Add on Navigation & Control System for Outdoor Autonomous Wheelchairs for Physically and Mentally Challenged People

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Introduction

- Statistical Facts
  - Visually Impaired: 1.3 million blind in the US [1]
  - Paralysis: 5.4 million in the US [2]
  - Arms Amputee: 350,000 in the US [3]
  - Lack of Independent Mobility: 19 millions: [nih.gov]

Semi-Autonomous Outdoor Wheelchairs)

	Sensors	Features	Limitations
Alam Wheelchair (2019) [1]	3 Sonars (Object Avoidance), 3-Axis Accelerometer (Tipping Detection), GPS (Communication)	Voice/Gesture/Joystick, Tipping detection, Text notification, Semi-Autonomous	No path planning or mapping
Bangladesh University Wheelchair (2017) [2]	Sonar (Object Avoidance), 3-Axis Accelerometer (Slope Detection), Encoders	Voice/Joystick, Speed control based on slope, Semi-Autonomous	No Path Planning nor mapping
Tunku Abdul Rahman University Wheelchair (2017) [3]	Webcam, 2 Magnetometers	Edge/Free space Detection, Semi-Autonomous	No Path Planning nor mapping
Gaziantep University Wheelchair (2021) [4]	Camera	Image Processing via vanishing point detection, Semi-Autonomous	No path planning, no mapping, and no obstacle avoidance

