TEAM B1: IR Man

AI smart home IoT Hub

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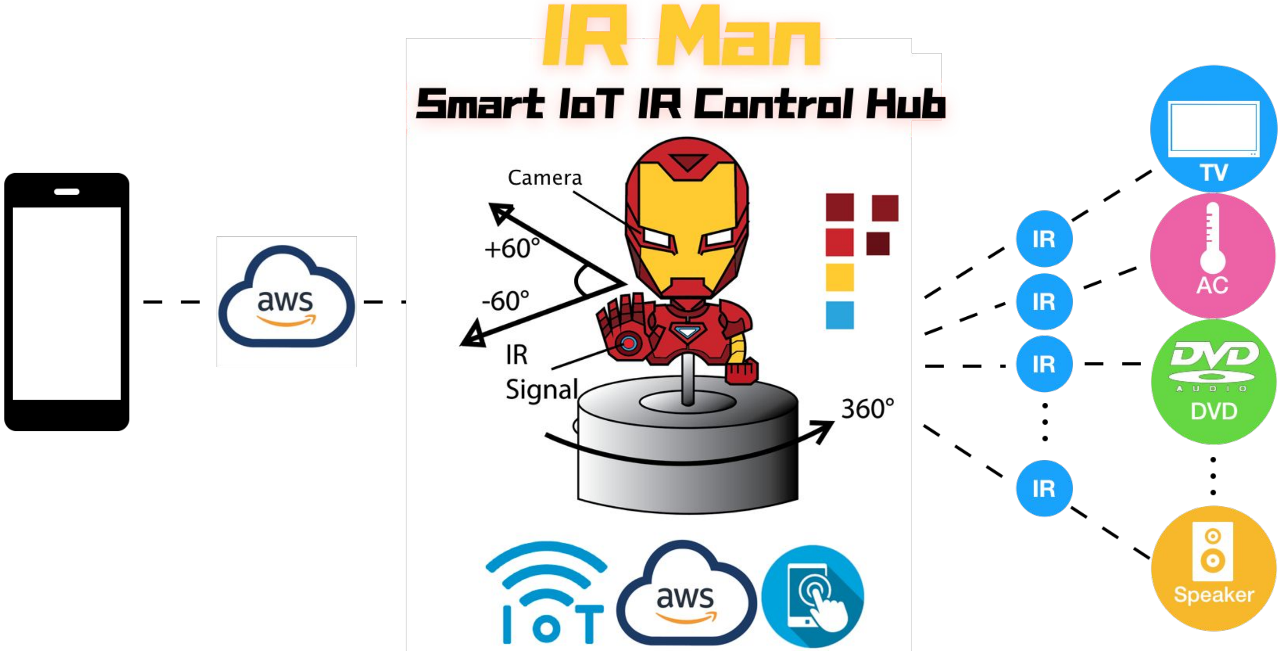
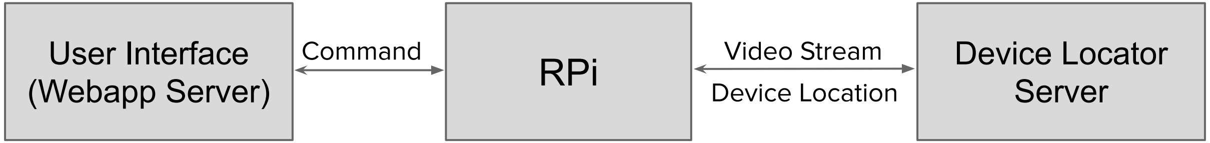
Application Area



Solution Approach



User Interface (Webapp Server)

