xWALK

Shayan, Yasaswini, Jeanette

The Problem

- Many intersections lack features to facilitate crossing for the visually impaired, some even without crossing signals
- We attempt to tackle those intersections that simply have traffic signals and two-lined crosswalks (not a zebra crosswalk)
    - Zebra crosswalks have ridges on the lines to direct those with white canes in the right direction
- Seeing Eye dogs may not recognize the traffic signal due to color blindness
- Hybrid cars are not loud enough for a visually impaired person to hear when they've stopped

Use Case

- Wearable device that will help people cross intersections without proper crosswalks
- Realtime wearable headband with a camera that detects when someone should cross the street on a specific intersection
    - Gives back auditory signal

https://thepawsitive.co/blogs/happytails/information-about-guide-dogs-for-blind

Requirements

- Small and portable wearable device (Headband)
  - Camera: unobstructed view with appropriate look direction
  - Physical dimensions: 3” width, circumference range of 21”-24”
  - Weight: 300g or less
- Weather resistance
- Nonvisual Feedback to the User (Speaker with different sounds for “walk”, ”don’t walk”)
- Target intersection: no dedicated crossing signs (i.e. only traffic lights); no aural cues to cross
- Must correctly: detect traffic lights, identify the traffic light in the user’s crossing direction, and determine the state of said look direction traffic light

Requirements (continued)

- Reaction Time / Latency (< 0.5 sec)
  - Account for reckless driving & pedestrian safety
- Accuracy (>90% accuracy; < 10% false positive rate)
  - High accuracy required because collisions are a significant adverse event
- Battery life (15 hours)
  - Expected use up to roughly 2 hrs/day

Technical Challenges

- Speed of feedback to user
  - Ideally want to let the user know in 1-2 sec
    - Want this delay due to the danger of incoming cars
- Robustness with regards to different intersection conditions
  - Day v. night, sunny v. overcast v. rain v. snow
  - Varying presence of other objects (i.e. other pedestrians, vehicles)
- Accuracy of stoplight detection (aiming for 90%)
  - Need to train images
- Utilizing appropriate data sets
  - Morewood/Ellsworth Intersection

Solution Approach

- Detect traffic light in crossing direction
- Detect State of said Traffic Light
- When said light is detected as green, after certain delay, inform user to cross
- When said light is detected as ***red***, after certain delay, inform user ***not*** to cross

https://medium.com/@nilesh.chopda2112/understanding-tensor-flow-object-detection-api-for-traffic-lights-detection-cef3b297f15b

Solution Approach: Technology

- Raspberry Pi
  - 40x faster than an arduino
- Intel RealSense Depth Camera D435
  - Wide view, low power, depth and rgb camera
- Raspberry Pi Camera V2
  - small/compact, no depth
- OpenCV with Python
- Build a headband to hold the camera and raspberry pi and Adafruit Mini Speaker
  - Good for any weather conditions
- Use battery power

Testing, Verification, and Metrics (Part 1)

- Verification of CV algorithm correctness and robustness
  - Test Dataset
    - Multiple angles, distances from traffic lights
    - Multiple Traffic Lights; No traffic lights in shot
    - Different weather conditions (sunny, cloudy, rain, snow, nighttime)
    - Have varying amounts of other objects in it (cars, pedestrians)
  - Metrics - calculate accuracy in (1) detecting traffic like *in crossing direction*, (2) determining state of light

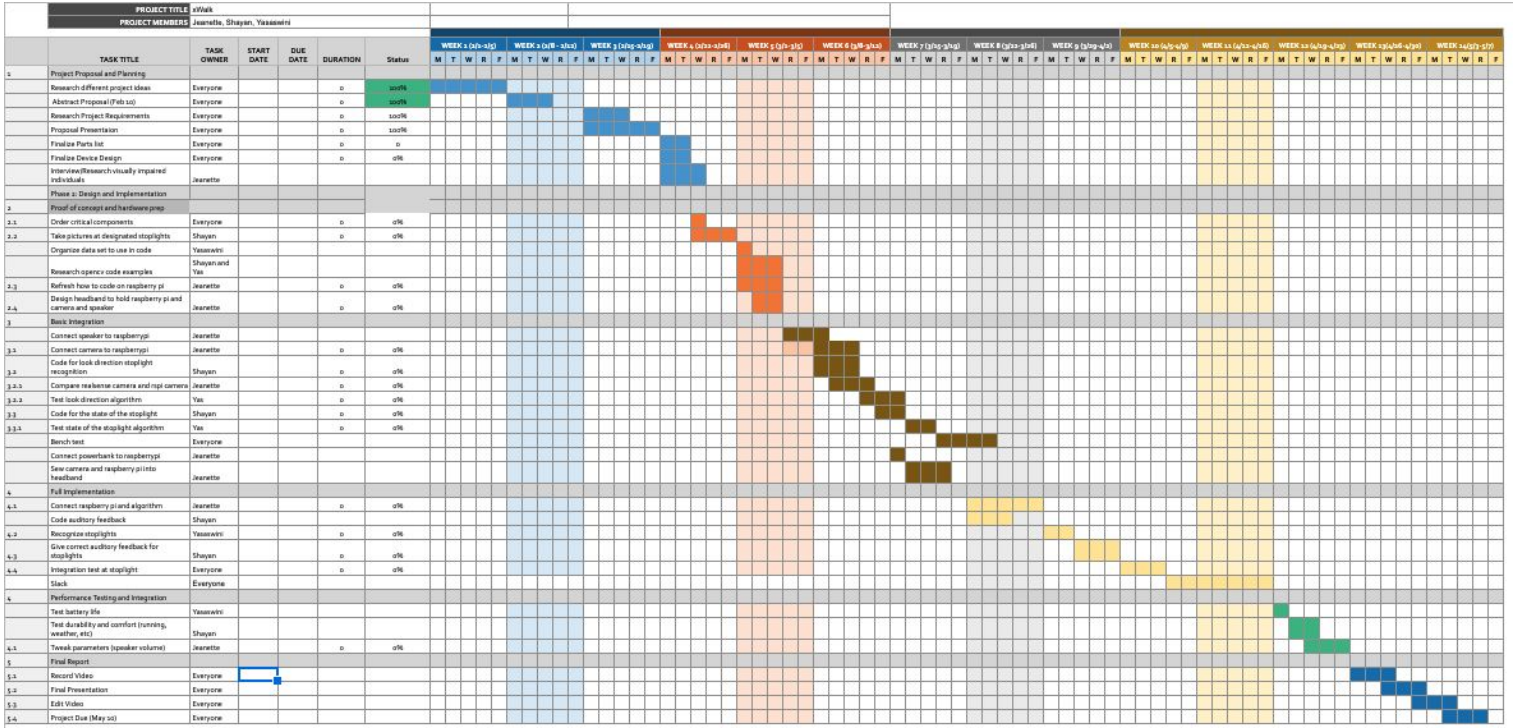
Testing, Verification, and Metrics (Part 2)

