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1 Introduction

1.1 Acknowledgement

We would like to thank Daji Qiao for pointing us in the right direction when it comes to our communications technologies.

We would also like to acknowledge Andrew, our client. He always believes in us and gives us hope whenever we would meet. He is the perfect client, giving the team concise requirements and being understand of our lives outside of senior design.

1.2 Problem and Project Statement

Problem: There are inherently a lot of problems with not knowing where people are located at. Whether they are in the location they are in or if they are missing and trying to find them. Then if you do know where people are located at, how do you visually show it to people?

Project Statement: The goal of the project is to create a Hololens application that shows a live map of where different people are at any given time. The personnel are tracked through a small token, which is attached to issued Personal Perspective Equipment (PPE), that communicates with a distributed tracking system that relays data to the Hololens that a supervisor will utilize for monitoring purposes.

1.3 Goals

Our team would like to have a finished, working Hololens application that can accurately track 6 or more people in a playground-sized (20 meter x 20 meter) environment. Our goal is to be accurate from 0.5 meter - 1.0 meter in length from the location of the user.

We want to also be able to provide our customer with a realistically-sized token that can be attached onto a belt clip. This would allow users to wear it without it interfering with other protective gear. This is alternative to putting it onto a hard hat, since construction workers often throw their hard hats on the ground, and we would not want to break the device.

1.4 Operational Environment

- There will be two specific environments where the system will be in.
- There will be one where the personnel who will be wearing the token device. This environment will be outside in a construction site. This construction site will have fast wifi throughout the entire site. The speed of the wifi will be 60 MB/S and above.

- The people using the hololens will be in an office setting, specifically there should be a large table where the hologram will be displayed on. This room must have high availability wifi.

1.5 Intended Users and Uses

The primary intended user for this product is a supervisor on a construction site. They will be using the Hololens application to view the workers on their site. The secondary users will be the construction workers who are wearing the token on their hard hats. The comfort and satisfaction of both types of users are important to us because we want to make sure the token does not interfere with their equipment they are required to wear or with their daily tasks. Since the companies will be investing a significant amount of money in the Hololens to use the product, we want to make sure they are investing in a product that is useful for them and provides a pleasant experience for the user.

The primary intended use is to allow a construction supervisor to visualize where their workers are at a given time and to be able to play back a visual to see data within the day. This use represents the core functionality of the product we will be building.

The aforementioned use is primarily for safety purposes, since 1 in 5 worker deaths in 2015 occurred in a construction work environment (osha.gov) and these numbers could be decreased if supervisors were able to know where their employees were to avoid dangerous situations. Secondarily, our product will be used by construction supervisors to ensure that their employees are where they are supposed to be at any given time in order to track their productivity.

1.6 Assumptions and Limitations

- Assumptions
    - The product must be wearable.
    - The tracking device casing should be IP67.
    - The tracker should be able to relay info to our service.
    - The product should be protected from unauthorized users.
    - The product service should be scalable to fit as many users realistically as possible.
    - The product should be able to be viewed on a website and HoloLens
    -
- Limitations
    - The end product shall be no bigger than a iPhone 8.
    - The end product must track at least 6 people in playground-sized environment (20 x 20 m).
    - The end product must be accurate within 0.5 - 1 meter.
    - The end product must be able to last a work day (at least 8 hours).

    - The end product shall have a sensor communication range of within 10m.
    - The end product shall track with a delay at most 1 second.
    - The end product shall track moving people at maximum 5 mph.
    - The end product shall work in all outdoor environments.
    - The end product shall be droppable by at most 3 meters.
    - The product budget shall not exceed $5000.
    - The product shall have a proof of concept before the end of May, 2018.

1.7 Expected End Product and Deliverables

- The end product shall have a tracking service.
- The end product shall be a scalable outdoor personnell device.
- The end product shall have documented source code.
- The end product shall be a Proof of Concept for the client to showcase.
- The end product shall have an UI for tracking for Microsoft HoloLens and possibly Web interface.
- The end product shall have some possible casing for the product.
- The end product shall have reliable communication between devices.
- The end product shall be demonstrable by the end of the project (April 2017).

