the intended action from the user to the control hub, which will be in charge of managing the IoT devices.



Communication Architecture

A higher level visualization of this system shows that the HoloLens will get a trigger from any constellation that is in the field of view and display an appropriate user interface. After the user interacts with the interface, the HoloLens will initiate an API call to a hub that controls the internet connected device to execute an action and collect status data.

4 Competing Technologies

The area of IoT is highly competitive with many manufacturers upgrading existing systems to the connected devices that shape the smart homes we find today. With the increase in these individual components, companies have been developing hubs and standards to unify the experience via various mechanisms including shared APIs, proprietary frameworks, and wireless standards to name a few. These create two distinct kinds of competitive forces in the IoT market: hardware/accessory manufacturers and the software hub developers that connect the devices themselves. For this projects, our primary competing technology are the smart home hubs that bridge an interface between hardware and the user. The competitors this report will address in area are Apple HomeKit, Wink, Amazon Alexa, Samsung SmartThings, WeMo, and AT&T Digital Life.

Apple HomeKit - The HomeKit framework enables developers and device manufacturers to build IoT tools using a common communication protocol. As a proprietary protocol, manufacturers must enroll in the program to receive the technical details to connect into the HomeKit interface. Manufacturers are also required to embed specific hardware in their devices for security purposes. On the user interaction side, iOS has a built-in app that displays all the connected devices and customized controls to interface with the device features.

SmartThings and Wink - Wink and the SmartThings Hubs function similarly to HomeKit as a proprietary protocol accessible via manufacture enrollment. Wink connected devices communicate via ZigBee, Z-Wave, and Bluetooth to the hub, and the hub interface is inside a mobile app that give the list of connected devices and the methods to interface with them.

Amazon Alexa - Amazon uses Alexa and the Echo speaker to connect IoT devices and allows user interaction via voice commands.

AT&T Digital Life - This implementation of a IoT hub is the most distinctive of those mentioned as it is packaged as a subscription service with access to AT&T branded IoT devices. The devices connect to the AT&T security system as a hub, and then the user interacts with the devices via the web or a AT&T Digital Life app on a mobile device.

5 Engineering Requirements

The table below details the specific objectives, constraints, functions, and means for the project. To provide a brief overview, the core objectives of the project consist of creating a marketable and widely-distributed platform for consumers to interact with IoT in the home. The main functions of the project revolve around displaying information about IoT devices in the home and allowing the user to interact with IoT devices through the display we will create for the HoloLens. The means listed below provide methods for achieving the desired functions. For example, positional tracking of IoT devices, through a constellation ID tracker or Software Development Kit like Vuforia, represent a means that will enable the functionality of recognizing the spatial location of an IoT device and synchronizing an AR display with it. The constraints span the limitations of the HoloLens, as well as existing IoT devices in the home, that may not have the capability of sharing or providing information that the user would benefit from knowing when wearing the HoloLens.

Currently, developing applications for the HoloLens requires use of Unity to build software, and then Visual Studio to deploy software to the HoloLens. The hardware components will attach to IoT devices for positional tracking, therefore it must be small, portable, and inconspicuous, as not to disturb the aesthetic of the home.

Table 1.1 Engineering Requirements of Simplifying the Interaction Between Humans and Smart Devices (O = Objective, C = Constraint, F = Function, M = Means)

Characteristics	O	C	F	M
Create a useable software platform for Microsoft HoloLens	X			
Improve user's interactions with in-home IoT devices	X			
Accessible and easy to use, even for user's with limited technical experience	X			
Recognize, and distinguish between, IoT devices in a room			X	
Establish connections with the IoT devices			X	
Communicate with IoT devices			X	
Recognize the spatial location of an IoT device			X	
Display information through AR about the IoT device			X	

Synchronize AR display with IoT device position			X	
Facilitate interaction with IoT device through AR display			X	
Constellation ID Tracker, or similar hardware component				X
API-based controller				X
Network protocols to send to, and receive data from, a specified device				X
Use Unity and Universal Windows Platform for Software Development		X		
Portability of hardware component		X		
Must consider limitations of HoloLens spatial mapping		X		
Must consider ability to control existing IoT devices		X		

6 Appendix A References.

Internet of Things: By 2020, You'll Own 50 Internet-Connected Devices:
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