Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Summer 2019

Team R.O.B.
Omnidirectional Synchronous Camera Gimbal

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	07.05.2019	NL	document creation
0.2	07.05.2019	NL, DL, HN, MT	complete draft (part 1 - 12)
0.3	07.07.2019	NL	completed part 13

Contents

List of Figures

1 Vision

The vision of this project is to create a gimbal that provides a live feed of surrounding area to a Virtual Reality headset. It gives customers access to a live feed to area that is inaccessible or difficult to access by humans. This allows safe access to places that would be hazardous to humans such as exploring a high radiation area, viewing the undercarriage of a car in a checkpoint for any bombs or restricted components.

2 Mission

The outcome of the project is to produce Camera Gimbal prototype. The camera system captures and provide live video feeds into a Virtual Reality (VR) headset. As the VR headset moves, the camera system will also provide live video corresponding to the direction of the facing headset. The camera system can either utilize one or two physically cameras or five non-moving camera to provide video feeds into a computing unit. The computing unit is a computer with high graphic processing power that will process incoming video feeds and provide the outputs into the VR headset.

3 Success Criteria

Upon completion of the Camera Gimbal prototype, we expect the following success indicators to be observed on VR software/hardware interaction:

- Comfortable user experience when interfacing via Virtual Reality headset
- Complete head movement support in all directions
- Functional passive background update to simulate "pseudo-real-time" feed

Within 6 months after the prototype delivery date, we expect the following success indicators to be observed:

- Increased quality and stability of "pseudo-real-time" video feed
- Increased camera stability against motions and vibrations
- Optimized hardware to VR transfer speed and quality

Within 12 months after the prototype delivery date, we expect the following success indicators to be observed:

- Seamless integration to multiple target systems (Plug and Play)
- Adaptable mounting and orientation design
- Fully mobile operation with dedicated battery and wireless communication

4 Background

There are many places around the world that are not physically reachable by human. These places can include unexplored areas around the world, to man-made disaster areas such as Chernobyl, or the Fukushima nuclear plant in its March 2011 incident. Current solutions which include three dimensional mapping can provide good ideas of how certain areas look, but does not provide enough details of the environment. When it comes to border security, the current solution can be using a piece of glass attached to a pole to check for possible harmful materials underneath vehicles. Even though it is a direct live feed, it is an outdated solution and might not provide enough coverage and take longer to cover certain areas. Other today solutions use robotics and computer vision to provide live feeds to operator. However, some of these camera solutions do not have the quick flexibility when it comes to providing quick video feeds of the environment. Today's autonomous robots might not be smart enough and will occasionally need operator manual override.

5 Related Work

There are other solutions out there in the world that pertain to hand-held camera gimbals. Companies such as Zhiyun, Feiyu, and Moza opted to have camera gimbals that will work best for cell phones and DSLR cameras [**?**]. These camera gimbals are only a product of keeping a camera stable as it is being used with one focal point of view. Our product will have a camera system that will allow us to have a 360 field of view with a virtual reality headset. We will have to deal with the issue of image stitching for the cameras that are connected to give one field of view. The image stitching will allow us to have a clean and smooth turn as we transition from one camera to another. Another problem gimbals have is having gimbal locks. Gimbal lock is when two of the three axis align which causes the movement of the object to be limited and an entire range to be impossible [**?**]. Another problem with the the single use of a camera is the camera stabilization. With one camera potentially being used, as it moves with the turning of the headset, there has to be a solution to make the stabilization of the camera so the user will not get dizzy inside the camera [**?**].