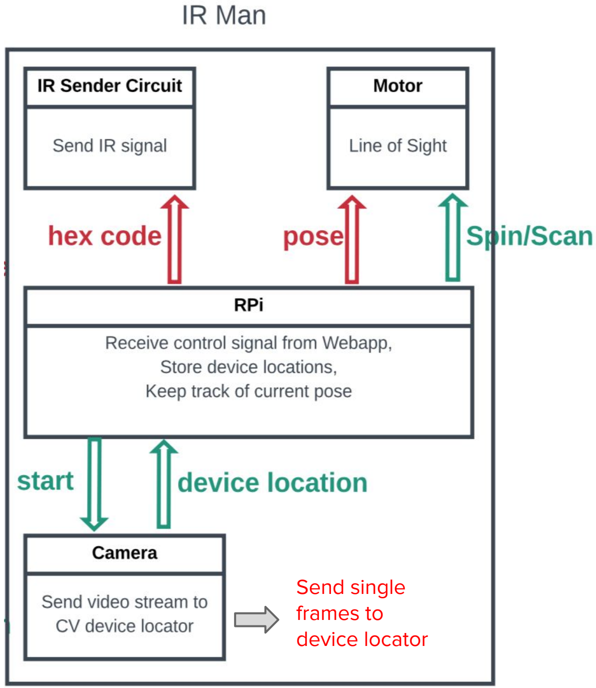
Command

RPi

Video Stream

Device Location

Device Locator Server



IR Man

IR Sender Circuit

Send IR signal

Motor

Line of Sight

hex code

pose

Spin/Scan

RPi

Receive control signal from Webapp,
Store device locations,
Keep track of current pose

start

device location

Camera

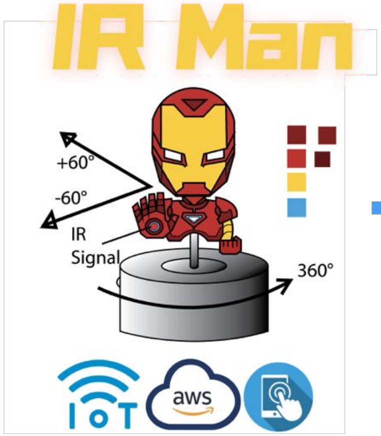
Send video stream to CV device locator

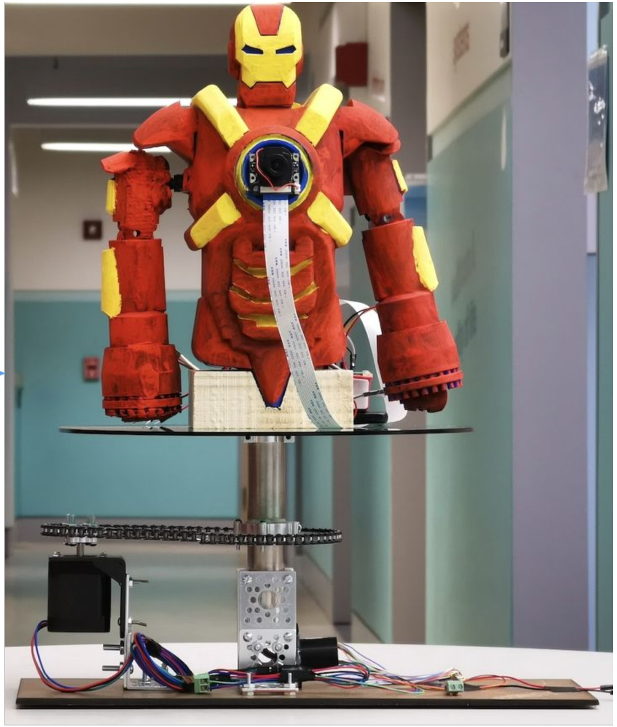
Send single frames to device locator

- Web App:
  - Accessible across all platforms
  - 3 command types:
    - Calibration
    - Device Operation
    - Senario Modes
- Device Locator Server:
  - Customized YoloV3 model
  - Data post-processing

- RPi:
  - 2 DOF Robot
    - Stepper Motor
    - Servo Motor
  - IR sender
  - Camera

