Use Case/Application

GOAL:

Improve usability of computer monitoring for those who have to look at a screen for long periods of time

PRODUCT:

Projector screen that follows the movement of the user's head

APPLICATIONS:

Medical Technicians, IT Professionals, Netflix and more!

Solution Approach

Camera detects head movement in order to align projection with user’s line of sight

- Face calibration process
- CV to calculate head movement
- Motor controlled projector
- Caters experience of working to the user

Specification: Central Hardware

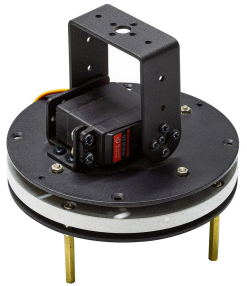
2 DOF Servo motor, can simultaneously move up to 180 degrees horizontally, 90 degrees vertically

Motor linked to an Arduino to receive commands

Stable projection, no vibration

Estimated battery life: 3 hours

Estimated weight: 8 lbs



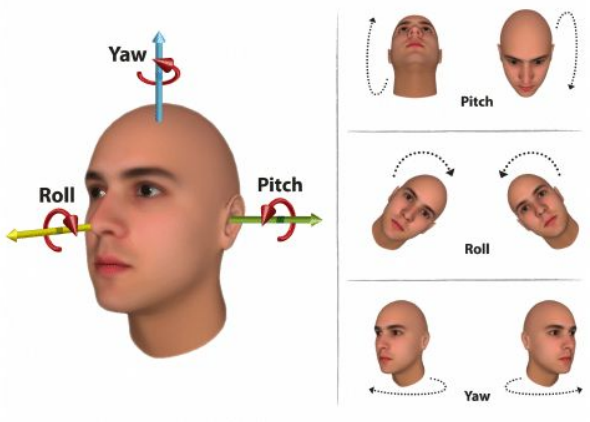
Specifications: Computer Vision

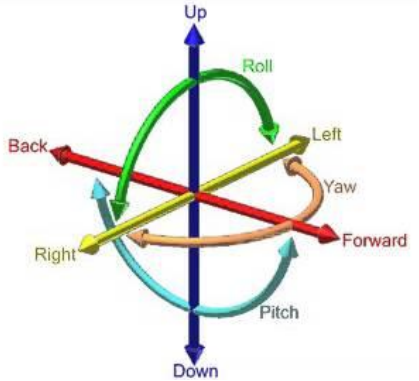
User's head rotation detected and calculated in real-time (< 30 ms)

From centered position, head rotation can be detected up to ±45° for each DOF (yaw, pitch)

System can handle head movement up/down, left/right, and backward/forward up to 4 feet from initial, calibrated position

Small head movements, resulting in < 1 foot change in projection center, ignored by system





