THE UNIVERSITY OF
ALABAMA IN HUNTSVILLE

“Common Fence Media”

For: Professor Hite in Senior Design

By: Abram Coleman, Alex Rankin, Erik Fong, Nathan Wight

Agenda

- Background
- Problem Statement
- Project Goals
- Configuration
  - Project Specifications
  - Component Specifications
- Final Design
- Testing
  - Stage 1
  - Stage 2
  - Stage 3
  - Field Test
  - Requirements
- Constraints
- Patent and Market Research
- Work Breakdown Structure
- Schedule
- BOM
- Team Roles
- Recommendations
- Demonstration

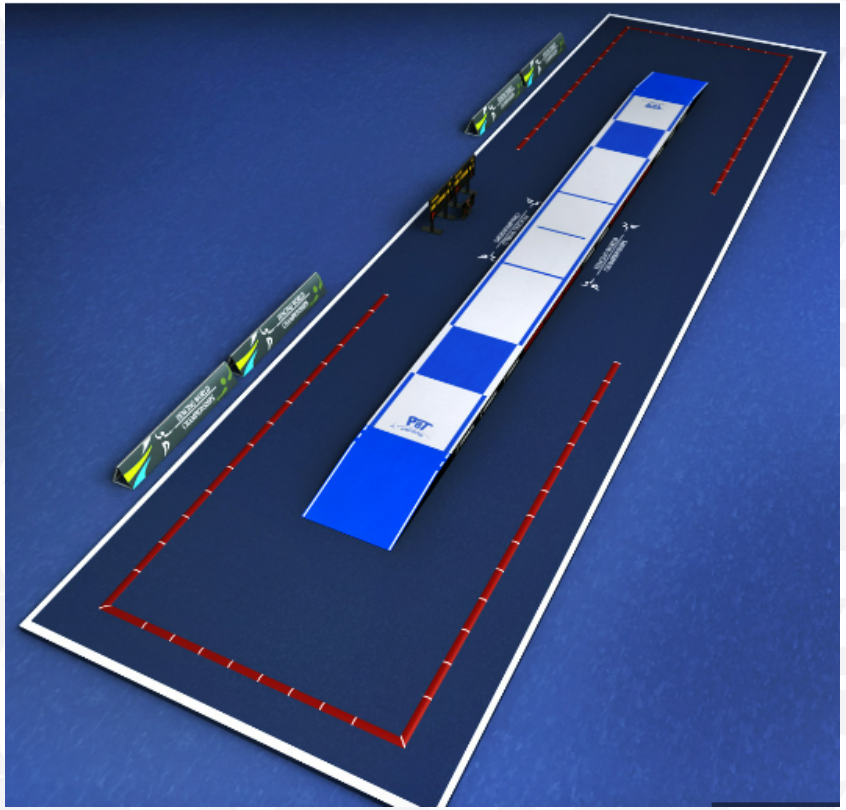
Background

Problem Statement

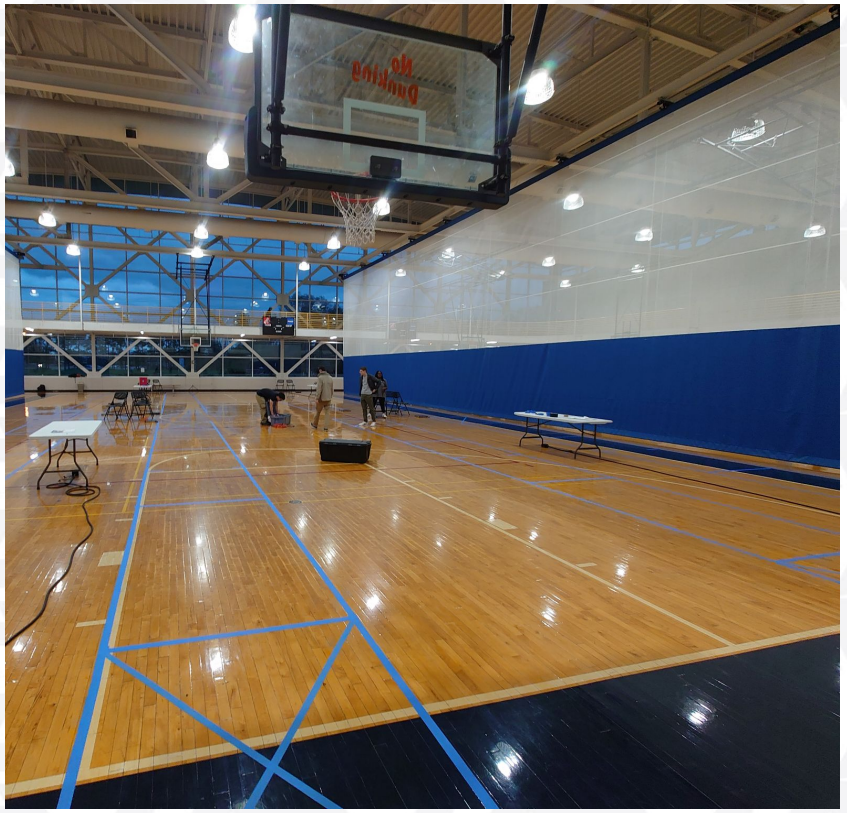
- Video replay systems are used in fencing tournaments to aid in the scoring of a bout, or fencing match, and to train both athletes and referees. However, the footage and recordings available are often hard to find, and when available, the quality is poor with jerky camera movements and unintelligible referee audio as prime examples.
- Our goal is to create a camera that can automatically pan, tilt, and zoom to keep the athletes in frame in a smooth fashion. The system will also incorporate a separate audio stream from the referee in the media stream.