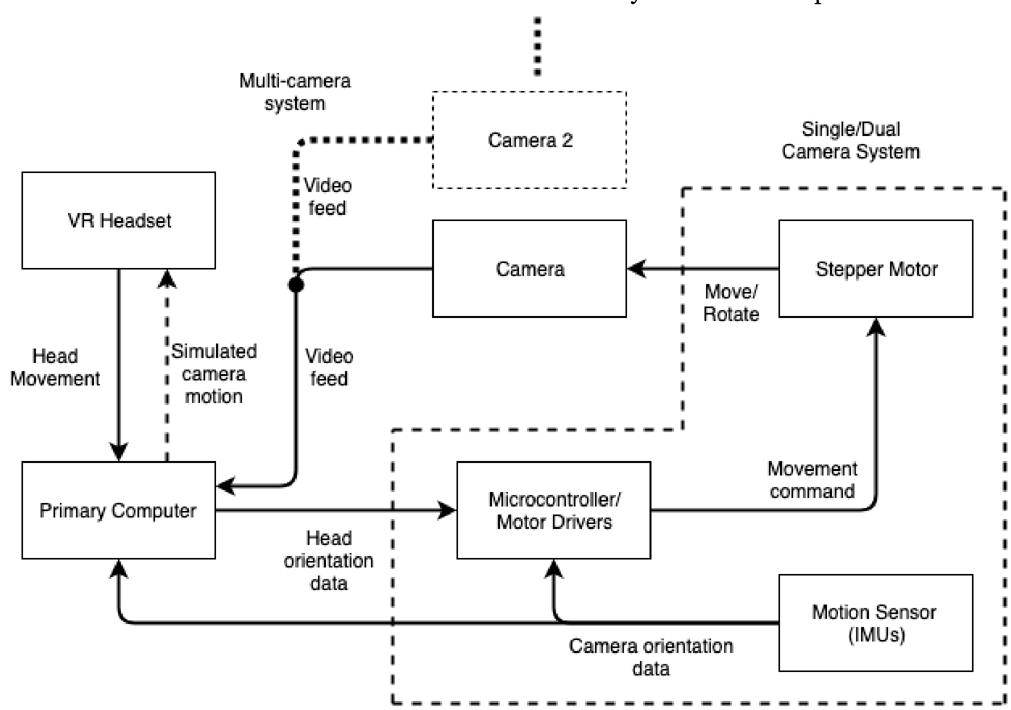
6 System Overview

Currently, there are three possible implementations for the project under consideration. These options are: single camera on omnidirectional motorized gimbal that translate VR headset motion to synchronous camera motion, 4-6 cameras pointing in all direction of FOV rendering a "pseudo" realistic world, or 2-3 cameras, 1 acting as the live head motion translation and 1 or 2 cameras updating the surrounding by spinning around an axis and delta-update the video feed. For the single camera system, the camera will be mounted on a rigid, rotating platform that can cover 360°on the horizontal plane and up to 100°vertically to simulate commonly used human head motions. The platform will be actuated using a system of stepper motors in combination with mechanical transmission and end-stops initially to provide smooth, precise, and stable camera motion. All communication from the single camera will be feed directly to a computer, which process the video, feed it to the VR headset, and transfer the headset motion back to the motor controllers to execute the movement.

For the 4-6 stationary camera system, the VR headset motion will be virtualized and translated to a viewport in a stereo video hemisphere constructed by the set of cameras. Essentially, where the user is looking at in the virtual world will be the only real-time frame. All others area will be set to passive delta updating (change detection) to simulate a live feed. What this means is that what the user see is a virtualized "pseudo-real-time" which looks identical to the view the user have in the one camera system, but eliminating the motion control section and therefore drastically improve response time and image stability.

The last solution is a hybrid of the first two solutions, with one mounted camera that simulates head motion and one do the passive updating by rotating around and delta updating the scene frame by frame at a higher rotation speed. This option was considered as a compromise to ensure bandwidth for live viewing and faster real-time video rendering rate since part of the scene is already rendered with the help of a secondary camera.

Ideally, this is how the data should be handled and how the system should operate:



7 Roles & Responsibilities

Team Members

- David Chavez: Hardware implementation and design of the camera gimbal system
- Nhan Lam: Image and video processing video inputs from camera system and output processed video to VR headset
- Nhan Le (Scrum Master): Image and video processing video inputs from camera system and output processed video to VR headset
- Hunter Nghiem: Image and video processing video inputs from camera system and output processed video to VR headset
- Minh Tram: Hardware implementation and design of the camera gimbal system

Scrum Master

- The role of the scrum master will be not be change periodically. However, should something significant come up the role of scrum master could change depending on the severity of the situation.

Product Ownership

- All members in team [insert team name] have equal part ownership of the project. In addition, the University of Texas at Arlington also own the project as it is an official project under the the University of Texas system.

Advising Faculty

- Christopher Conly

8 Cost Proposal

The project does not have many components but a few major components. It requires a VR headset to get directional input from users and to display video feeds. A central graphic processing unit handles all the raw video and image processing. Lastly, the cameras are needed in order to capture raw video and images. Other costs might arise during the project development but likely going to be minor.

8.1 Preliminary Budget

Tools and Equipment		
No.	Name	Appr. Cost (USD)
1	Oculus Rift	399.99
2	Intel RealSenseâ Depth Camera D435	539.97
3	Processing Unit	2000.00

8.2 Current & Pending Support

Funding for the project will come the University of Texas at Arlington Computer Science and Engineering department. The approximate budget for all the equipment and tools is less than 1000 USD. Sponsorship might arise during the project development should there be interests from outside party in which additional funding can be provided.

