B.L.I.N.D.S.

Blocking Light IN Domestic Spaces

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Use Case

- Light in your room, but too lazy to adjust the blinds?
- Direct sunlight bothers people
  - Obstructs vision
  - Negatively affects visual comfort, eye health, and productivity [1]
- But: Completely eliminating natural light negatively impacts a person's mood and mental health [2]
- Our project:
  - Top down bottom up blinds that roll upwards and downwards depending on whether sunlight from the window hits the person in a room, to maximize sunlight but minimize the amount of light that hits a person in rest
  - Motors will adjust the blinds to prevent sunlight from reaching a person's face
- ECE Areas: Software Systems, Circuits

1. Boyce, Peter R. "Review: The Impact of Light in Buildings on Human Health." Indoor and Built Environment, vol. 19, no. 1, Feb. 2010, pp. 8–20, 10.1177/1420326x09358028.
2. Shishegar, N, and M Boubekri. "Natural Light and Productivity: Analyzing the Impacts of Daylighting on Students' and Workers' Health and Alertness." International Journal of Advances in Chemical Engineering and Biological Sciences, vol. 3, no. 1, 21 May 2016, 10.15242/ijacebs.ae0416104.

Use Case Requirements

- Ability to detect a person in a 300 ft^2 space
  - The size of an average bedroom in the US
- Physical latency should be around 60s
  - Commercial motor controlled blinds also take roughly the same amount of time
- Feedback latency of blinds ≈ 10s
  - Popular face detection methods take under a second to detect faces
  - Small survey on college students said they would be startled if blinds are constantly moving, and would rather the blinds wait 10 seconds to determine if a person is planning on staying in one place before adjusting
- Accuracy ≥ 90%
  - Error defined as lack of adjustment or error in adjustment calculation
  - Small survey on college students asked about maximum error rate they would tolerate

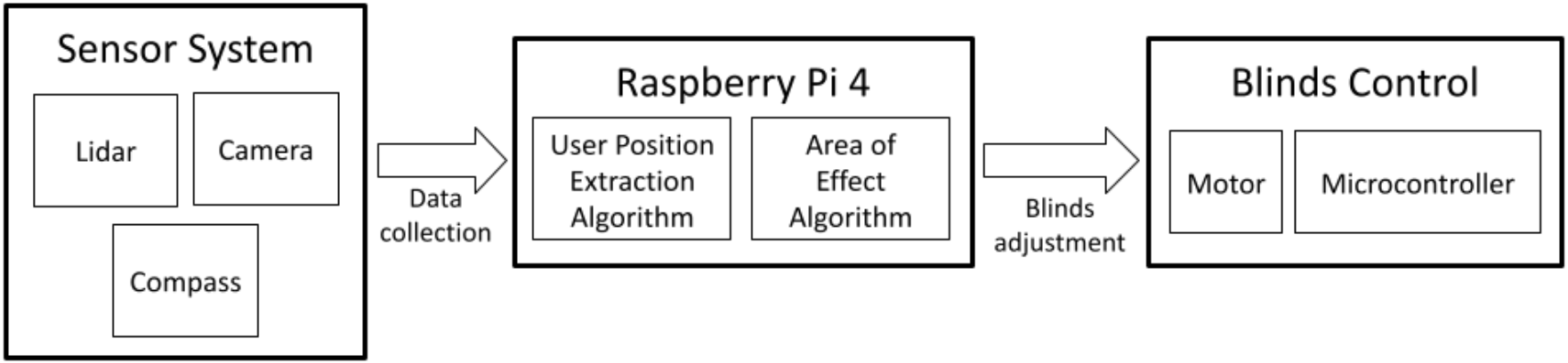
Technical Challenges

- Ability to extract a person's position relative to the blinds with high accuracy
  - It will be harder to determine the position when the person is further from the camera, such as in a 300 ft^2 room
  - The slightest adjustment could let in too much or too little light
- Motor system that is not overly slow compared to motorized blinds in the market
  - The system should be beneficial, not a nuisance

Solution Approach

- Camera + LIDAR + compass combined system
  - Takes pictures of the room and determines orientation of window
  - Sends data to user position extraction algorithm and Light AoE algorithm
- User Position Extraction
  - Use CV to detect the person, and LIDAR to determine the depth away from the window
  - Raspberry Pi
  - OpenCV
- Sun position API
  - Uses time, location, and window orientation to determine sun's position relative to the window
  - Can find the angle at which sunlight enters the window
- Light Area of Effect Algorithm
  - Using the user's position and the sun's position, can determine whether or not the person falls within the area of effect of the sun and what the adjustment should be
- Blinds control
  - Arduino to receive adjustment and perform adjustment
  - Motors to open/close blinds

Solution Diagram



Testing, Verification, and Metrics I

- Camera + Lidar System
  - Test by making sure camera feed sent to Raspberry Pi is correct by having a person visually check it.
- Blinds control
  - Test by sending control signals to our motorized blinds and observe if the desired actions are performed.
  - Test to make sure blind full rolls up within 60 seconds to meet spec.
- User Position Extraction Algorithm
  - Unit tested by feeding images of user at known position and seeing if it algorithm correctly extract the same position information.
  - Assuming each algorithm's error aggregates into the total error, then the individual Algorithmic Error must not be more than 10%

Testing, Verification, and Metrics II

- Light Area of Effect Algorithm
  - Unit Test by feeding information from a time in the past with a manually determined area of effect from a physical window
  - Assuming each algorithm's error aggregates into the total error, then the individual Algorithmic Error must not be more than 10%
- Final test
  - Real time testing. Cumulative Error should be less than 10% as written in the Requirements and sends out Blind Control Signals within 10 seconds.

