AR Monitoring System

Project Plan

Team Number: Dec1714
Client: Andrew Gui
Advisor: Dr. Johnny Wong
Arbaaz: Team Leader
Ben: Key Idea Holder
Sam: Key Idea Holder
Nipun: Communication
Patrick: Webmaster
Dheeraj: Communication
dec1714@iastate.edu
dec1714.sd.ece.iastate.edu
April 27, 2017
Version 3

Introduction

1.1 Project statement

With the advancement in technology the ability to simplify life has become easier. With the possibilities of AR, we can minimize the human labor and make the tracking/oversight of autonomous vehicles easier. The intention of this project is to design an augmented reality monitoring system that will be integrated into the cab of an autonomous tractor. This system is based on a Hololens application that will load up an aerial map view of a user defined location and show virtual 3D models of the actual vehicles moving throughout the map in real time. The user can then click on and access the information of a vehicle (i.e. current operator of vehicle, speed, etc.) and be able to experience a first person view of what the driver is seeing.

1.2 Purpose

This project aims to provide an easy to use and vertical solution to remotely monitor and/or control autonomous vehicles. With enough refinement, the solution could be used for efficient oversight of a work force or autonomous fleets.

1.3 Goals

Upon completion of the project, we hope to have a complete set of software and hardware needed to remotely manage, store, and visualize a wide array of devices and machinery. This would include but not be limited to:

- HoloLens application
  - Intuitive and Easy to use
- Centralized server
  - Secure and ensures only the appropriate devices access the system components
- Remote solution
  - Custom tailored device to be placed on a monitored object
  - Provides visual feedback
  - Unhindered by remote locations

This project gives us ample opportunity to learn and experiment with new technology. We hope to gain a greater understanding and appreciation for AR in general by working through this project and to improve our abilities to be effective team members.

2 Deliverables

By the end of the spring semester we plan to have a flow chart and wiring diagram for all hardware integration as well as a rough prototype for our application which demonstrates the primary functionalities which we plan to bring to completion by the end of the second semester. By the end of the fall semester of 2017 we plan to have the capability to both create and save user profiles, use head tracking technology to control a 2-axis camera gimbal, view a 2D map in 3D, and show where monitored machines are on Google Earth in real time.

Server

- Authenticate connecting devices
- Handles and sets up all communication from gimbal setup and hololens

Raspberry Pi/Remote Device

- Have an assembled gimbal
- Research controlling the gimbal with streamed accelerometer data from Hololens - implement as proof of concept if have time
- Transmit GPS data from Raspberry Pi to server
- Transfer video output from Raspberry Pi to server
- NOTE: The Hololens will not communicate directly with the Raspberry Pi nor vice versa - instead all communication will pass through the server for both directions

Hololens App

- Draw a scrollable 2D map in visual space
- Display simplistic 3D models to represent monitored vehicles on 2D map
- User authentication on server

3 Design

3.1 Previous work/literature

Development for the Hololens started on March 30th, 2016 so complex applications have only just started to be released. One of the applications which we have drawn inspiration from is the Hololens maps application which displays cities and their buildings in 3D so that you can view them on a table. We would like to use LiDAR cameras to map sites and create the equivalent of a maps application with custom rendered maps.

There are also architecture companies that use an app called SketchUp to view their buildings and projects from the inside as well as outside. This is an interesting idea for us to consider because this application may be targeted towards construction companies in the future. Tying this in with the hololens maps, we could create custom maps and view them for each company's site.