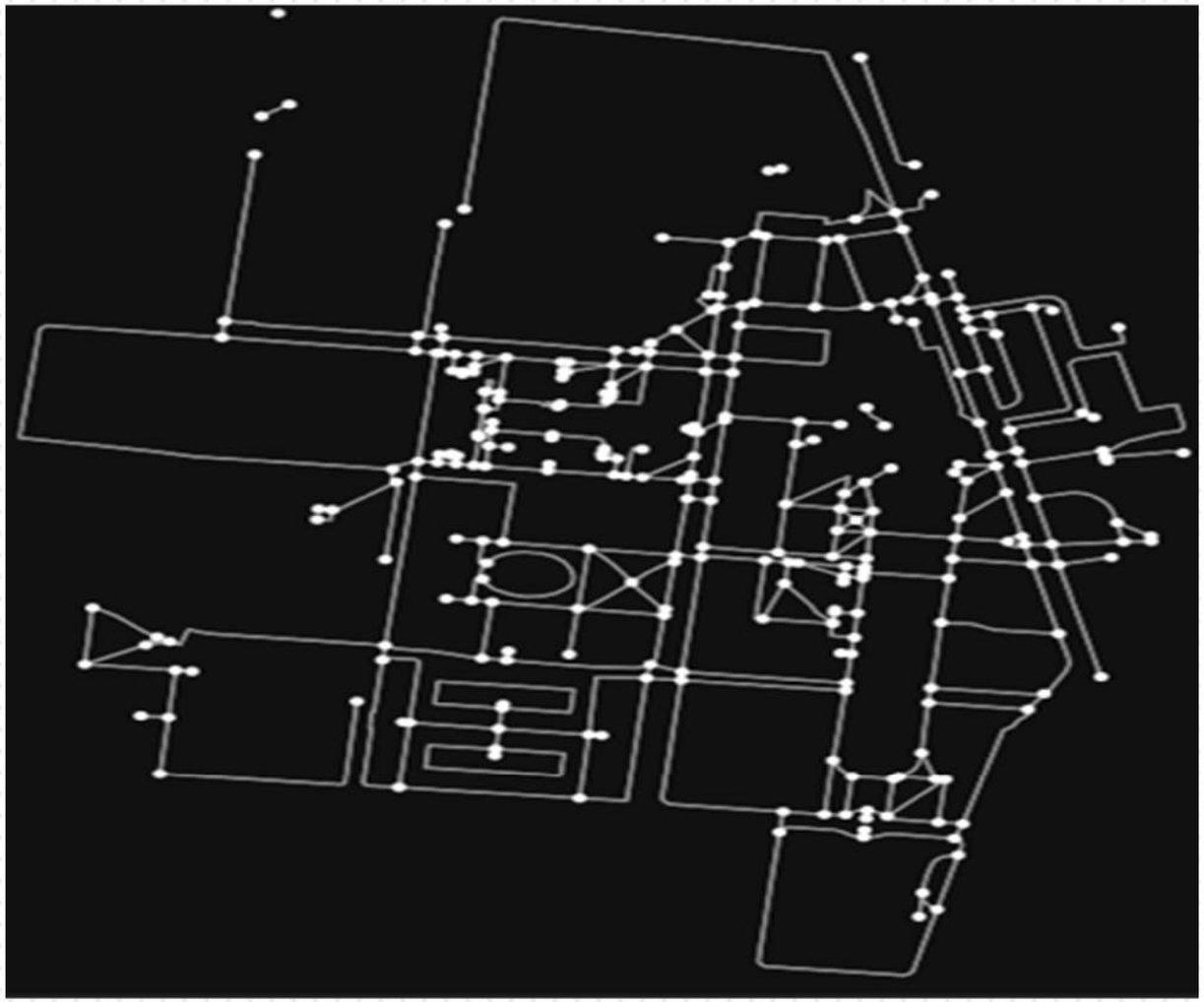
Fully-Autonomous Outdoor Wheelchairs

	Sensors	Features	Limitations	Cost
Lehigh University Wheelchair (2014) [5]	2 IFM 3D Cameras, 2D LiDAR	Stochastic Terrain Classification (PMF), Landmark map, Automatic Path Planning, Fully-Autonomous	Highly computational, Struggle with terrain borders	>$4500 not including wheelchair
The Free University Wheelchair (2020) [6]	Spherical Omnidirectional Camera, IMU, GPS	VCA, Visual Memories, Fully-Autonomous	Guided Tour, Manual Path Planning	>$1700 not including wheelchair

Motivations

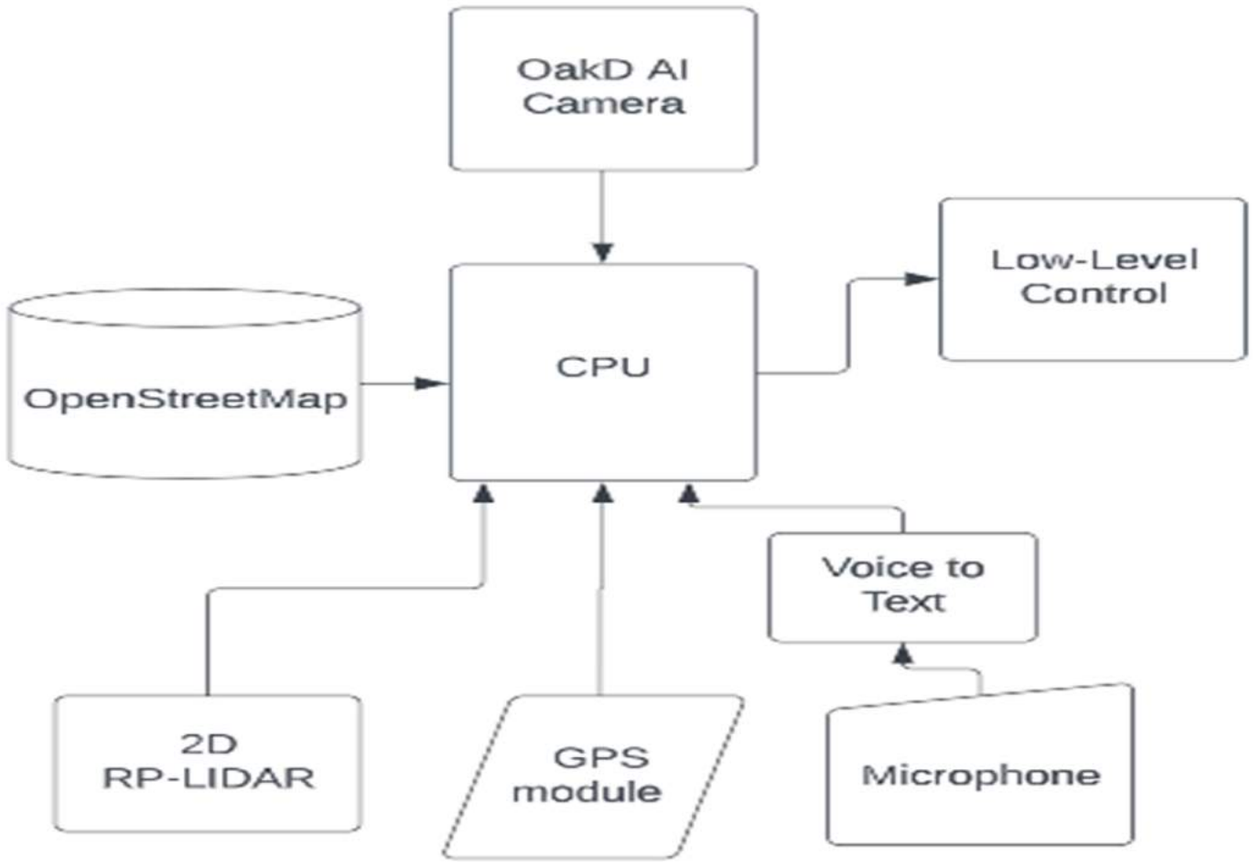
Provide Mobility Independence to Include physically as well as mentally challenged people