JANUARY 2023
NORTH AMERICAN CUP
LOUISVILLE ★ KENTUCKY
USA
USA

Problem Statement



Setup at national and international tournaments



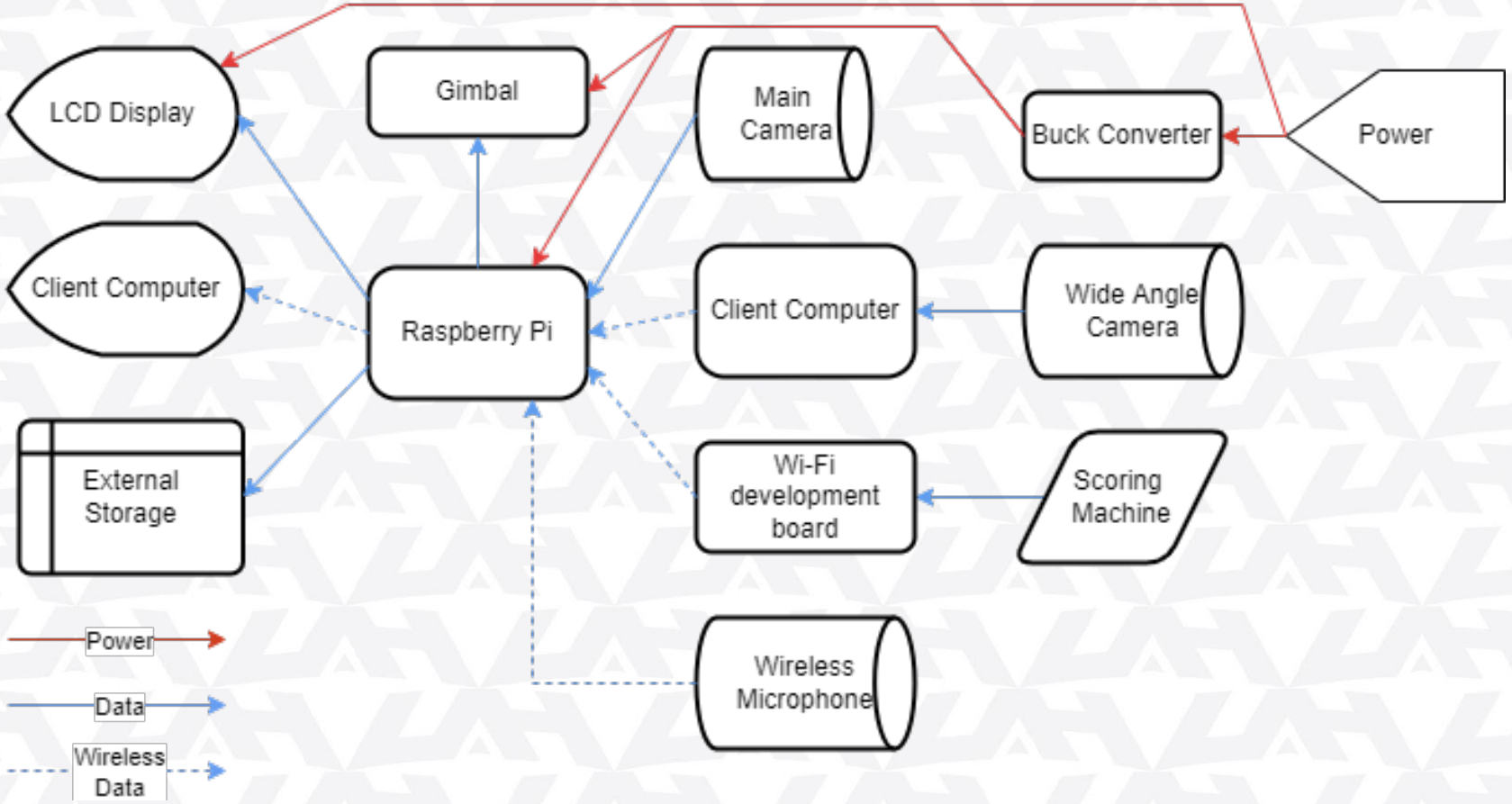
Setup at local tournaments

Project Goals

The Common Fence Media System shall have:

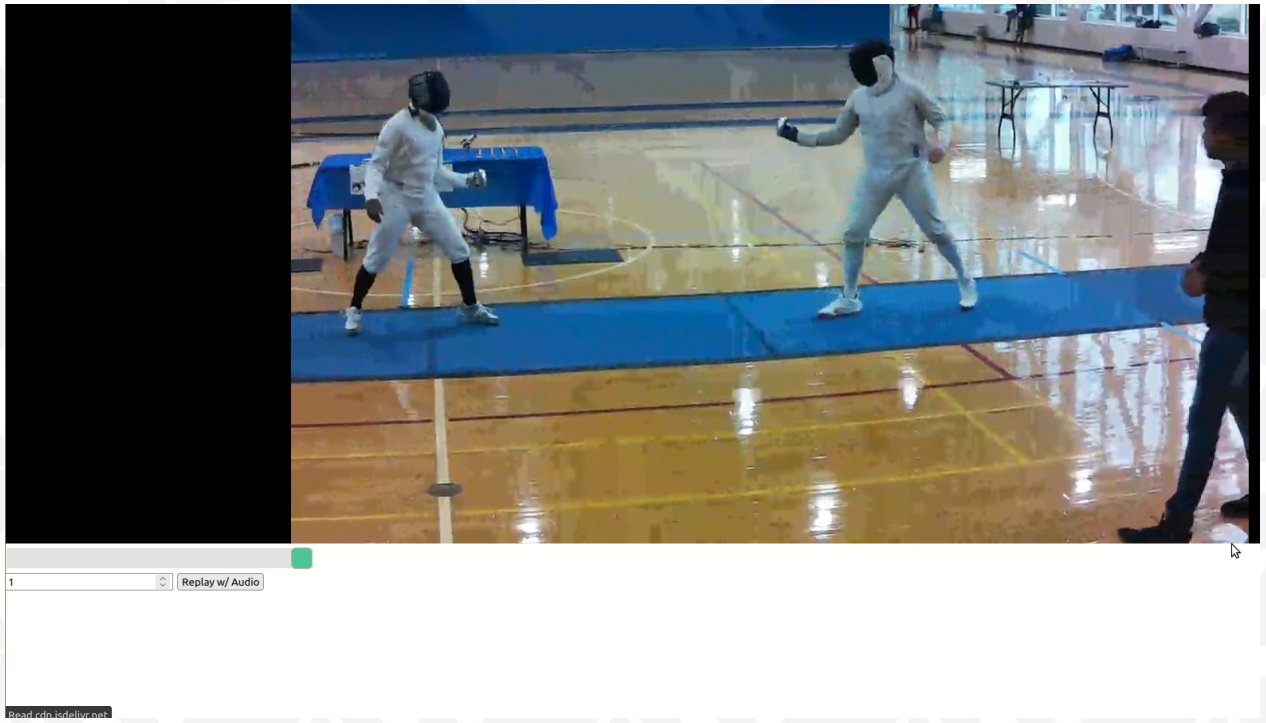
- Automatic Camera Control with pan, tilt, and zoom
- Wireless lapel microphone for referee audio
  - Violations
  - Scoring calls
- Web interface for control of
  - Video replays
  - Video streaming

Configuration



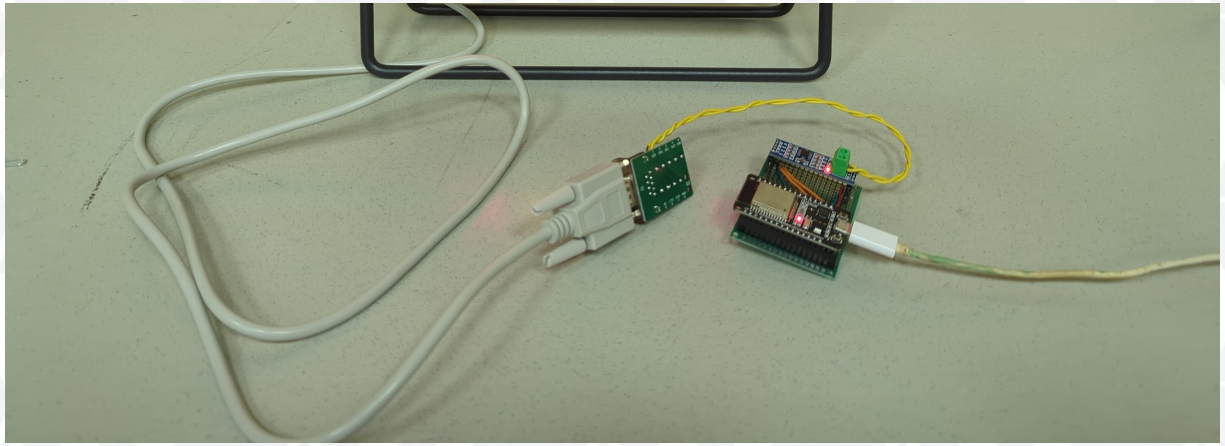
Project Specifications (Replay UI)