Specification: System and Calibration Components

Full Pipeline will be built to respond < 0.2 seconds

Pipeline will communicate using pySerial

Projector will be within 10 meters of the wall

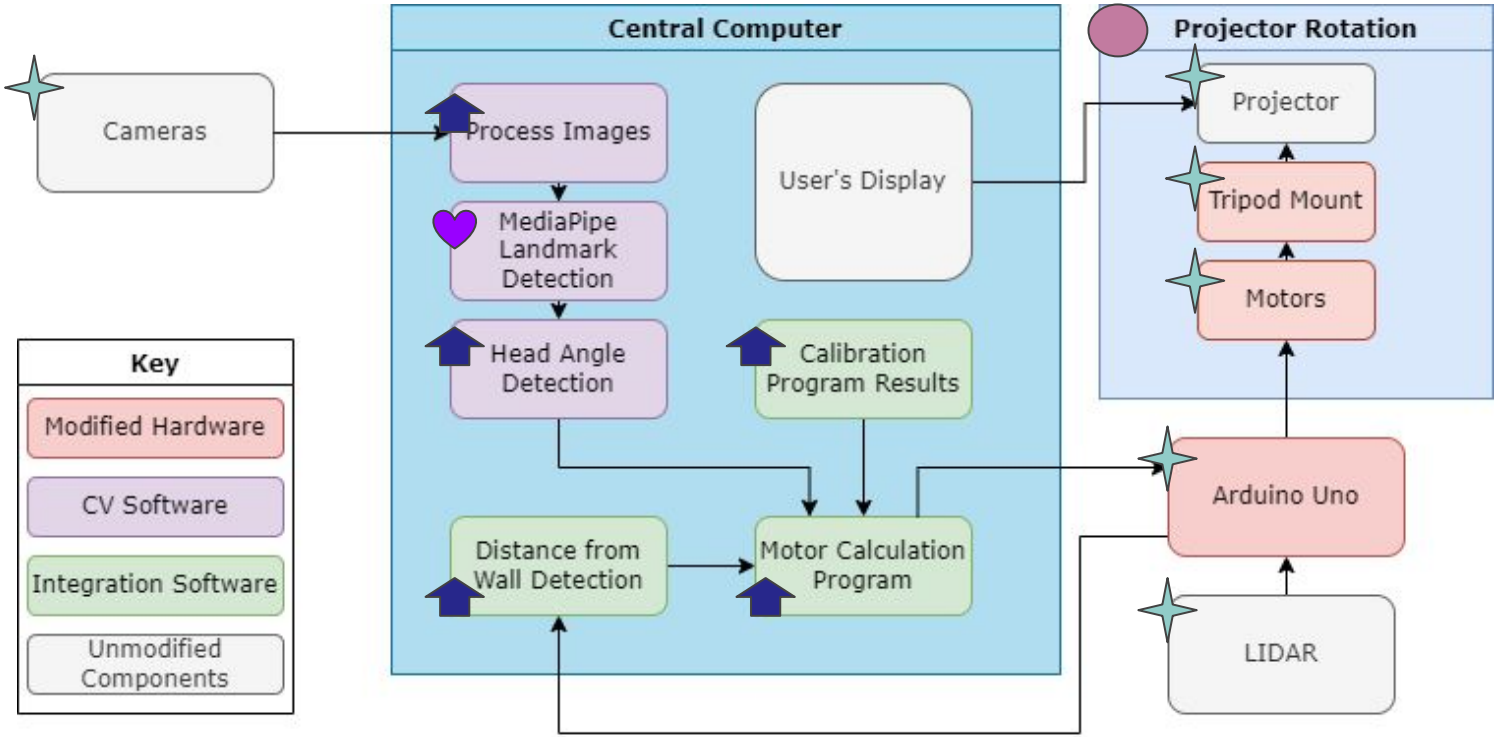
Calibration system relies on user camera input (CV) and LiDAR < 0.125 of projection away from central head view

LIDAR range shall be > 10 meters, and accuracy must < 0.05 meter error

Camera must be responsive enough for CV specification in dim lighting

Buying Downloading Developing Assembling

System Diagram



Implementation Plan

1. Gathering the pieces: CV, pySerial, Hardware
    a. Hardware
        i. Tripod with servo controlled “joint” that holds projector
    b. Software
        i. Use MediaPipe to identify facial landmarks
        ii. Calculate head rotation based on yaw and pitch of head
2. Testing and Connecting the Pieces
    a. Hardware
        i. Arduino code to translate movement calculations to motor speed and direction
        ii. Cap motor speeds to avoid jerky movements
    b. Software
        i. Calculations to connect head movement to projector movement (based on gaze estimation, position of person, position of projector)
3. Calibrating and Refining

Risks and Mitigations

Risk #1: Calibration program will need a lot of refining

- Aim to get a running version of pipeline before break
- Use hard coded estimation to start, and then refine and test different methods

Risk #2: Difficulties with distinguishing between unintentional and intentional head movements

- Research ways of making CV program robust to ignore unintentional small movements (ex. averaging the head pose between frames)
- Test different methods in calibration phase if necessary
- Introduce lock/unlock gesture so that user can opt for projection to not move