The client has not specified the exact date of deliverables. We are in current discussion on what deliverables should be done and what has priority. The main product focus is on tracking and shall be in full Proof of Concept as late as mid-Spring.

2. Specifications and Analysis

2.1 Design Specifications

Our main design specification is the accuracy of our tracking. We would like to make our solution as accurate as possible, with a minimum accuracy of less than 1m in error. It also must track, in real time, six different people inside the range. In addition to this, the token itself must last at least an average work day (10 hours), and must be able to store a day's worth of data. It also has to be able to relay readable data to the hololens to be displayed.

This token has to be able to withstand rough conditions, must be water resistant, and reasonably sized so it will not hinder the worker wearing it. We would like it to attach to PPE so it must always be worn. The relay will also be secure so unauthorized users cannot access the information or create false data. The final requirement is that the system must be scalable, so it will be able to handle more people at larger construction sites, as well as maintainable to last the length of the construction project.

2.2 Proposed Design/Methods

The design that our team has chosen is using CSI (channel state information) and active tokens to track the personnel, and then send that information to our server and display it for the user. The job site will be completely covered in WiFi with an appropriate amount of access points to guarantee anywhere the personnel go they will be in the range of at least three access points. The token will be a Raspberry Pi Zero, which will be attached to the belt of the worker. This token will gather RSSI and CSI data, and send it through the network to a hub that has a specific WiFi chip that allows you to view the CSI data. The hub will then apply algorithms to the information it gathers and finds an accurate location of the multiple different tokens. Once it generates the location of the tokens, it will send this data to an offsite server. From this server we will get the information, and generate avatars at the locations on a 3d mapping of the site on the Hololens.

2.3 Design Analysis

So far the team has looked through a few different possibilities for tracking methods. We have looked at research papers discussing different ways that others in the past have tracked locations of different tokens.
-We have narrowed down our tracking possibilities to CSI and RSSI
-We are currently preparing research on the possibilities for tracking and will present to our client and advisor
-After this, we will make our choice and begin work on our prototype
- One strength of RSSI is that every WiFi connected device can be tracked and see the data easier
- One strength of CSI is its very high accuracy because more data is being transferred

3 Testing and Implementation

3.1 Interface Specifications

- Hardware
    - Raspberry Pi Zero (Token)
        - Will connect to wifi and send back through wifi to the RSSI Collection Service the tokens RSSI information
    - Raspberry Pi 3/Mini ITX Board (Hub)
        - Uses the Intel 5300 Chip to sniff the wifi access points to gather accurate positions of the tokens and compile data on Hub
        - The hub will then send back data over wifi to the CSI Collection Service
    - Microsoft Hololens

        - Will connect through wifi to the Hololens Map Creator to gather the bing maps to create 3D render of the location the personnel are at
        - Will connect through wifi to the Hololens Personnel Tracking Service that will feed in data about where people are located at
- Software
    - RSSI Collection Service
        - Token
        - Location Fusion Service
        - RSSI Database
    - CSI Collection Service
        - Hub
        - Location Fusion Service
        - CSI Database
    - Location Fusion Service
        - RSSI Collection Service
        - CSI Collection Service
        - Location Fusion Database
        - Group Information Service
    - Group Information Service
        - Location Fusion Service
        - Web Application Personnel Tracking Service
        - Hololens Personnel Tracking Service

3.2 Hardware and Software

- Hardware
    - Raspberry Pi Zero W & Raspberry Pi 3
    - GPS Hat
        - Adafruit GPS Raspberry Pi Hat
        - Berry-IMU Raspberry Pi Hat
            - GPS
            - Temperature Sensor
            - Barometer
            - Gyroscope
            - Accelerometer
    - Microsoft HoloLens
    - MSI Gaming Laptop
    - Intel Wifi 5300 Chip

We are using a Raspberry Pi as a main hardware tool for tracking. We will be using the onboard Wifi chipset and a Intel Wifi 5300 Chip. We are using two chips for RSSI and CSI. We will be using RSSI on the Raspberry Pi Wifi and CSI on the Intel Wifi 5300. We are going to use a GPS Hat as a Proof of Concept and a backup technology for tracking. The Berry-IMU contains

various chips and sensors to help determine our height and acceleration of the tracked object. The main UI will be through the Microsoft HoloLens. The MSI Gaming Laptop will help us run and build our code quickly for the Microsoft HoloLens. (Our Clients laptop) The two different Raspberry Pis' are to determine if the CPU on the RPI (Raspberry Pi) 3 is better than the Pi Zero.