Affordability

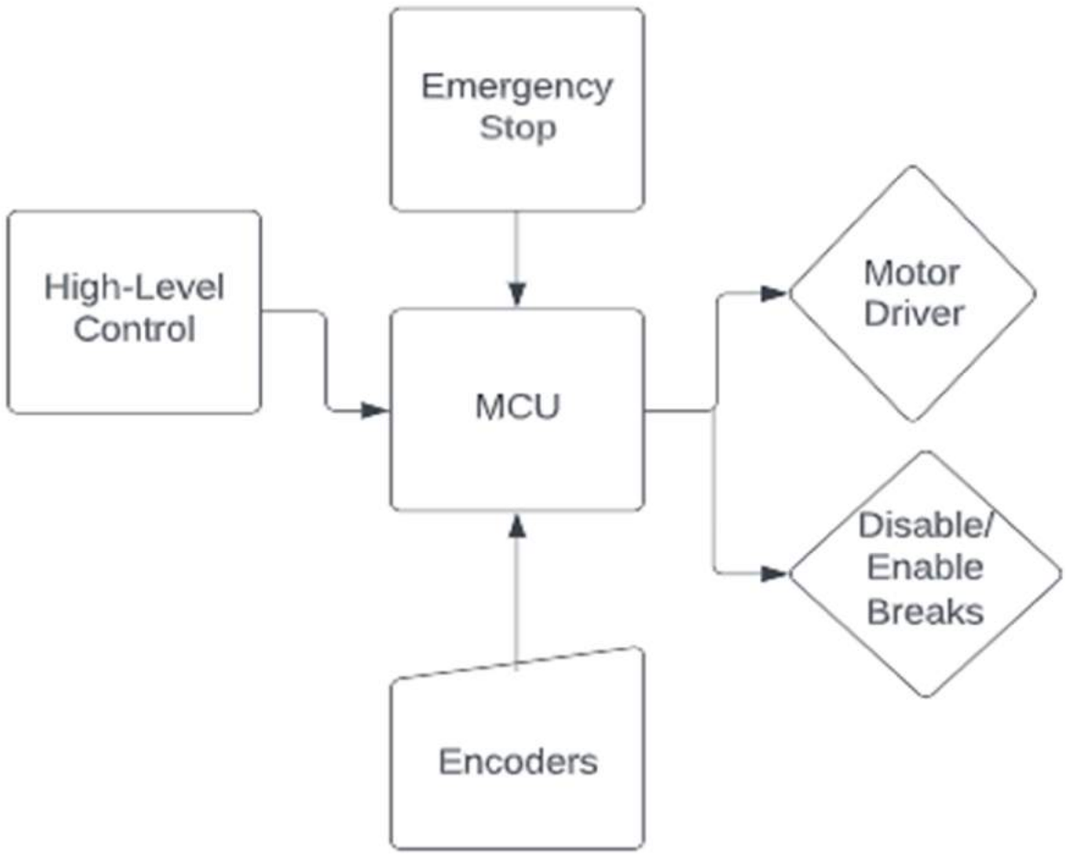


TTU Campus Map

Proposed System



High-Level Control Block Diagram

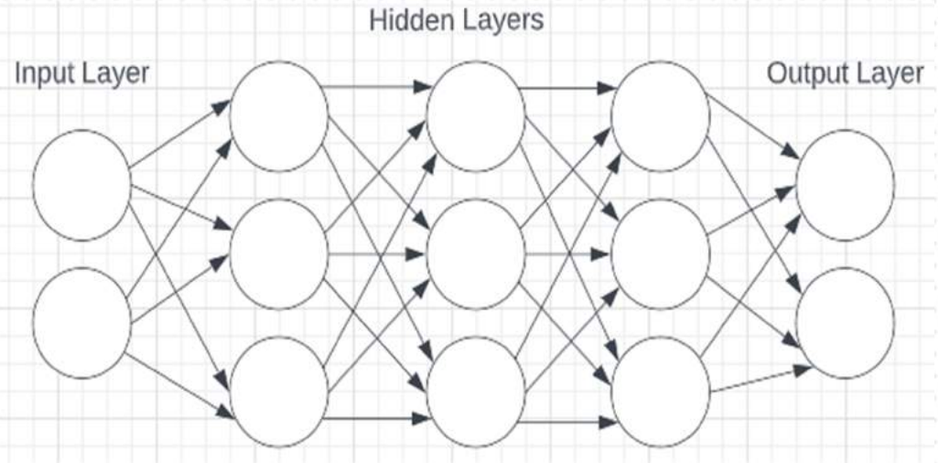