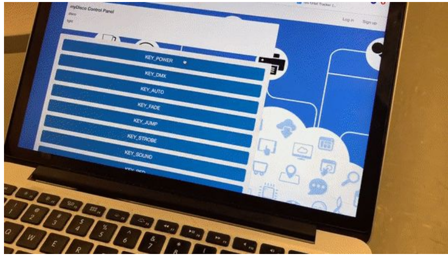
Solution Approach





Complete Solution

- Calibration
  - CV Locating 3 devices (AC, TV, Disco Lights) at a distance of 6-9 feet
- Device Operation
  - IRMan rotate to point to the device
  - IRMan sends the correct IR signal



- Senario Modes
  - IRMan working correctly and precisely even after multiple consecutive commands

Cozy Party
Quiet Away

Component Metrics and Validation

Component	Requirement	Testing Method	Result
WebApp Latency	Server to RPi latency under 500ms	Timestep, stress tested with a mock webapp server sending 100 messages to 10 concurrent simulated raspberry pi clients	Avg latency of 24.41ms Maximum 26.07ms Minimum 20.49ms
IR Circuit Success Rate	success rate of 90% within range of 4-10 feets	Collect success rate of all types of command signals from 3 different devices/protocol under distances of 4 to 10 feet	100% for 4-9 feet 75.2% for 10 feet 96.5% overall

Component Metrics and Validation

Component	Requirement	Testing Method	Result
Motor Position Accuracy	± 5 degrees of correct pose	Feed in 8 expected positions and manually check the result	Accurate for stepper motor Avg error 0.375 degrees for servo motor (Max 2, min 0)
Motor Rotation Time	Time to specific pose < 1s	Record time it takes for a full rotation and rotations with 5 different layouts (no overlap, minimum 10 degrees in between)	Takes <3 seconds

Component Metrics and Validation

Component	Requirement	Testing Method	Result
Device Locator Accuray	Image validation accuracy > 75%	Manually set up 140 validation images, run through model and collect result	83.5% accuray in unmonitored environment
Device Locator Latency	~~RPi to server latency < 500ms~~ Image transfer latency < 750 ms	~~5 simulated video stream transmission to server~~ Record time for 10 image transfer of camera-sized images over websocket	Avg 612 ms Max 635 ms Min 607 ms

Video transmission latency is not tested because we changed the implementation, which made this test non-relevant.

Component Metrics and Validation

Component	Requirement	Testing Method	Result
Device Locator Output Position	± 10 degree of the correct pose for each devices	10 test calibration runs (10 images) in different environment with TV, Disco lights, AC	Avg 2.74 degrees Max 6.5 degrees
Calibration Latency	Total calibration time < 3 mins	10 complete calibration runs in different environment with TV, Disco lights, AC	Worst case 103 seconds. Normally avg 33 seconds.

Test devices needs to be put into the camera's field of view

Device locator can always find disco light and AC.

Device locator performs worst on Vizio TV since there are a lot of interference from other monitors

