UCF Senior Design I

Head-Mounted Display (HMD) Mini Map for Laser Tag

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Initial Project Document and Group Identification

Divide and Conquer

Group 2

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Project Narrative Description

When was the last time you even thought about playing some Laser Tag? It used to be cool and exciting when it first came out back in the 1980's but has received very few significant improvements since then. The last laser tag game that I played was about a year ago and while the game was fun, there were a few complaints that I had with it that left it feeling underwhelming overall.

Throughout the entire game, I learned that the best way to win was by camping. In other words, if you just stayed still in one place and allowed others to come to you, you would have your laser gun at the ready and have the reaction time to shoot the other person usually before they even see you. Then when you have the reset window, you could just move to a new spot to set up camp and wait for another person to walk by you. The current state of laser tag games encourages this boring style of play where the main game essentially becomes hide-and-seek. The seekers continually get punished for being aggressive and proactive while the hiders get rewarded for being passive and reactive. If you wanted to play hide-and-seek, you could do that at home for free. What you paid (probably a decent amount of money) for is an exciting game of Laser Tag and what's available in the market now just isn't living up to that.

The concept of camping isn't a new one at all. In video games like Call of Duty, camping is one of the most effective strategies if you want to do well. However, in Call of Duty there are ways to get around camping. An easily obtainable killstreak called a UAV reveals enemy locations as red dots on a mini-map in the corner of the screen. A heartbeat sensor can be attached to your main weapon to show nearby enemy locations. Unlike in laser tag, the guns make noise when you shoot them, so your location can also be found by sound. Maps in Call of Duty are also designed such that ideally there are no spots on the map that are extremely good for camping (every spot that you could camp at has some drawback associated with it). With features like these, more aggressive gameplay is encouraged and those who play more aggressively are rewarded and do better than those who play more passively.

Wouldn't it be nice if we could implement one of those solutions in real life? Keeping these ideas in mind, our group has come up with the idea of bringing video games into reality to improve the meta of laser tag. We believe that laser tag can be greatly enhanced with some augmented reality technology and that laser tag has the most potential to be improved by AR over something similar like paintball or airsoft. A laser isn't going to damage the equipment while a paintball or an airsoft pellet might be significantly risky with AR gear. There are currently no known Laser Tag sites or products that have tried to implement these solutions

Our Head-Mounted Display Mini Map for Laser Tag will bring the concept of the UAV killstreak that you get in video games and integrate it into real life laser tag. The key feature behind this system will be a Heads Up Display that displays the locations on enemy players on the screen. We will be using sensors to track the movement of other players via an attachment equipped to each player. The widget we are making will be a head mounted attachment that uses AR optics to project a miniature map in the corner of your vision. The entire system will be run through a central hub that will act as the device that feeds the information to the HUDs and runs the software to calculate and relay locations of all the players.

The attachment should be as light-weight as possible to ensure that it is comfortable enough to be wearable. The attachment will be placing a screen in front of your face but should be transparent enough that your vision isn't heavily impacted. The placement of the mini-map on the screen should be easily accessible but should not obscure normal sight (you could get all the information that you need with a quick glance). Enemy locations on the mini-map should be constantly tracked and updated in real time with decent accuracy. The orientation of the map should reflect the direction that the user is facing and enemy locations on the map should change with the orientation of the user. The HUD should be reminiscent of a HUD that you would see in a video game, allowing for quick recognizability of the system without lengthy explanation. Cost will try to be minimized while keeping minimal functionality of all features. The range of the central hub that controls all the HUDs should have a big enough range to cover an entire Laser Tag Arena.

We currently have no sponsors or backers, but any Laser Tag Arena or place that has a Laser Tag game might be interested as we go further into development. The ultimate hope of the project is to get the system working such that real Laser Tag Arenas might be interested in adopting the system.