- “Bench” Verification of CV algorithm latency
  - Take videos while approaching intersection when light in crossing direction and determine how quickly the algorithm detects change in state of light
  - Metrics: latency (via # frames * frames/sec) , accuracy (% frames where state correctly guessed)
- Bench Electrical testing
  - Battery life - measure current drain
- “Bench” Physical/Mechanical Testing
  - Weight measurements
  - Weather and sweat resistance - exposure to various moisture levels, temperatures
  - Durability testing - simulations in Solidworks and/or physically dropping the device
- User Testing
  - With fully developed embedded system, have user wear the system and report on ease of navigation relying solely on our system
  - Metrics: Some quantitative user satisfaction score

Tasks and Division of Labor

Task	Jeanette	Shayan	Yasaswini
Data collection: Take pictures of Morewood/Ellsworth and Amberson/Ellsworth		✓	✓
CV/algorithm training and development	✓		✓
State machine algorithm		✓	
V/V for CV and combined CV + State Machine	✓	✓	✓
Equipment, component procurement	✓		
Assembly - Integration Testing	✓	✓	✓
Assembly - Hardware (Intel Real Time Camera, Audio, Processor)	✓		
Assembly - Software build		✓	✓
Meeting with visually impaired stakeholders	✓		

Tentative Timeline



	PROJECT TITLE	xWalk				
	PROJECT MEMBERS	Jeanette, Shayan, Yasaswini				

	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	Status
1	Project Proposal and Planning					
	Research different project ideas	Everyone			0	100%
	Abstract Proposal (Feb 10)	Everyone			0	100%
	Research Project Requirements	Everyone			0	100%
	Proposal Presentation	Everyone			0	100%
	Finalize Parts list	Everyone			0	0
	Finalize Device Design	Everyone			0	0%
	Interview(Research visually impaired individuals	Jeanette				
	Phase 1: Design and Implementation					
2	Proof of concept and hardware prep					
2.1	Order critical components	Everyone			0	0%
2.2	Take pictures at designated stoplights	Shayan			0	0%
	Organize data set to use in code	Yasaswini				
	Research opencv code examples	Shayan and Yas				
2.3	Refresh how to code on raspberry pi	Jeanette			0	0%
2.4	Design headband to hold raspberry pi and camera and speaker	Jeanette			0	0%
3	Basic Integration					
	Connect speaker to raspberrypi	Jeanette				
3.1	Connect camera to raspberrypi	Jeanette			0	0%
3.2	Code for look direction stoplight recognition	Shayan			0	0%
3.2.1	Compare realsense camera and rspi camera	Jeanette			0	0%
3.2.2	Test look direction algorithm	Yas			0	0%
3.3	Code for the state of the stoplight	Shayan			0	0%
3.3.1	Test state of the stoplight algorithm	Yas			0	0%
	Bench test	Everyone				
	Connect powerbank to raspberrypi	Jeanette				
	Sew camera and raspberry pi into headband	Jeanette				
4	Full Implementation					
4.1	Connect raspberry pi and algorithm	Jeanette			0	0%
	Code auditory feedback	Shayan				
4.2	Recognize stoplights	Yasaswini			0	0%
4.3	Give correct auditory feedback for stoplights	Shayan			0	0%
4.4	Integration test at stoplight	Everyone			0	0%
	Slack	Everyone				
4	Performance Testing and Integration					
	Test battery life	Yasaswini				
	Test durability and comfort (running, weather, etc)	Shayan				
4.1	Tweak parameters (speaker volume)	Jeanette			0	0%
5	Final Report					
5.1	Record Video	Everyone				
5.2	Final Presentation	Everyone				
5.3	Edit Video	Everyone				
5.4	Project Due (May 10)	Everyone				