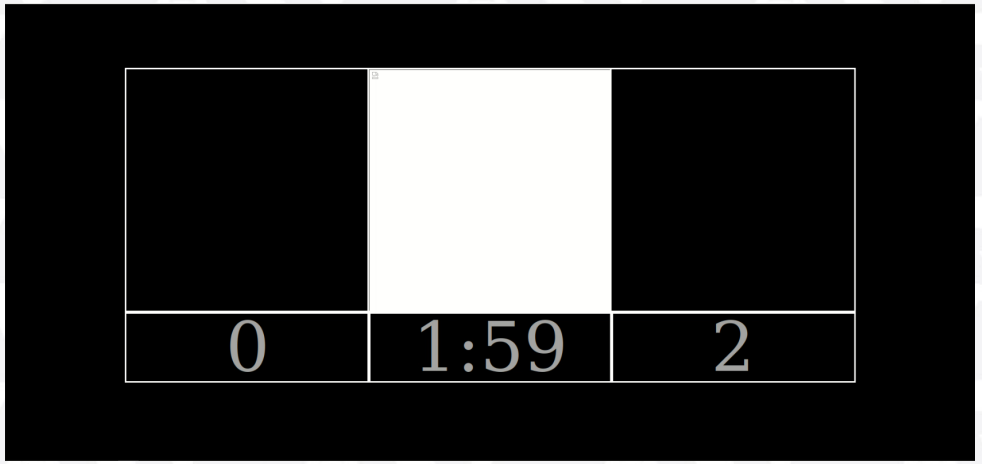
- Live with no audio video latency of less than 2 seconds.
- Live with audio video latency of less than 11 seconds.
- Replay buffer of at least 1 minute.
- Playback speed adjustable from 10% to 100%



Project Specifications (Scoring)

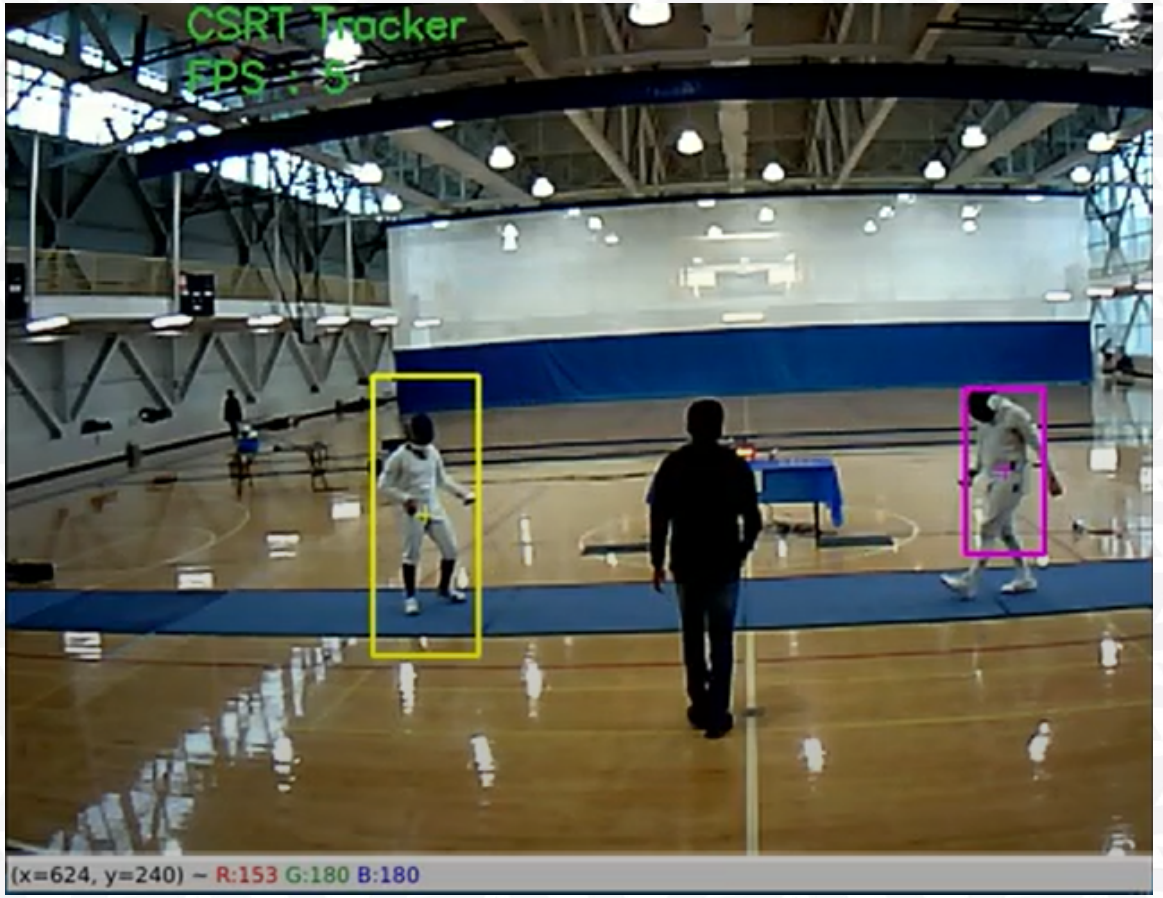
- Scoring Machine Data
  - Left and Right Score
  - Timer
  - Left and Right Lights
- UI
  - Scales to window size
  - Customizable Logo
  - Live updates with WebSockets





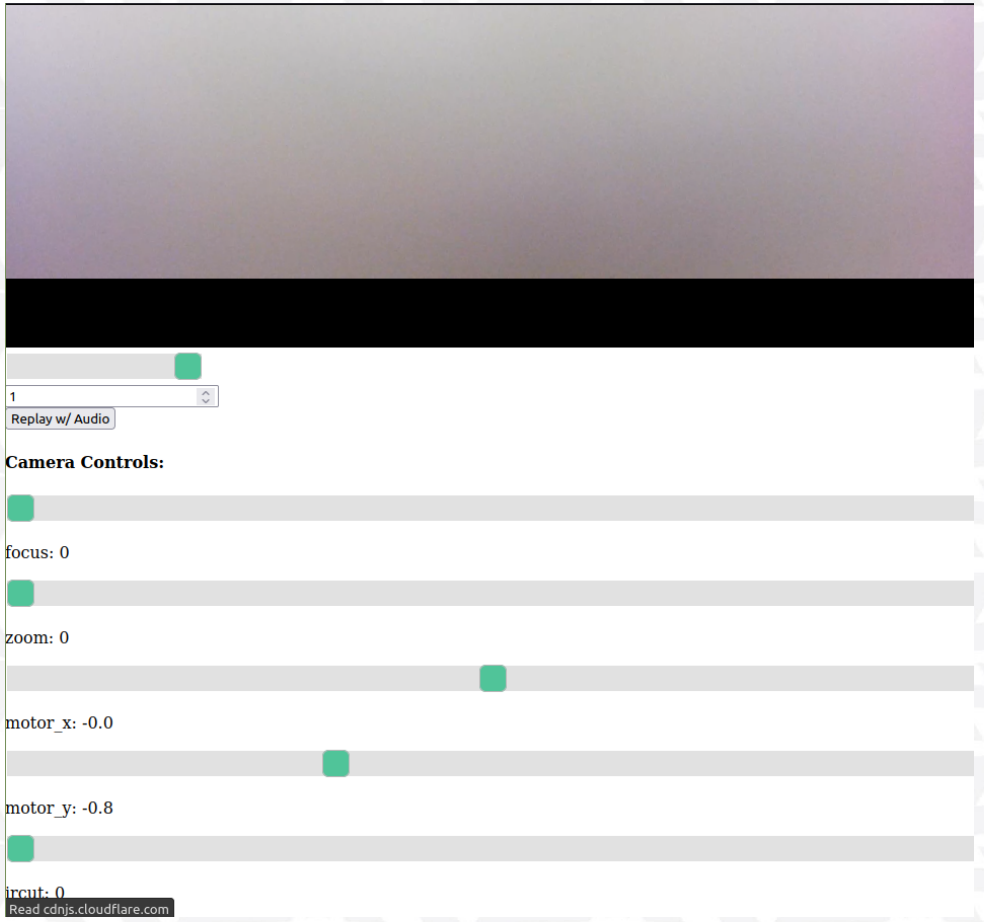
Project Specifications (Tracking)