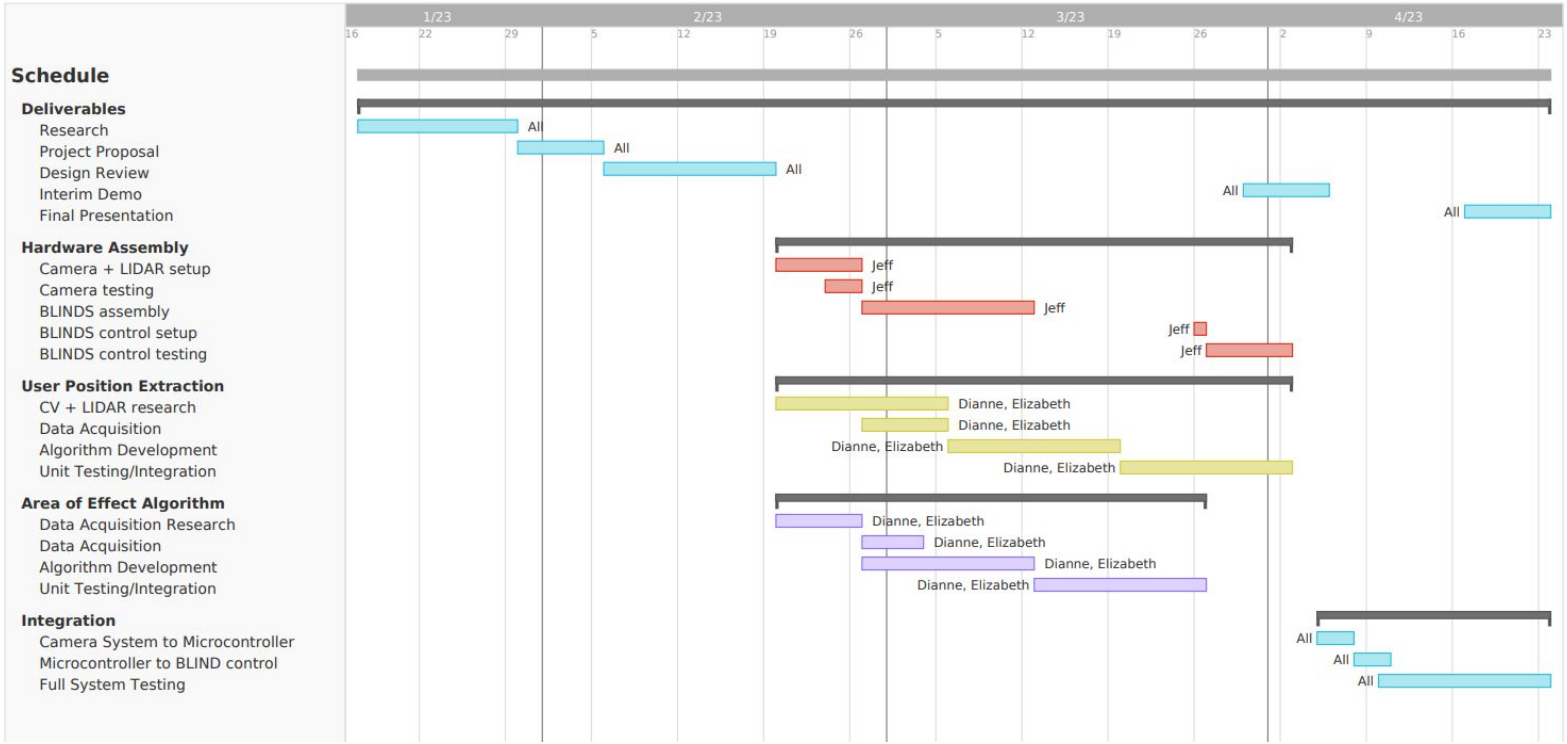
Tasks and Division of Labor I

Task	Sub Task	Assignee
Hardware Setup	Camera + Lidar Setup	Jeff
	Blinds control	Jeff
User Position Extraction Algorithm	CV model to track user	Dianne + Elizabeth
	Extracting Position from Lidar Data	Dianne + Elizabeth

Tasks and Division of Labor II

Task	Subtask	Assignee
Area of Effect Algorithm	Obtain Sunlight Orientation Data	Dianne + Elizabeth
	Calculating Area of Effect and Adjustment	Dianne + Elizabeth
Integration	Integration	Jeff + Dianne + Elizabeth

Schedule


Schedule
Deliverables
Research
Project Proposal
Design Review
Interim Demo
Final Presentation
Hardware Assembly
Camera + LIDAR setup
Camera testing
BLINDS assembly
BLINDS control setup
BLINDS control testing
User Position Extraction
CV + LIDAR research
Data Acquisition
Algorithm Development
Unit Testing/Integration
Area of Effect Algorithm
Data Acquisition Research
Data Acquisition
Algorithm Development
Unit Testing/Integration
Integration
Camera System to Microcontroller
Microcontroller to BLIND control
Full System Testing
1/23
2/23
3/23
4/23
16 22 29 5 12 19 26 5 12 19 26 2 9 16 23
All
Jeff
Dianne, Elizabeth

Conclusion

- Going forwards:
  - Fleshing out the design for design review
  - Figuring out what equipment we will be purchasing for our project
  - Getting started on setting up camera/LIDAR, as this is a requirement for a bulk of our project
- Our system will eliminate the need to manually adjust blinds, and allow people to focus on the task at hand in an ideal lighting environment