Requirements

- Head mounted display HUD
    - Wearable system, less than 5 lbs.
    - Image field of view at least 12˚
    - Display frame rate at least 30 Hz
    - Display at least 256 x 256 pixels
    - Orientation subsystem accurate to a minimum 2˚ at 30 Hz
    - Untethered from computer
- Laser tag system
    - Overall range at least 30 m
    - Laser alignment accuracy within 30 cm at 15 m or more
    - Laser system less than 5 lbs.

    - Tag Receiver and Marker system less than 10 lbs.
- Wireless marker system to track position of players
    - Marker system accuracy to variation of 3 m
    - Refresh rate of 2 Hz
- Battery Life for all systems at least 4 hrs.
- Full system sets need to be able to communicate wirelessly

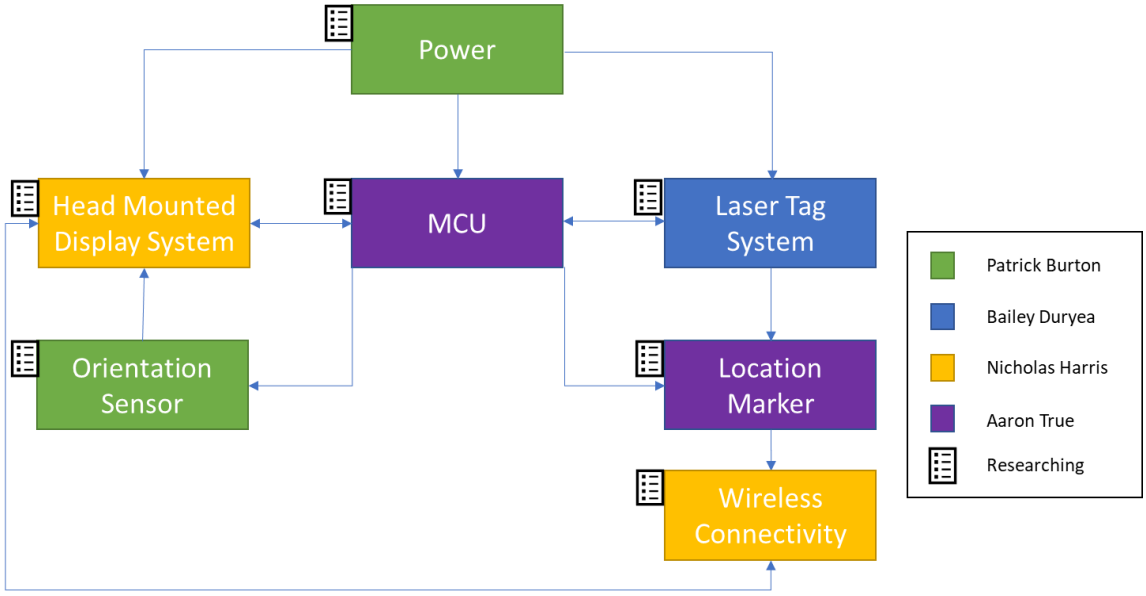
Head mounted display weight being less than 5 lbs. comes from common helmet weights and various attachments that could be attached to said helmets. The 30 Hz frame rate is in set in comparison to human visual perception. 30 Hz would allow for seamless animations for the average person. The requirements for the display itself are approximated in relation to small portable augmented reality systems, such as Google Glass. The orientation subsystem requires a minimum of 2˚ variation detection in the horizontal plane so to relate the system to an object of 3-pixel width for the display of 256 by 256 pixels at the outer edges. The orientation system also needs to update at a minimum of 30 Hz so the position relationship is seamless to the human eye. The system also needs to be untethered to allow users to be freedom of movement.

There aren't very many systems like this out there for comparison so the bounds on the requirements for the laser tag system are set in approximation of the minimum of what a user could want. The marker accuracy is 10% accuracy of minimum total range of the system. The refresh rate is low, only 5 Hz as there isn't a need for the data from the location to be entirely seamless but still needs to be indicative of movement of the target. Battery life of 4 hours will allow for the system to be used multiple times between charging. The systems need to be untethered from a hub to allow freedom of movements to users and minimize tripping hazards.