- Object Detection
  - Haar feature-based cascade classifier
- Tracking
  - CSRT tracking algorithm
- Manual Selection



Project Specifications (Camera Control)

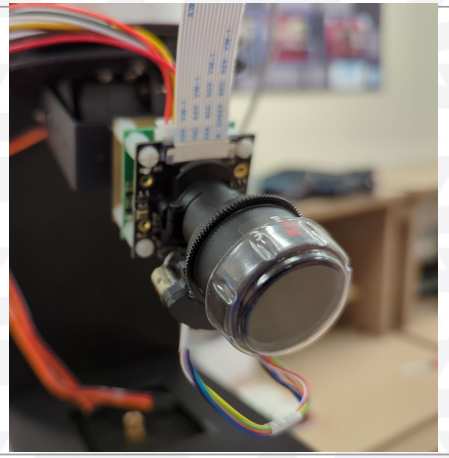
- Websockets based API
- JSON Formatted
- WebUI for manual control



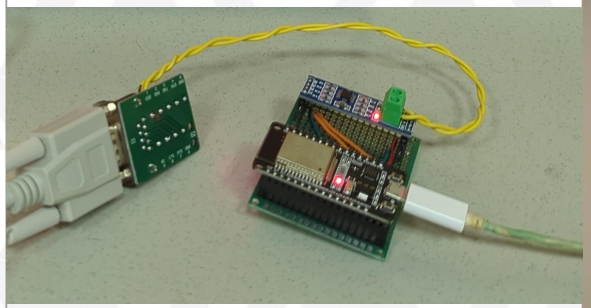
Component Specification

Raspberry Pi 4	Arducam PTZ Camera	PYLE Display

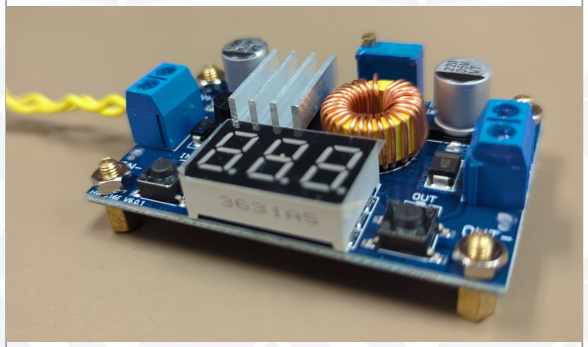
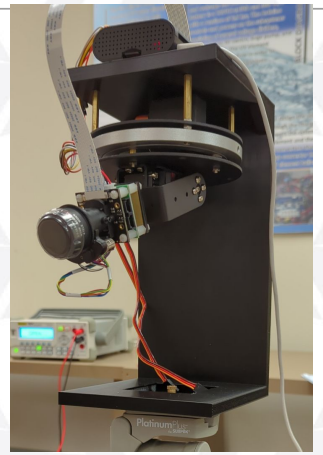
● RAM
  ○ 4GB
● Storage (Expandable):
  ○ 32GB
● Hardware H264 & MJPEG encoder
	● Sensor Size:
	  ○ 5MP 2592×1944
	● Focal Length:
	  ○ 3.2-11.1mm±5%
	● Supports 720p @ 60fps *
		● Video Interface
		  ○ PAL/NTSC
		● On hand

Component Specification

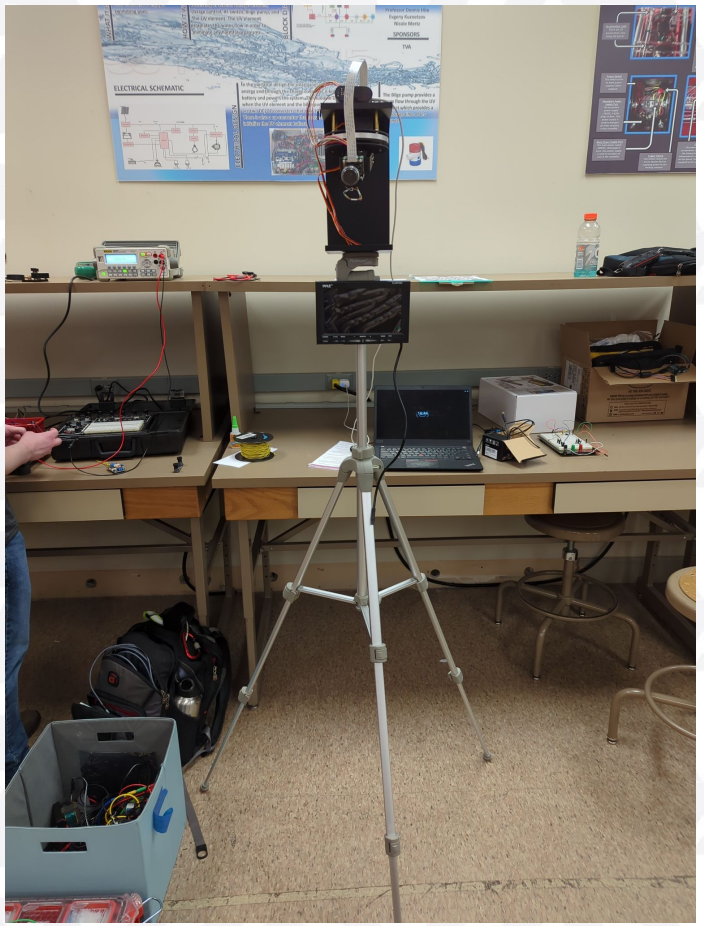
Wide Angle Camera	ESP32	Wireless Lapel Microphone
● 120° FOV* ● 2 MP Sensor	● WiFi and Serial Interfaces	● Wireless FHSS ● Battery Life: ○ 10 Hours ● USB 2.0 Interface
		