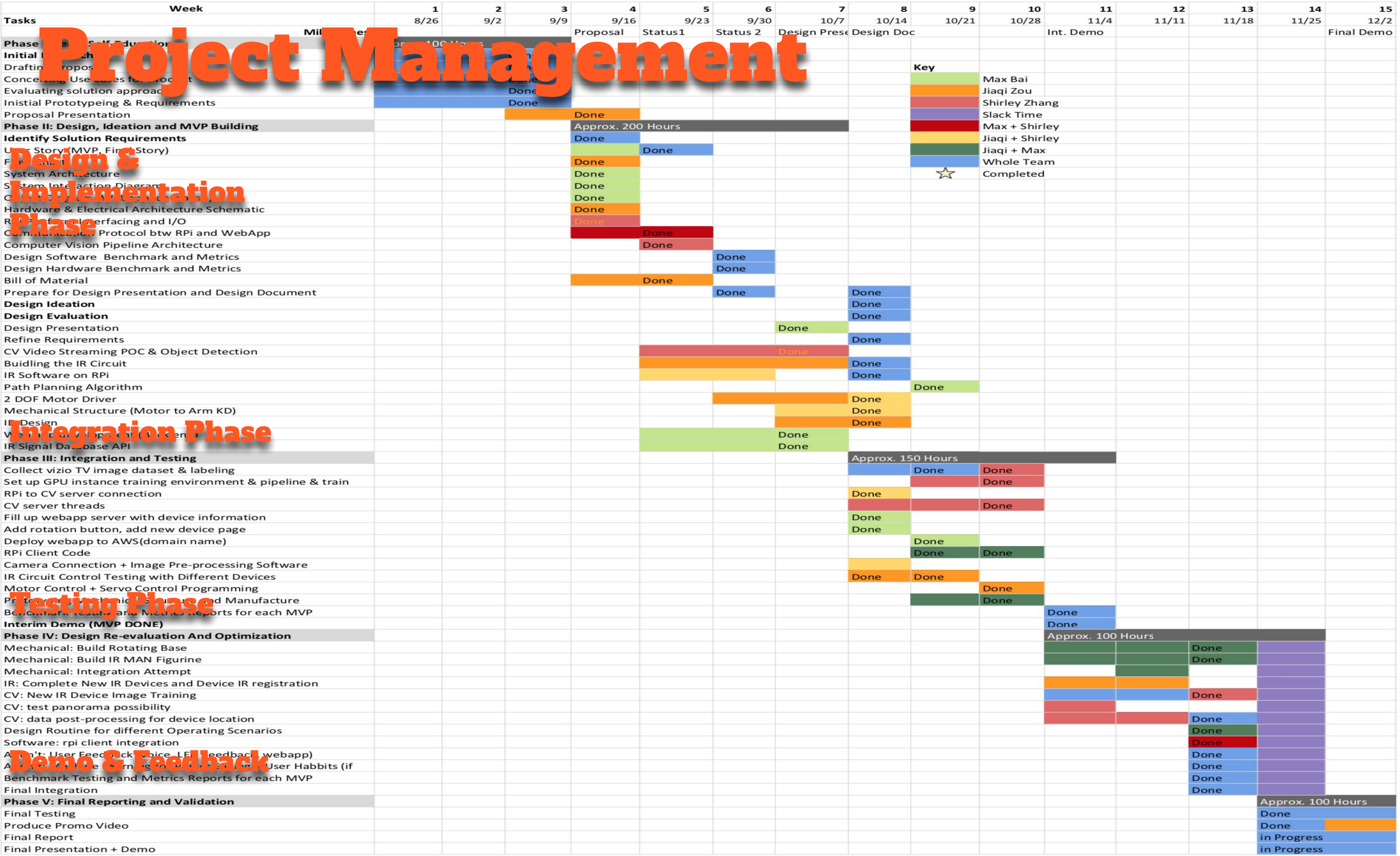
System Metrics and Validation

Component	Requirement	Testing Method	Result
User Success Rate	Success rate > 90%	Run 30 IR commands on test devices with correct pose information	86.67% (26 out of 30)
User Latency	Average Latency < 2s	Run 30 IR commands on test devices with correct pose information	Average total time: 3.107 s

IR signal command performs worst on the disco light. We assumed it's due to the interference from its light.

Total time to send IR signal is 3.107s.
Average time it takes to raise arm and send IR signal: 2.614s.
Average time to spin to device = 3.107s - 2.614s = 0.493s