- Software
    - Unity
    - Raspbian
    - Visual Studio
    - Atom
    - C# & Python

Unity and Visual Studio are needed to run, build, and test the Microsoft HoloLens application. Raspbian is the base OS for Raspberry Pis. Atom will be our text editor for any code. C# and Python will be our languages for our projects.

3.3 Functional Testing

- Must track at least 6 people in playground-sized environment (20 x 20 m)
- Must be accurate within 0.5 - 1 meter
- Token relays info to Hololens
- If active sensor, battery life = 1 work day (10 hours)
- Sensor communication range: 10 m
- Real Time tracking: acceptable delay of 1 second
- Store 1 day's worth of data
- Track people moving at maximum of 5 mph

3.4 Non-Functional Testing

- Test to see if the helmet is durable with the token attached (Drop Test)
- Test to see that the helmet is still protective of the worker's head even with the token attached for safety purposes
- Test security of the location tracking system by having one of the teammates try to create disfunction in the location tracking
- Have group members attempt to disrupt the location tracking service and see if it is safe
- Test the waterproof abilities of the location-tracking token

3.5 Modeling & Simulation

- Testing Scenarios
    - Hardware
        - Model: Code on hardware

        - Simulation: Send over signals that test to see how accurate the RSSI and CSI algorithms are
    - Software
        - Model: All the services created
        - Simulation: Send over internet differing positions of differing personnel and test to see how accurate our location fusion algorithm works.

3.6 Implementation Issues

- Implementing our Hololens application without knowing the map of the worksite
- Time constraints with finishing the prototypes
- Constraints with finding open source algorithms for the method of tracking we choose
- Obtaining all of the hardware necessary for implementing the different location tracking methods while keeping the cost down
- Designing the software architecture using both RSSI and CSI
- Understanding how the towers will communicate with the access points and location tokens

3.3 Process

In regards to tracking, using the CSI approach we have narrowed down the solutions to focus on the implementation of the solutions outlined in several papers. These papers are *SpotFI: Decimeter Level Localization Using WiFi* and *Decimeter-Level Localization with a Single WiFi Access Point.* These papers focus on localizing devices using approaches based on used specialized algorithms that process the CSI data and accurately compute location of the targets that they track. The algorithm that we choose to implement based off of the complexity of the algorithm, and which will be the most scalable solution. There will be comprehensive tests to figure out which algorithm will work the best. As our team consists of 6 members we will be able to split up the work between the different members of our team to streamline the testing process. Once we have the solution then we can start to introduce the solution to the other portions of our system including services that will turn the data into usable content to displayed on 2D and 3D maps over different interfaces such as the Microsoft Hololens and a web application.

3.4 Results

At this point in time, we have been focused on the research of the best tracking solution to meet the goals of our personnel tracking system. It has been challenging finding a solution that will meet both are functional and nonfunctional requirements. Most solutions that were found by the team included tracking solutions were not accurate enough for our requirements. After much

research we are now able to narrow the scope down to a couple of papers dealing with localization using channel state information. In addition, now that we have narrowed down potential solutions, are in the stage of ordering the correct parts to start testing which solution will be the best.

4 Closing Material

4.1 Conclusion

Thus far, we have kicked off our project and discussed specifications with our client. We have also worked with our advisor, Dr. Qiao, to establish functional and nonfunctional requirements for the product after deciding what product we wanted to build: a hardware token and a Microsoft Hololens application. Our goals for this project are to enable our user, a construction supervisor, to visualize where their employees are at a given time for safety purposes. Our solution is to use a Raspberry Pi Zero for the hardware token and use CSI, channel state information, to achieve tracking of personnel. This surpasses other solutions we have considered because it will lead to the highest accuracy and the most affordable solution. It will allow us to get within out 1-1.5 meter error goal. Overall, we believe we have a strong start on our project and will continue working diligently with the oversight of our client and the guidance of our advisor to solve this problem and accomplish our goals.

4.2 References

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