Component Specification

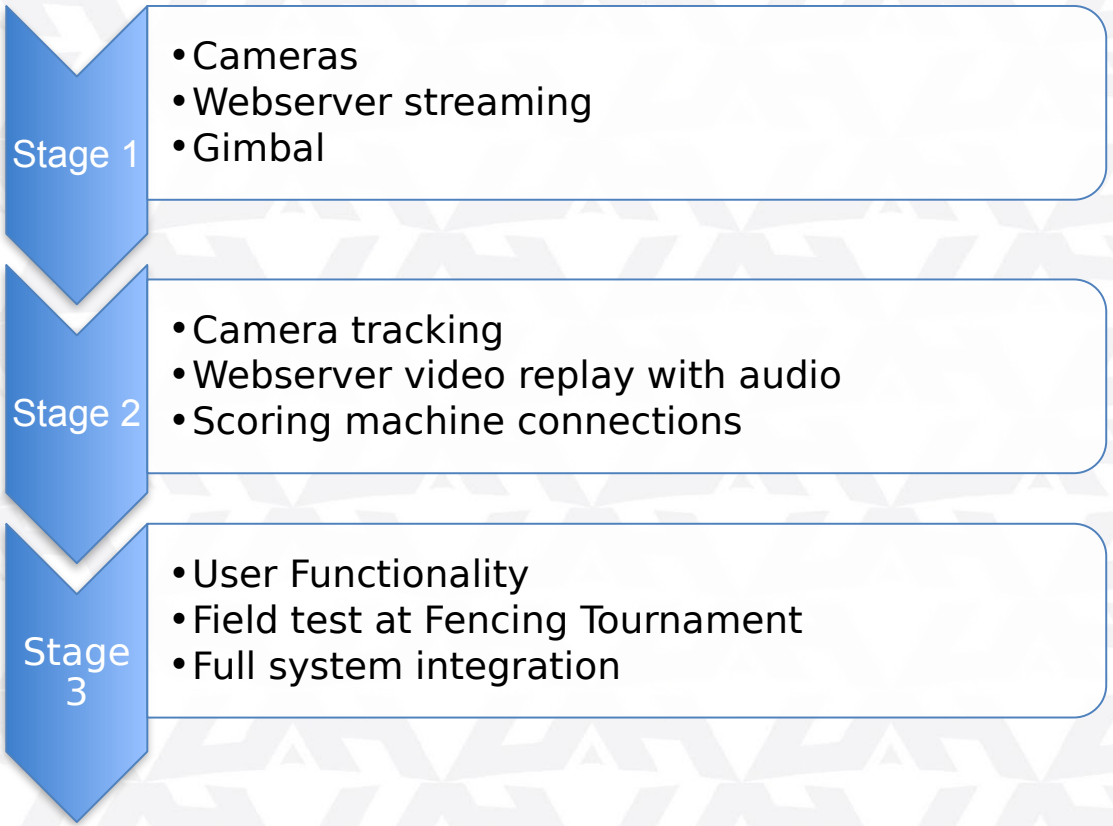
Buck Converter	Camera Gimbal	Tripod
● Input: ○ 4-38 V ● Output: ○ 1.25-36 V ● Max Current: ○ 5 A	● 2 Degrees of Freedom ● Both 0-180 degrees	● On Hand ● Max Height ○ ~5 feet
		

Final Design

- Dimensions:
  - w/ Tripod:
    - 900x780x1972 mm
  - w/o Tripod:
    - 142*127*254 mm
- Weight:
  - ~4 lbs
- Input Power
  - 5V @ 5A
    - Supplied from Buck Converter
  - 12V @ 3A
    - Supplied from AC adapter



Test Plan


Stage 1
•Cameras
•Webserver streaming
•Gimbal
Stage 2
•Camera tracking
•Webserver video replay with audio
•Scoring machine connections
Stage 3
•User Functionality
•Field test at Fencing Tournament
•Full system integration

Stage 1 Test

- Camera systems
  - Tracking camera
    - tracking one fencer
    - sending data to Raspberry Pi
  - Main Camera
    - manual control (Pan, Tilt, Zoom)
    - speed of movement
    - stability of video
- Webserver
  - video streaming
  - video recording

Conditions for success:

- video streams at 720p 30fps
- record video at 720p 30fps
- stereo camera issues movement data

Stage 2 Test

- Camera systems
  - Tracking camera
    - tracking two fencers
  - Main Camera
    - automatic control (Pan, Tilt, Zoom)
    - speed of movement
    - stability of video
- Webserver
  - video replay
  - audio inclusion
- Scoring Machine Integration

Conditions for Success:

- fencers only leave the frame once per point
- audio can be understood clearly
- scoring machine data is able to be viewed in video stream

Stage 3 Test

- Camera systems
  - full system integration
- Webserver
  - user interface
- User Functionality
  - ensure a lightly trained user can operate the system

Conditions for Success

- fencers leave frame less than 0.6 times per point
- system records, replays, and displays scores
- system operates independently after setup