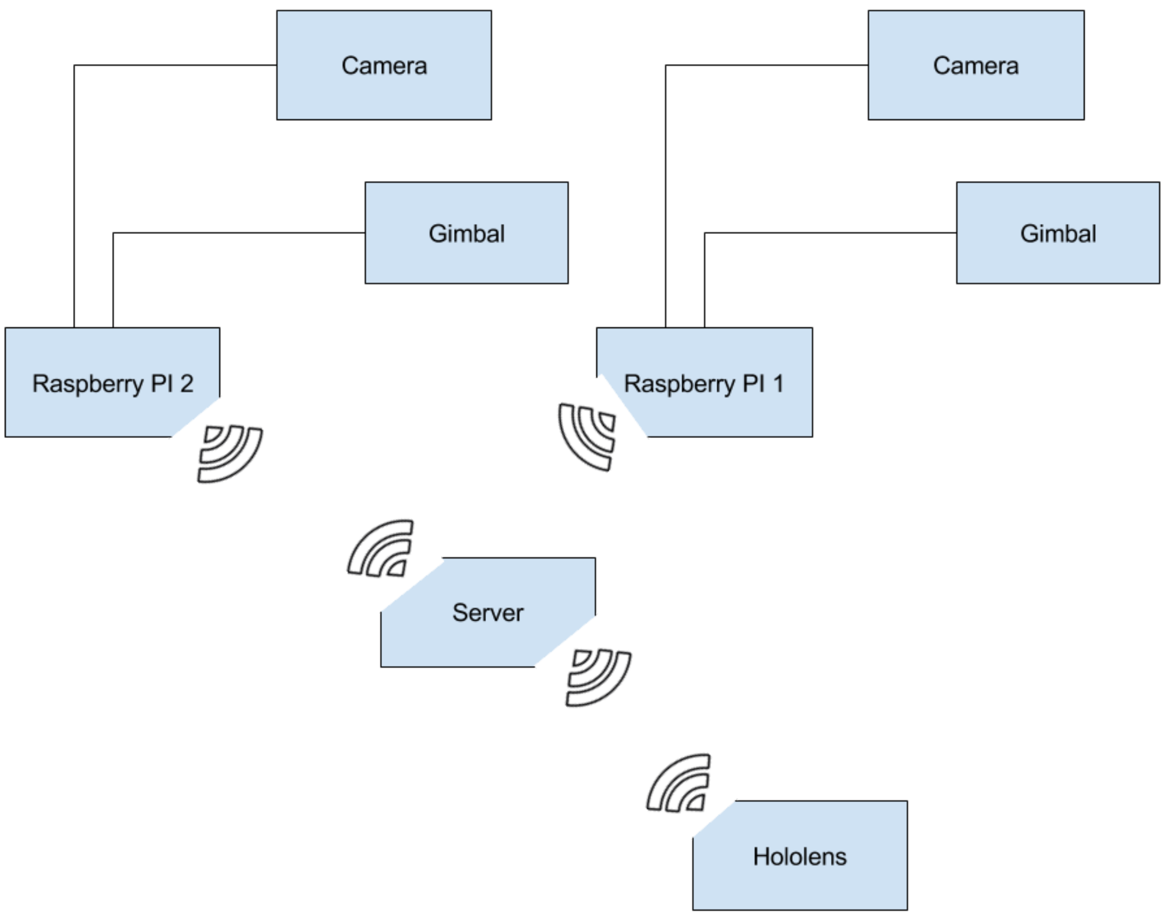
Microsoft has also used a light reflecting tape placed around the edge of a table to stabilize an AR component. This was seen during their E3 demonstration for minecraft. This would be a useful application of technology for our application because it would allow for more stabilized maps and viewing experience.

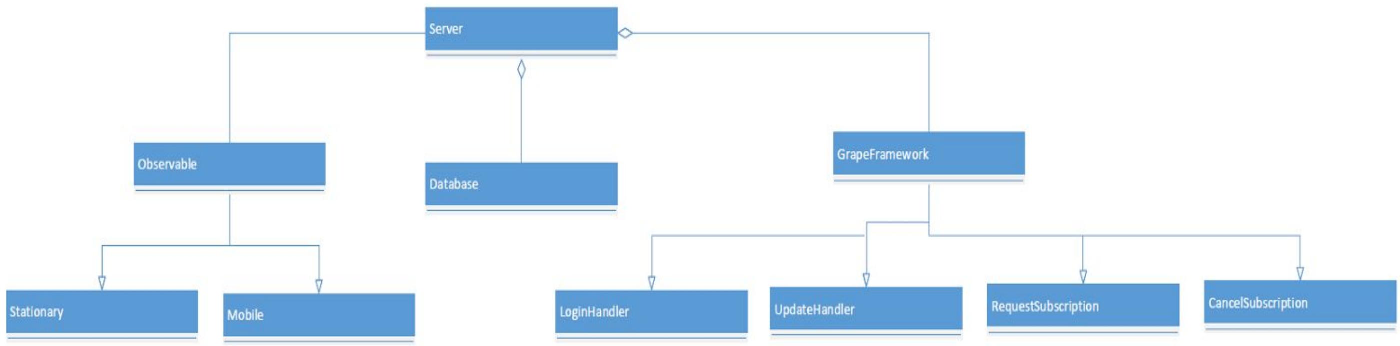
We plan to use a gimbal to control the in-cabin camera that is streaming to the hololens. We have been researching different gimbal, motors, and Raspberry Pi-compatible video streaming components.

en.wikipedia.org/wiki/Microsoft_HoloLens
https://youtu.be/xgakdcEzVwg?t=2m26s
https://hobbyking.com/en_us/multi-rotors-drones/camera-gimbals.html

3.2 Proposed System Block diagram

The following image shows the overview of how our final product should look like. The Raspberry PI and all components that are physically connected to it, is the Gimbal system. Whereas the Server and Hololens communication is meant to be done through an app.