Block Diagrams

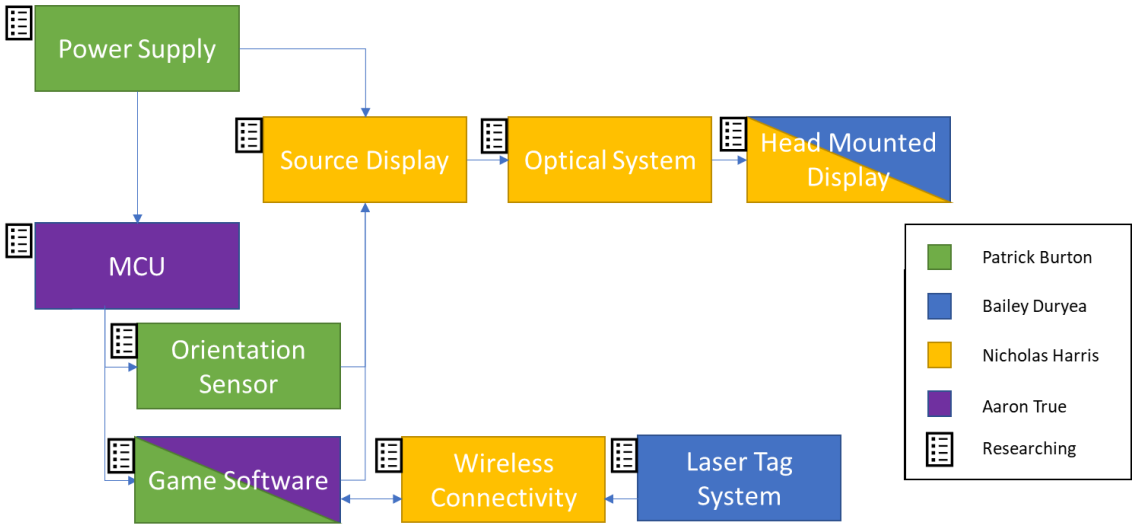
In Block Diagram 1, a general outline of the subsystems which will need to be designed and researched are shown. Our project will include both a Head Mounted Display (HMD) system to show the locations of targets in relation to the user and a laser tag system. An orientation sensor will be used in conjunction with the HMD to ensure the map of target locations is displayed accurately and shifts with head rotation. To collect information on the location of other targets, a location marker, possibly using GPS, will be included in the laser tag system so that each participant will transmit location data. The HMD and laser tag systems are explained in further detail with Block Diagrams 2 and 3. All components and systems are currently in the research phase, as possible solutions to the design and component options are explored

.Block Diagram 1: General Diagram



The components which must be researched and designed are shown below in Block Diagram 2. The source display will need to generate an image of the target map using all information regarding position and head orientation, which is why the laser tag system data is necessary. In order to generate the image, data must first be processed using software written for the game that defines radial distances in the map, target icon shapes, and possibly score. The display generated image will then be focused on the main HMD through a system of optics.

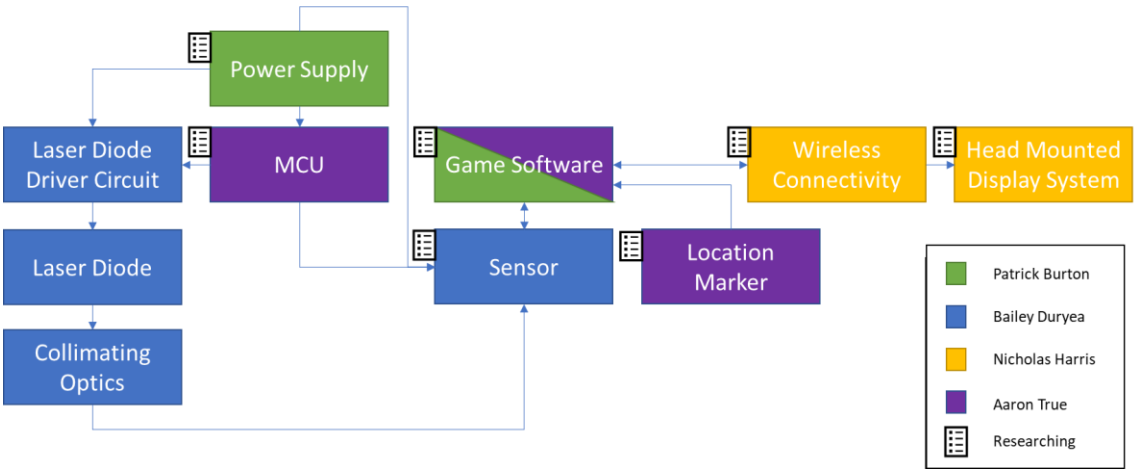
Block Diagram 2: Head Mounted Display System