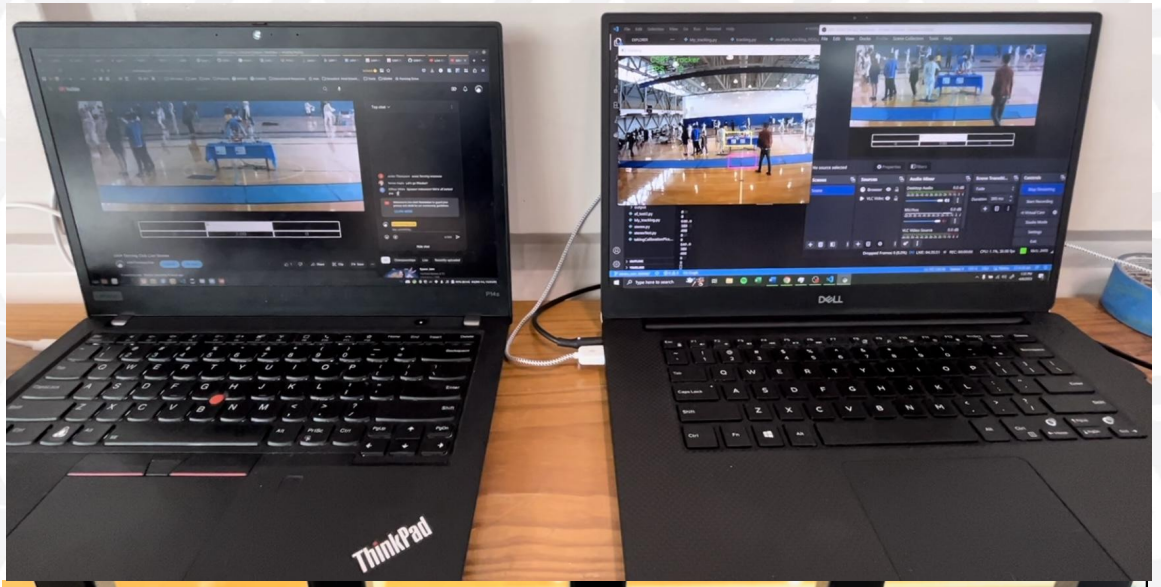
Field Test

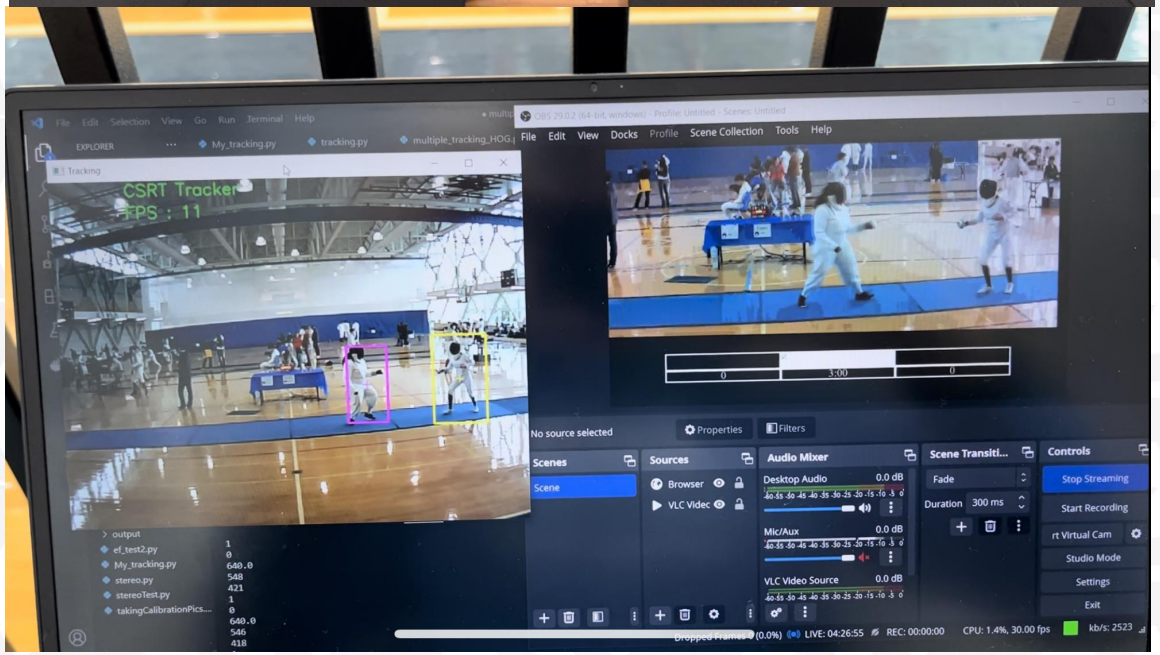
<u>Full System Test</u>

- Camera system
- Tracking
- WebUI
- Fencing Tournament

<u>Conditions for Success</u>

- fencers leave frame less than 0.6 times per point
- system records, replays, and displays scores
- system operates independently after setup





Successful Full System Requirements

- Current Standards
  - fencers leave frame 0.6 times per point
  - camera jerk* 5 movements per point
  - correct score displayed before next point begins
  - no clear referee audio
- Successful test will depend on
  - fencers leave frame less than 0.6 times per point
  - camera jerk* below 5 movements per point
  - correct score displayed before next point begins
  - distinguishable referee audio per point

*camera jerk defined as unnecessary movement of the camera when both fencers are in center frame already.

Constraints

1. **Design Budget**

   The total budget for the Common Fence Media System is $540 (USD) and is self funded. For future marketability, the system needs to be cost effective. Hardware for the system was fairly expensive. Therefore, hardware with fewer capabilities and less resolution had to be purchased.

2. **Marketability**

   The marketability of the product is somewhat limited to fencing clubs at universities and USA Fencing. Since the above market is small and most fencing matches are generally reliant on volunteers or other participants, the system has high marketability. Since the system is an automated system, it allows for one less person to be needed to operate a fencing match.

Constraints

3. **Power Requirements**

   The sensor, camera, and processor require a 5 volts DC to operate. The LCD Display requires 12 volts. Therefore, two power sources are required to supply sufficient power.

4. **Health and Safety**

   The potential safety hazards are electrical shock if a person touches a connection or the processor, possible physical harm from the moving camera, and/or a possible tripping or choking hazard if the power supply cord is not properly secured.

5. **Legal**

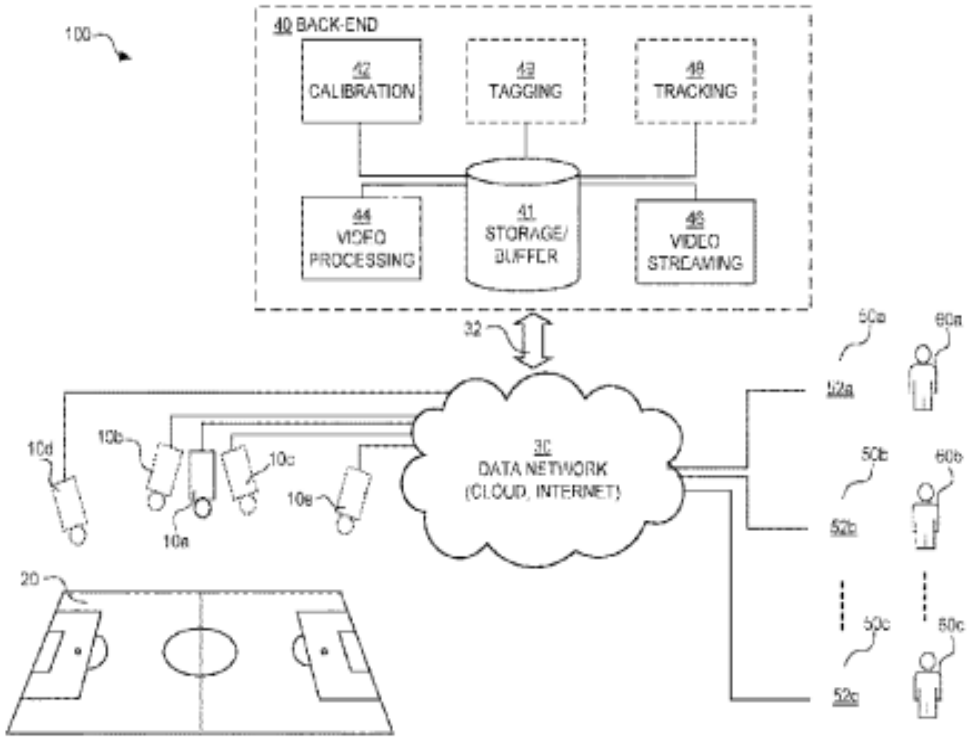
   Possible legal concerns stem from the potential safety hazards and not having the consent to film the bout from match affiliates, participants, referees, and/or members of the public in the background or field of view.

Patent and Market Research

1. **United States Patent #US-11283983-B2**

   “System and method for providing virtual pan-tilt-zoom, PTZ, video functionality to a plurality of users over a data network.”

   Differences: Our system can operate locally if needed. Our system uses a USB camera to track movement, and our system uses one camera to record action while theirs uses multiple network cameras.



Patent and Market Research

2. Worldwide Patent WO-2021084165-A1

“METHOD AND SYSTEM FOR CHARACTERIZING A MOVEMENT OF AN ENTITY IN MOVEMENT.”

Differences: Our system does not track movement by changes in geometry, but rather it uses general object tracking from OpenCV.