9 Facilities & Equipment

The project will be mainly developed in Senior Design Labs provided by UTA CSE department. The lab rooms have most of the tools and equipment needed for the development of the project. The project will require a small portion of free space for the purpose of setting up the VR equipment but the lab rooms have enough to accommodate the needed space.

10 Assumptions

- Senior Design Labs will be providing the Oculus Rift VR headset and graphic processing unit
- A few Intel RealSense cameras will be provided by UTA Senior Design lab although more will likely needed
- UTA will provide physical security access to each senior design labs to each individual
- The basic prototype is expected to be complete by the end of October 2019
- The team is expected to hold meeting at least once a week but not as part of scrum development process

11 Constraints

- A fully optimized prototype demonstration must be completed by November 15th, 2019
- Any purchases will have to be approved by UTA Department of Computer Science and Engineering
- No University equipment and tools may leave Senior Design lab areas without approval from advising faculty
- All computerized developments must abide by the university Office of Information Technology's policies
- Total development costs must not exceed $800

12 Risks

The risks of the RC Gimbal Car would range from connection issues to hardware damage from the driving of RC around. The risks of the project would include synchronization between cameras, dizziness and/or projectile vomit, USB bandwidth issues, damaging the RC car, and the stabilization of the camera. The probability of damaging the RC car could possibly be moderate(50%) due to an unfortunate accident. The dizziness would be moderate because the camera angles could be unsettling for people who get motion sickness easily, however, there are also people out there who do not get motion sickness(50%). USB connectivity, camera stabilization, and the synchronization issues would also be likely high because the camera would directly affect how the user would feel while using the headset(85%).

The size of loss for each risk would set back these amount of days: -USB Connectivity, Camera Synchronization and Stabilization (High) = 1 Week -Damaging RC car and Motion sickness (Moderate) = 3-5 Days

Risk Exposure: -USB Connectivity, Camera Synchronization and Stabilization = (.85) X 7 = 5.95 days -Damaging RC car and Motion sickness (Moderate) = (.50) X (5) = (2.5) days

Risk description	Probability	Loss (days)	Exposure (days)
Availability of X sensor module due to contractor delay	0.50	20	10
Outdoor testing grounds are not available	0.20	14	2.8
Internet access not available at installation site	0.30	9	2.7
Delays in shipping from overseas vendors	0.10	20	2.0
Certification delays at compliance testing facility	0.15	10	1.5

Table 1: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

The project charter will generally be updated more often earlier in the project as the details have not been fully hash out. The expectation is that it will be updated at least twice a month initially. As closer to completion, it might or might get even updated at all

13.1.2 System Requirements Specification

System Requirements Specification will be updated at least few times a week. Similar to the project charter, there are multiple designs that have not been fully thought out in details. As the time approaches near the end of Fall 2019 semester, there will be less adding and more crossing out requirements.

13.1.3 Architectural Design Specification

This document will be updated frequently later on during the designing process. However, once implementation and development started, it should not be updated that often or at least not anything significant. The expectation is that the document should be mostly complete by the end of Phase 1.

13.1.4 Detailed Design Specification

This document will be updated frequently during Phase 1 and the early part of Phase 2 as it contains many detail design of the project. The initial version should be completed by the end of Phase 1. The final version should be completed by the middle of Phase 2

13.2 Recurring Sprint Items

13.2.1 Product Backlog

Items will be add to the backlog mostly based on group vote. However, should it be deem necessary individual can add items to the backlog. However, the group will need to be informed. Items will be prioritize based on a numbering prioritization system based on their severity. The group will determine the severity of each item most of the time. Currently, product backlog will be documented through a spreadsheet but may change should more viable software become available and agreed upon by the team

13.2.2 Sprint Planning

Each sprint will generally last about a week. Currently, the plan is to have around 15 sprints which is roughly around one full semester

13.2.3 Sprint Goal

The sprint goal is determined by the group, mainly agreed by at least three members of the group

13.2.4 Sprint Backlog

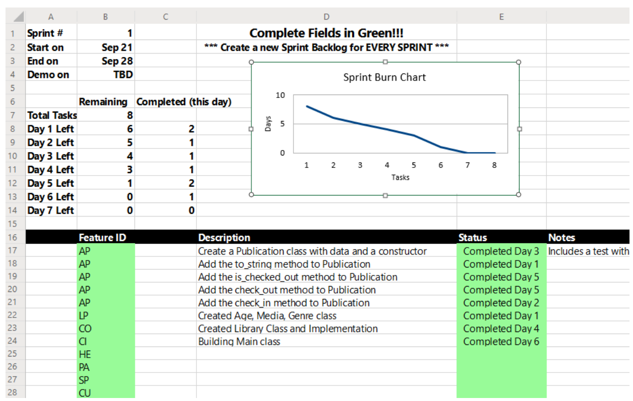
The team or through majority will determine which product backlog items will be making their way to each sprint backlog. The backlog is going to be documented under a Microsoft Excel spreadsheet

13.2.5 Task Breakdown

Each individual will get chances to select which items to work on from the sprint backlog. However, scrum master will assign some tasks should it deem necessary. A majority vote can also determine task assignment to each individual.