The laser tag system will likely make use of a laser diode, which through collimating optics, can be focused on a sensor worn on a vest by a member of an opposing team in the laser tag game. It may also be an option to use an LED for detection by the sensor, and instead only use the laser diode to provide a visual reference for targeting by the user, although

this has yet to be decided. The sensor system will be mounted on a vest for the user to wear which will also include the location marker to transmit data to the HMD system. The game software will be controlled by the MCU. The laser diode transmitter circuit will also need to be frequency modulated so that the game can determine which player hit the target, requiring use of the MCU. In Block Diagram 3, the connections between components in both the laser transmitter and sensing receiver circuits are shown.

Block Diagram 3: Laser Tag System



Estimated Project Budget and Financing

Being that we are only in the initial stages of our project, we have not yet secured any sponsorships to assist with financing. We plan on pursuing sponsorships as the project progresses. In some very brief research and discussion, we have established a goal to keep the budget at 1000 dollars. We realize that this may be wishful thinking, so we have also discussed a worst-case budget, and we established that budget to be 2000 dollars. We still have a considerable amount of research to do in establishing which parts we are using, so the following budget is subject to a large amount of change. The quantities given in the below chart include projected spare parts that may be needed.

Furthermore, this table is not yet comprehensive, and items will surely be added and removed as we move forward.

Item Type	Item Possibilities	Quantity	Vendor	Estimated Cost
Microcontroller Unit	Arduino, Raspberry PI, MSP-430,	1 to 2	Amazon	$50-100

	Etc.			
Printed Circuit Board	Fabricated	3-5	TBD	$30-50
Power Supply	TBD	3-5	Amazon	$50-100
HUD Housing	3D Printed Housing, Modified glasses frame	3-5	3D Printer Shop, Amazon	$25-50
Laser Tag Housing	3D Printed	3-5	3D Printer Shop	$50-100
Laser Diode	TBD	3-5	Amazon	$50-100
HUD Optical System	TBD	2-3	TBD	$300-500
GPS System	Able to be MCU integrated	2-3	Amazon	$25-50
Laser Sensor	TBD	2-3	TBD	$25-50

Project Milestones

In this section we will outline the projected milestones for our senior design project. This will cover both the semester of Spring 2019 and the semester of Summer 2019. The milestones with bold font indicate actual assignment due dates, and the milestones with a regular font indicate personally assigned milestones. This milestone list will be modified and updated as we move further into the project.

Milestone No.	Milestone	Due
1	Generate Ideas	1/22/19
2	Select Final Idea	1/22/19
3	**Divide & Conquer – Initial**	2/1/19
4	Finalize group member roles	2/4/19
5	Begin extensive research based on assigned roles	2/4/19
6	Revise Divide & Conquer based on meeting results and professors' suggestions	2/8/19
7	**Divide & Conquer – V2**	2/11/19

8	Choose MCU	2/15/19
9	Begin design for PCB	3/1/19
10	Begin ordering optics parts	TBD
11	**60 Page Draft**	3/29/19
12	**100 Page Submission**	4/12/19
13	**Final Document Due**	4/22/19