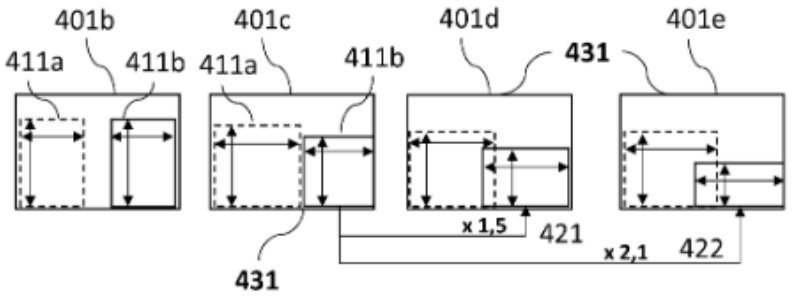
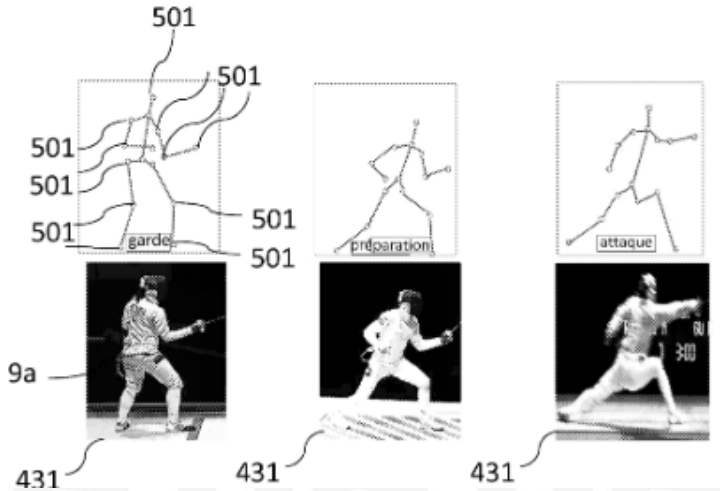
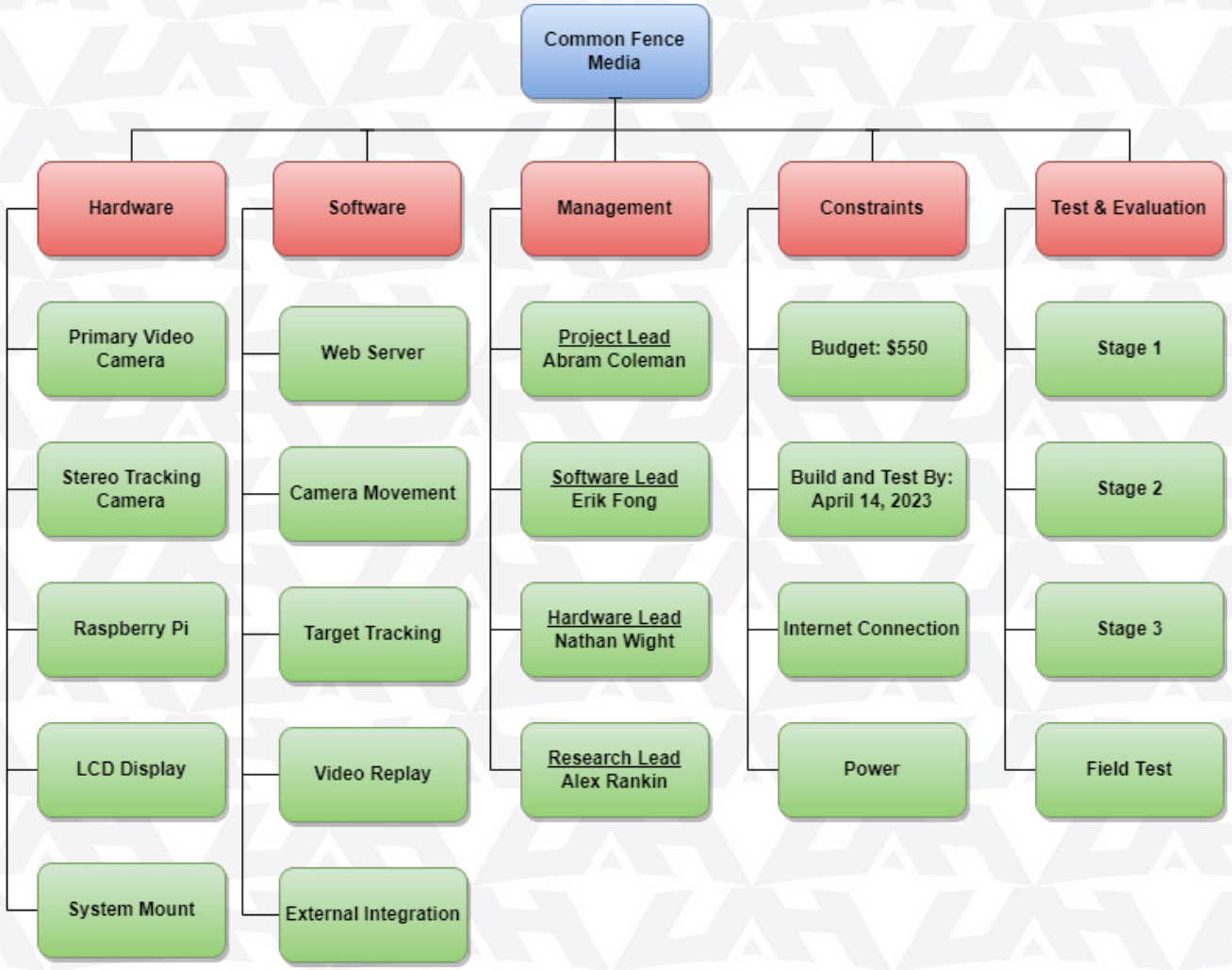


FIG. 6



Work Breakdown Structure

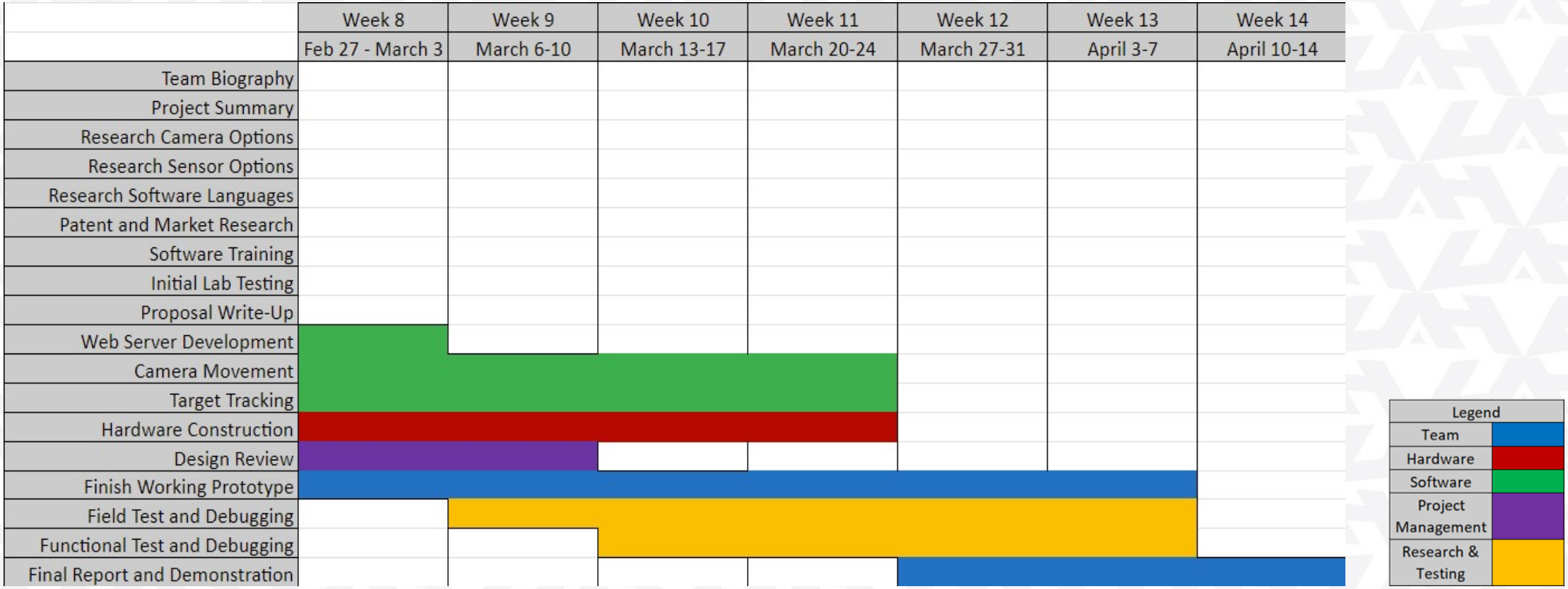


Schedule

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
	Jan 1-9	Jan 16-20	Jan 23-27	Jan 30 - Feb 3	Feb 6-10	Feb 13-17	Feb 20-24
Team Biography							
Project Summary							
Research Camera Options							
Research Sensor Options							
Research Software Languages							
Patent and Market Research							
Software Training							
Initial Lab Testing							
Proposal Write-Up							
Web Server Development							
Camera Movement							
Target Tracking							
Hardware Construction							
Design Review							
Finish Working Prototype							
Field Test and Debugging							
Functional Test and Debugging							
Final Report and Demonstration							