Risk #3: Difficulties with dim lighting

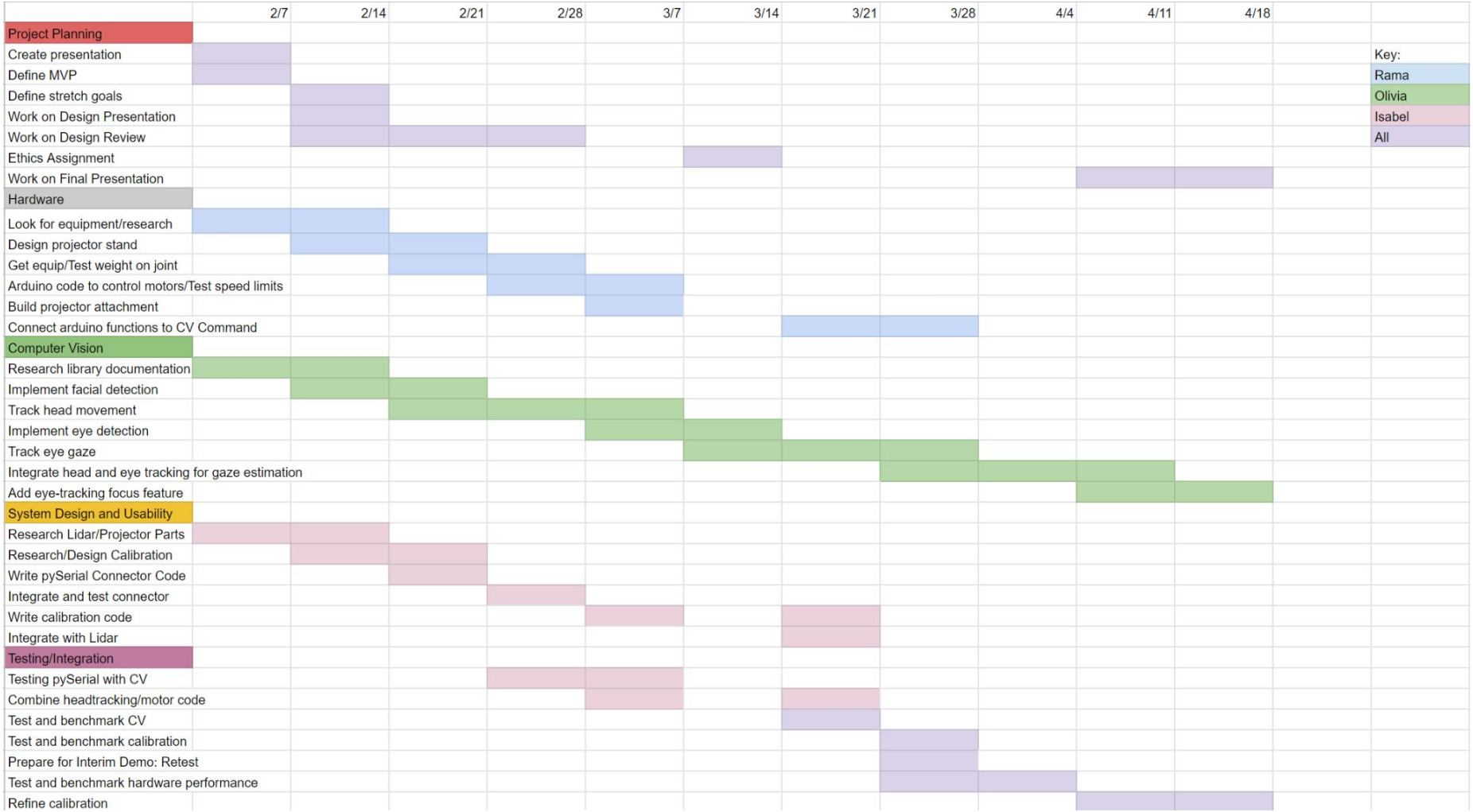
- Research cameras that can work well in our setting

Test, Verification, and Validation

Requirements	Metrics	Test Plan
Gaze Estimation Speed	Real-time (< 30 ms)	Time from head movement to gaze estimation calculation
CV to motor pipeline latency	0.2 seconds	Time from when CV information is calculated to when motor moves
Motor responds to command	95%	20 Trials - Run function to move motor, respond incorrectly or not at all once
Projection placement accuracy	95%	20 Trials - Projection aligns with person's line of sight Error rate: 1 trial
System does not unnecessarily move	N / A	When user is making small movements (resulting in < 1 ft move in projection center), projection stays in place

Work Distribution

Isabel - Integration/Calibration Integrating CV and hardware with PySerial for projector movement, calibrating + refining + testing	
Rama - Hardware Obtaining motor and arduino, connecting arduino to motor and CV, calibrating + testing	**Olivia - Computer Vision** Facial landmark detection, calculating gaze estimation, calibrating + testing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Project Planning
Create presentation
Define MVP
Define stretch goals
Work on Design Presentation
Work on Design Review
Ethics Assignment
Work on Final Presentation
Hardware
Look for equipment/research
Design projector stand
Get equip/Test weight on joint
Arduino code to control motors/Test speed limits
Build projector attachment
Connect arduino functions to CV Command
Computer Vision
Research library documentation
Implement facial detection
Track head movement
Implement eye detection
Track eye gaze
Integrate head and eye tracking for gaze estimation
Add eye-tracking focus feature
System Design and Usability
Research Lidar/Projector Parts
Research/Design Calibration
Write pySerial Connector Code
Integrate and test connector
Write calibration code
Integrate with Lidar
Testing/Integration
Testing pySerial with CV
Combine headtracking/motor code
Test and benchmark CV
Test and benchmark calibration
Prepare for Interim Demo: Retest
Test and benchmark hardware performance
Refine calibration
Key:
Rama
Olivia
Isabel
All