Project Management



Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tasks	8/26	9/2	9/9	9/16	9/23	9/30	10/7	10/14	10/21	10/28	11/4	11/11	11/18	11/25	12/2
Mil[illegible]es				Proposal	Status1	Status 2	Design Prese	Design Doc			Int. Demo				Final Demo
Phase [illegible] Self-Education	[illegible] 100 Hours														
Initial [illegible]ch			[illegible]												
Draftin[illegible] propos[illegible]			[illegible]												
Conce[illegible] Use cases fo[illegible] t			Done												
Evaluating solution approac[illegible]			Done												
Inistial Prototypeing & Requirements			Done												
Proposal Presentation				Done											
Phase II: Design, Ideation and MVP Building				Approx. 200 Hours											
Identify Solution Requirements				Done											
U[illegible] Story(MVP, Fir[illegible] Story)					Done										
F[illegible]				Done											
System Arch[illegible]ecture				Done											
S[illegible]stem Int[illegible]action Diagram				Done											
C[illegible]				Done											
Hardware & Electrical Architecture Schematic				Done											
R[illegible]erfacing and I/O				Done											
C[illegible] Protocol btw RPi and WebApp					Done										
Computer Vision Pipeline Architecture					Done										
Design Software Benchmark and Metrics						Done									
Design Hardware Benchmark and Metrics						Done									
Bill of Material					Done										
Prepare for Design Presentation and Design Document						Done		Done							
Design Ideation								Done							
Design Evaluation								Done							
Design Presentation							Done								
Refine Requirements								Done							
CV Video Streaming POC & Object Detection							Done								
Buidling the IR Circuit								Done							
IR Software on RPi								Done							
Path Planning Algorithm									Done						
2 DOF Motor Driver								Done							
Mechanical Structure (Motor to Arm KD)								Done							
I[illegible] Design								Done							
W[illegible]en[illegible]							Done								
IR Signal Da[illegible]base API							Done								
Phase III: Integration and Testing								Approx. 150 Hours							
Collect vizio TV image dataset & labeling									Done	Done					
Set up GPU instance training environment & pipeline & train										Done					
RPi to CV server connection								Done							
CV server threads										Done					
Fill up webapp server with device information								Done							
Add rotation button, add new device page								Done							
Deploy webapp to AWS(domain name)									Done						
RPi Client Code									Done	Done					
Camera Connection + Image Pre-processing Software															
IR Circuit Control Testing with Different Devices								Done	Done						
Motor Control + Servo Control Programming										Done					
P[illegible]d Manufacture										Done					
Be[illegible]rts for each MVP											Done				
Interim Demo (MVP DONE)											Done				
Phase IV: Design Re-evaluation And Optimization											Approx. 100 Hours				
Mechanical: Build Rotating Base													Done		
Mechanical: Build IR MAN Figurine													Done		
Mechanical: Integration Attempt															
IR: Complete New IR Devices and Device IR registration															
CV: New IR Device Image Training													Done		
CV: test panorama possibility															
CV: data post-processing for device location													Done		
Design Routine for different Operating Scenarios													Done		
Software: rpi client integration													Done		
A[illegible]n't: User Feed[illegible]ck [illegible]oice, LE[illegible] [illegible]eedbac[illegible] webapp)													Done		
A[illegible]e[illegible]rn[illegible]g[illegible] User Habbits (if													Done		
Benchmark Testing and Metrics Reports for each MVP													Done		
Final Integration													Done		
Phase V: Final Reporting and Validation														Approx. 100 Hours	
Final Testing														Done	
Produce Promo Video														Done	
Final Report														in Progress	
Final Presentation + Demo														in Progress	

Key

🟩	Max Bai
🟧	Jiaqi Zou
🟥	Shirley Zhang
🟪	Slack Time
🟥	Max + Shirley
🟨	Jiaqi + Shirley
🟩	Jiaqi + Max
🟦	Whole Team
☆	Completed

Design & Implementation Phase

Integration Phase

Testing Phase

Demo & Feedback

Lessons Learned

1. Do not ever be unclear in what you are about to do.
2. When you think Capstone is done, it’s 50% done.
3. Shoot for the moon, and land among the stars.
4. Integration takes more time you think it would.
5. Our project can be widely applied to other applications.

Project Homepage: http://course.ece.cmu.edu/~ece500/projects/f19-teamb1/
Project Video: https://youtu.be/TVtRevxk900