3.3 Assessment of Proposed methods

There are many existing partial solutions to our whole that we can take advantage in designing our product. Many high-tech industrial vehicles are already equipped with their own communications systems to communicate with each other in larger areas of operations. In smaller areas, there may be existing wifi connections or one can be created via ad-hoc. High-tech machines normally also have standardized ports for debugging that expose a lot of the equipment's sensory information. We can install our own device to process and communicate the data to a remote server. Direct communication to the HoloLens is not an option as the device will not always be online and available and wouldn't be able to be reliably exposed for devices to connect to. The HoloLens can connect to the server to retrieve data on various devices in the field.

3.4 Validation

At the highest level, we can connect a GPS device to our system and physically move it around. The HoloLens should display a map with the GPS device being tracked in real time. Additionally, we have made a signed deliverables document signed by both the client and advisor that will help assess our progress at the end of the semester.

With the deliverables that we have defined, in terms of Hololens application we will doing most of our testing in the programing editor; here we will focus on testing and making sure that the scripts that we wrote work properly. Additionally, for aspects that we cannot test within the editor will bes tested by deploying it to the hololens and visually checking whether it works or not. Server requirements will be assessed by sending requests to the server and checking to see if we get a response back. The test that we have plan to use for our Gimbal system is very similar to the methods we are using with the Hololens. Where we will be running code and checking to see if it works properly.

4 Project Requirements/Specifications

4.1 Functional

- Ability to view monitored machine on map using Hololens app
- Ability to view a custom area map on the Hololens app
- Ability to assess machine status from Hololens app
- Ability to control gimbal/camera with Hololens app

4.2 Non-functional

- The software should be able to be adapted for many different purposes and inputs.
- The software should be secure. Unauthorized devices should not be able to feed false data nor should they be able to view device data.

4.3 Standards

Given that our project's goal is to allow better oversight in large work sites, we believe that our project is very unlikely to intrude on the ethical space.

5 Challenges

- Limited bandwidth on some forms of communication
    - The gimbal/raspberry pi unit will be mounted on vehicles, so it is likely that we will run into network connectivity issues.
    - Even when a network exists, we might not have enough bandwidth to stream real-time video.
- Custom mapping requiring extra processing
    - Generating a 3D model of an entire worksite from sensor data may be very expensive
    - The compiled data may be too detailed to directly display and needs to be converted to a lower resolution.

6 Timeline

6.1 Challenges and Risks

We have faced a number of challenges as we have worked throughout the first semester on our project. One of the challenges we faced was limited documentation for the gimbal. This limited documentation in the operating specifications of the gimbal caused us to have limited knowledge going into this project and forced us to use a guess and check approach in figuring out how to use the gimbal. For instance it took us a while to figure out that we should be using varying frequencies instead of varying voltages to control the gimbal orientation.

Another challenge we faced involved the analog I/O capability of our Raspberry PI. We chose to use a Raspberry PI 3 in order to control our gimbal/camera module and we found that there was a lack of analog I/O pins. This constraint forced us to use the Raspberry PI's digital pins for controlling the gimbal/camera module. The problem with using the digital I/O pins was that the values we used in the code for controlling the gimbal did not match the values outputted from the PI. This discrepancy in values made it necessary for us to resort to a guess and check approach for obtaining proper values for controlling the gimbal/camera module with the Raspberry PI using the Raspberry PI's digital I/O pins.

Another hurdle we encountered was that of using the Python programming language to control the gimbal and camera on the Raspberry PI. Prior to this semester we did not have experience with using Python so we had to learn to use the language as we worked through the project. We initially were trying to use the C programming language instead of Python because of our greater familiarity with C, but we chose to switch to Python due to its greater accuracy with controlling the gimbal.

We also experienced issues with our camera. This problem had to do with interlaced versus progressive video. We initially had difficulties in getting out camera to record video correctly because the camera we were using used interlaced video, but our HDMI to CSI2 bridge did not support interlaced video. We were able to successfully resolve the issue by switching to a different camera which used progressive video instead of interlaced video.

Unity development was a challenge being that everyone was new to it and was learning game development in general alongside designing the application. On top of which, Unity is strict when it comes to network security. Many of the standard libraries are deprecated and replaced with limited functionality Unity equivalents or missing entirely. This limited our options of server communication severely. The HoloLens section of Unity development is also limited in documentation as the HoloLens is relatively new technology and is still undergoing major changes in its toolkit.

