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User Interaction with IoT Devices in Augmented Reality

Philip Colladay, Aidas Jakubenas, Jeffrey Matheson, Anvita Patel, Andrew Tran

Department of Electrical and Computer Engineering, University of Massachusetts, Amherst

BACKGROUND AND MOTIVATION:

Most IoT devices do not have physical interfaces to configure them. Traditional model is to rely on device-specific mobile applications that communicate with IoT devices for device discovery, configuration and management. This model demands *N* number of applications for *N* devices and does not scale well. There is a need for a generalized architecture and middleware that provides interaction with heterogeneous devices through a common interface. Augmented Reality (AR) is one such interface that is an intuitive way to interact with heterogeneous IoT devices in one's environment. It can enable smart, seamless, and secure interaction with heterogeneous devices.

PROBLEM STATEMENT:

Current IoT solutions require a separate application for each IoT device, which makes managing and interacting with these devices tedious and challenging. Additionally, smart home solutions to address accessibility are meant to cater to everyone. Thus, increased convenience is desired. Our solution aims to address these problems by using a common application to discover and control all IoT devices.

GOALS:

- Create an AR app to configure and control IoT devices
- Discover IoT devices automatically in AR
- Visualize sensor data in AR
- Control IoT devices through digital knobs in AR, and visualize its effects

DESIGN ALTERNATIVES:

Web Bluetooth Model:

- Requires a user to manually navigate a website to select the IoT device for connection [1]

Physical Web Model:

- The usability of the application is negatively affected when the number of IoT devices increases [2]

Dedicated Server Controller Model:

- Single point of failure; entire IoT ecosystem fails if server fails

METHODOLOGY:

System Specifications:

Hardware:

- Each IoT device shall communicate with the cloud
- Each IoT device shall be configured using the cloud
- The incorporation of IoT devices shall be modular, as opposed to a fixed number of devices

Software:

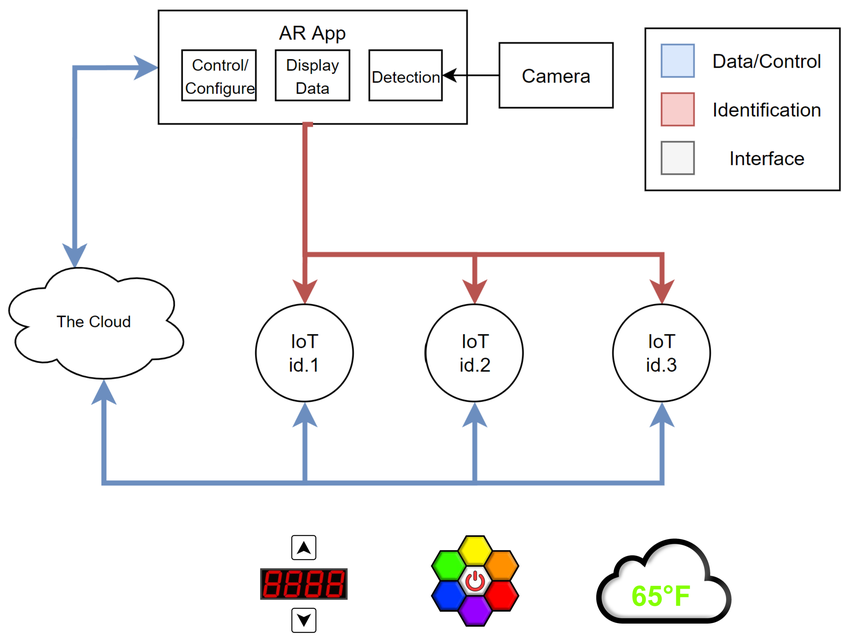
- AR App shall detect unique identifiers
- AR App shall track each identified visually
- AR App shall communicate with the cloud to distribute control commands

Solution:

We created a primitive framework that enables the user to centralize the control of *N* IoT devices through a single application for end user convenience. Our framework utilizes a simple communication method that connects the Particle I/O Cloud and RESTful APIs. This solution can instantly detect these IoT devices through recognition of target images using Unity/Vuforia.

Implementation:

Hardware Diagram:



RESULTS:

Evaluation:

Performance Latency:

- Average for executing commands: 0.53 seconds
- Average for reading sensor data: 0.12 seconds

User Gesture Analysis:

- Discovery: Place camera over device (1)
- Setup: Configure device to network, add device to cloud (2)
- Interaction: UI autoconnects, perform action (1)

Accessibility:

- Works with iOS and Android
- Many alternative solutions only work on Android

Size: 145.1 MB

Challenges and Limitations:

- Relies on internet connection
- Relies on the Particle I/O Cloud

Tradeoffs:

The use of cloud interface:

- Quick
- Abstracts away device management
- No single-point of failure unlike dedicated server

Technical Contribution:

1. Centralization of multiple IoT devices through one common application
2. Decouple the control of the device from its physical location
3. Performance latency is much smaller than previous work

REFERENCES:

[1] T. Zachariah and P. Dutta, "Browsing the Web of Things in Mobile Augmented Reality," Proceedings of the 20th International Workshop on Mobile Computing Systems and Applications, 2019.

[2] T. Zachariah, J. Adkins, and P. Dutta, "Browsing the Web of Connectable Things." [Online]. Available: https://lab11.eecs.berkeley.edu/content/pubs/zachariah20summon.pdf.