Legend	
Team	
Hardware	
Software	
Project Management	
Research & Testing	

Schedule


Week 8
Feb 27 - March 3
Week 9
March 6-10
Week 10
March 13-17
Week 11
March 20-24
Week 12
March 27-31
Week 13
April 3-7
Week 14
April 10-14
Team Biography
Project Summary
Research Camera Options
Research Sensor Options
Research Software Languages
Patent and Market Research
Software Training
Initial Lab Testing
Proposal Write-Up
Web Server Development
Camera Movement
Target Tracking
Hardware Construction
Design Review
Finish Working Prototype
Field Test and Debugging
Functional Test and Debugging
Final Report and Demonstration
Legend
Team
Hardware
Software
Project Management
Research & Testing

Bill of Materials

Part Number/ASIN	Part Description	Cost	Running Total
B0167B5	Arducam 5MP 1080p Pan Tilt Zoom PTZ Camera with Base for Raspberry Pi 4/3B+/3	$ 187.99	
B07TC2BK1X	Raspberry Pi 4	$ 165.00	
B009RIK3EO	LCD Screen	$ 47.99	
B09JNLWYSN	Lapel microphone	$ 32.08	
N/A	HBV-1609 USB Camera	$ 20.29	
N/A	3D-printed Case	$ 20.00	
B09GK74F7N	ESP32 DEVKIT WiFi Board	$ 18.99	
B07ZX5NKHQ	Tripod	$ 18.03	
B085T73CSD	DC-DC Buck Converter	$ 13.99	
B01N8WLEV0	MAX485 Chip Module TTL to RS-485 Instrument Interface Module	$ 8.99	$ 533.35

Team Roles

Abram Coleman – Project Lead

Team management, Responsible for deliverables, Project support

Erik Fong – Software Lead

Responsible for software development, Manage team coding, Consultant on hardware acquisition

Nathan Wight – Hardware Lead

Responsible for hardware implementation, Hardware research, Software Support

Alex Rankin – Research Lead

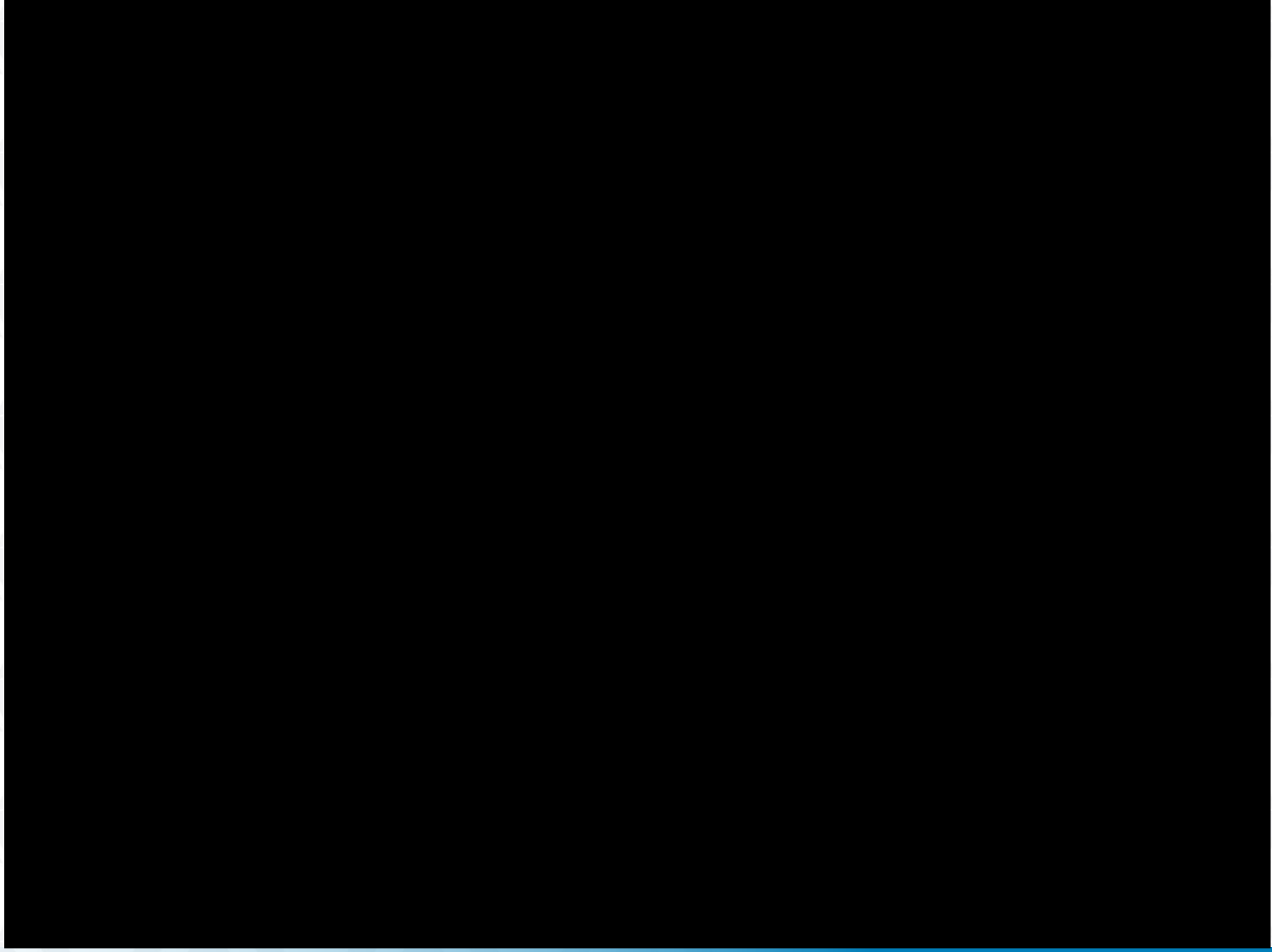
Organize Information, Hardware/Software Support, Support Team Lead with Deliverables

Recommendations

- Tracking
  - Programming Language
  - Training Object Detection Algorithm
  - User defined regions of interest
- Hardware
  - Different Camera Sensor
  - HDMI to CSI Adapter
  - Wider FOV for tracking camera
- Web UI
  - More intuitive scrub bar
  - Better Manual Control UI
  - Use of TLS

Demonstration Clips

We will demo replay, tracking, scoring, streaming, and audio.



References

1. “Fencing piste arena low poly,” *3DOcean*, 07-Mar-2017. [Online]. Available: https://3docean.net/item/fencing-piste-arena-low-poly/19557617. [Accessed: 08-Feb-2023].
2. L. Scruggs and J. Dubrovich, January NAC - Div I Women's Foil - Finals - Louisville, KY - 2023, Youtube, 7 January 2023, https://www.youtube.com/watch?v=FHChvJ9o6zk, [Accessed 2 February, 2023]
3. https://gitlab.kn4vhm.com/efong/fencing-video-tracker
4. https://github.com/UAHFencingClub/VideoReplaySystem

Questions?

Thank you!