13.2.6 Sprint Burn Down Charts

Everyone will be responsible to communicate with each other and update the burn down charts for each sprint cycle. The format of the burn chart will be under a Microsoft Excel spreadsheet.



Sprint #	1	
Start on	Sep 21	
End on	Sep 28	
Demo on	TBD	
	Remaining	Completed (this day)
Total Tasks	8	
Day 1 Left	6	2
Day 2 Left	5	1
Day 3 Left	4	1
Day 4 Left	3	1
Day 5 Left	1	2
Day 6 Left	0	1
Day 7 Left	0	0

Complete Fields in Green!!!

*** Create a new Sprint Backlog for EVERY SPRINT ***

Feature ID	Description	Status	Notes
AP	Create a Publication class with data and a constructor	Completed Day 3	Includes a test with
AP	Add the to_string method to Publication	Completed Day 1	
AP	Add the is_checked_out method to Publication	Completed Day 5	
AP	Add the check_out method to Publication	Completed Day 5	
AP	Add the check_in method to Publication	Completed Day 2	
LP	Created Age, Media, Genre class	Completed Day 1	
CO	Created Library Class and Implementation	Completed Day 4	
CI	Building Main class	Completed Day 6	
HE			
PA			
SP			
CU			

Figure 1: Example sprint burn down chart

13.2.7 Sprint Retrospective

How will the sprint retrospective be handled as a team? When will this discussion happen after each sprint? What will be documented as a group and as individuals, and when will it be due? The scrum master and other team members can ask for updates from each other progresses. These discussions can be through formal meeting or casually during the sprint development cycle. Each individual is responsible for handling their own documentation. However, scrum master will be responsible to organize all documentations to make sure they are all consistent with each other. These documents or discussions are generally due at the end of each spring cycle

13.2.8 Individual Status Reports

Each member is responsible to provide their status report at the end of each sprint cycle. A less formal report can be done verbally during each sprint cycle for a quick status update.

13.2.9 Engineering Notebooks

Each team members' engineering notebooks will be updated in every team meeting and at the beginning of each sprint cycle. There are no minimum number of pages but will need to have enough details being covered in each meeting. This is important during the design phases. The scrum master or at least one other team member will be responsible to sign as witness to each notebook pages.

13.3 Closeout Materials

13.3.1 System Prototype

The system prototype should have a camera system hook up to a graphic processing unit. The processing unit will also have an output connection to a VR headset. The prototype can be demonstrated by any one in any space with proper power outlet. There will be no Prototype Acceptance Test nor Field Acceptance Test.

13.3.2 Project Poster

The project poster should have screen-shots of the processed image from the graphic processing unit along with a complete setup of the project. The complete setup contain a VR headset, graphic processing unit, and the camera system. The poster will also have a few pages providing description of what the prototype does, the components used and how it works in general. This poster should be ready to deliver before the demonstration day toward the end of Phase 2.

13.3.3 Web Page

What will be included on the project web page? Will it be accessible to the public? When will this be delivered? Will it be updated throughout the project, or just provided at closeout (at a minimum, you need to provide a simple web page at the end).

13.3.4 Demo Video

The project will likely not to include any video as the produced outputs are going to be shown in a VR headset. However, this might change depending on the decided camera system later on. The video should be less than a minute and it should show how the product works in a general sense without going into much detail.

13.3.5 Source Code

Source code will be maintain through GitHub. The advising faculty will have full access to the source code should improvement can be made to the prototype in future times. In addition, the source code will be as open as possible to the general public with constraint of the UT System's guidelines. All licensing and used of other open source software will be documented as block comments in each source code file. The main documentation of the project will also include this detail.

13.3.6 Source Code Documentation

Source code documentations are current still not determined. However, this part will be updated once an agreed-upon tool is used.

13.3.7 Hardware Schematics

The project is likely going to be develop using purely software but can changed depending on the camera system.

13.3.8 CAD files

13.3.9 Installation Scripts

Any scripts will be provided as part of the step-by-step instruction on how to run the program

13.3.10 User Manual

A digital manual will be provided but no hard copy will be provided. There will also no video instruction provided

REFERENCES