6.2 First Semester

By the end of the spring semester we plan to have a flow chart and wiring diagram for all hardware integration as well as a rough prototype for our application which demonstrates the primary functionalities which we plan to bring to completion by the end of the second semester. The timeline chart below shows a very broad image of what we plan to be doing this semester and when we plan on doing it.

Version 1.0		TIMELINE		
Planed Dates		**Actual Dates**		**Task**
Start	**Finish**	**Start**	**Finish**	
1/10	1/10	1/10	1/10	Form Team
1/10	1/17	1/10	1/17	Choose a Design Project
1/17	1/24	1/17	1/27	First Meeting with Advisor
1/24	1/25	1/27	2/3	First Meeting with Company Sponsor
1/17	3/24	2/3	3/10	Research
1/16	3/10	2/3	3/19	Hololens
1/16	3/10	2/10	2/21	Gimbals
1/16	3/10	2/10	2/21	Motors
2/13	3/10	2/17	2/21	Flight Contollers
2/14	2/24			Project Proposal
2/14	2/17	2/16	2/24	Project Statement
2/14	2/18	2/16	2/24	Purpose
2/14	2/19	2/16	2/24	Goals
2/14	4/26			Deliverables
1/25	4/28	1/25		Class
2/14	2/24	2/14	2/24	Project Plan (V1.0)
2/18	3/10	2/28	3/10	Design Document (1st)
2/21	4/1	3/23	4/1	Project Plan (V2.0)
4/11	4/28	4/20		Design Document & Project plan (Final)
1/25	3/10	2/28	4/18	*Project*
2/21	3/24	2/28	4/18	Website
3/6	4/26	3/6	3/12	Gimbal Done
1/25	3/10			Design
2/6	3/3	2/3	2/16	Server Block Diagram
2/7	3/3	2/16	3/23	Gimbal block Diagrams
2/8	3/9	2/20	2/22	Circuit Diagrams
2/9	3/9	3/10	3/12	Bill of Materails
3/6	4/26			Prototype
3/20	4/26	3/6		Gimbal
3/6	4/1	3/6	3/12	Parts
3/25	4/1	4/19		GPS location
3/31	4/26	3/16	4/18	Gimbal Control
4/3	4/26	4/20		Accelerometer Control
3/6	4/26			*Hololens App*
3/6	3/10	3/6	3/10	Hololens recongnizes table
3/10	4/7	4/1		Map projected onto table
4/7	4/21			marker on map with dummy data
4/3	4/18	4/20		Powerpoint
4/11	4/28	4/20		Final Project Plan

6.3 Second Semester

By the end of the fall semester of 2017 we plan to have the capability to both create and save user profiles, use head tracking technology to control a 2-axis camera gimbal, view a 2D map in 3D, and show where monitored machines are on Google Earth in real time.

Version 1.0		TIMELINE		
Planed Dates		Actual Dates		Task
Start	Finish	Start	Finish	
8/28	8/28	N/A	N/A	First Meeting with Advisor
8/28	8/28	N/A	N/A	First Meeting with Company Sponsor
9/7	9/15	N/A	N/A	Define Deliverables
10/2	11/3	N/A	N/A	Prototyping
11/3	12/1	N/A	N/A	Testing

7 Conclusion

Our goal, during this semester for the project, was to understand how the HoloLens works and the technology that drives the augmented reality. With this understanding, we hope to be able to expand on the work that we accomplished during the spring 2017 semester and accomplish our task in designing and building the hardware and software needed to be able to use the Hololens to track our monitored machines.

What we were aiming to accomplish (this semester) was more of a “proof of concept” of the primary elements that we need to focus on for this project. The programs that we developed for this semester are meant to act as a springboard into the more in-depth work that we will be doing in our second semester of the project.

The key components that we have chosen to prioritize for the 1st semester of this project are: Gimbal system, HoloLens app, and Server. The gimbal system is comprised of 3 sections the mount, camera and Raspberry Pi. The sections of the gimbal system are all connected to the Raspberry Pi, and the Pi can be seen as the central hub for the gimbal system. The Pi not only controls the camera mount and camera but is also communicating with the server and HoloLens via wi-fi connectivity. The HoloLens section of the project focused on being able to start up the application and seeing a basic map view of a location.

8 References

en.wikipedia.org/wiki/Microsoft_HoloLens
https://youtu.be/xgakdcEzVwg?t=2m26s
https://hobbyking.com/en_us/multi-rotors-drones/camera-gimbals.html