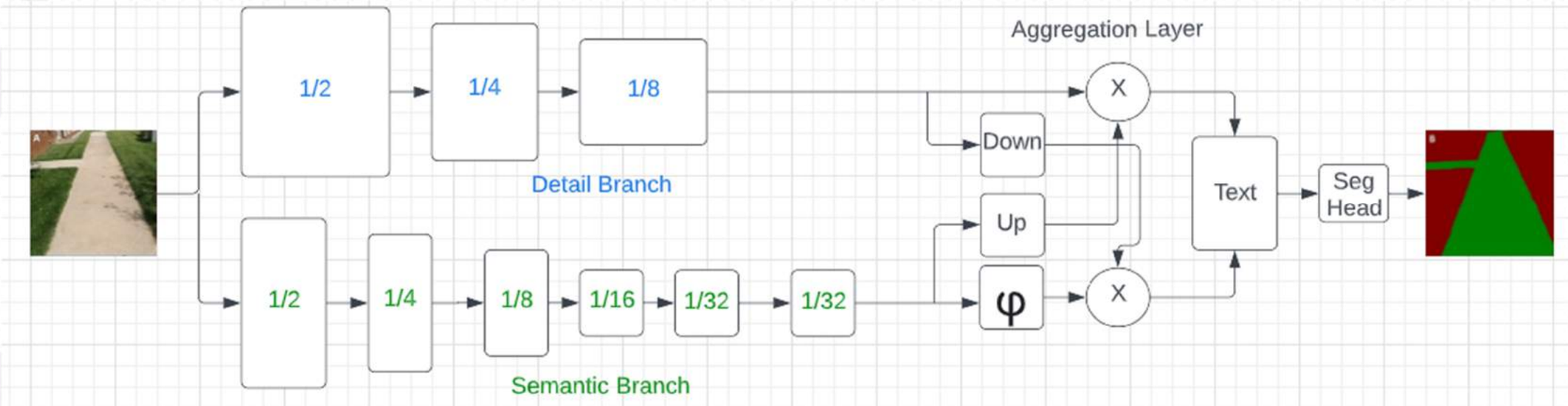
Low-Level Control Block Diagram

Implementation Using OpenStreetMaps

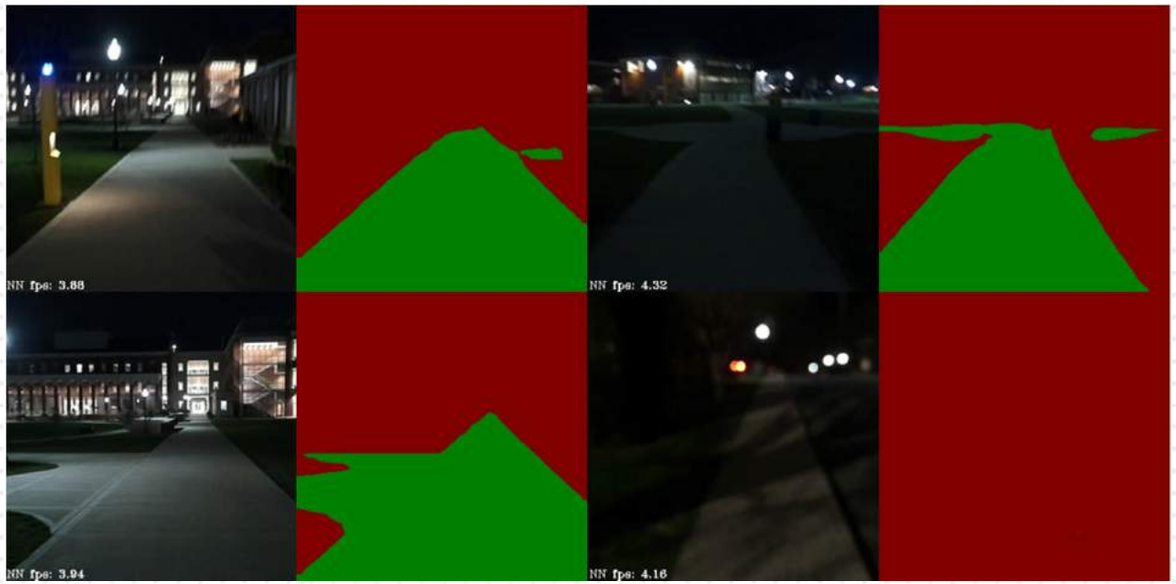
Applications

- Convolutional Deep Neural Network
  - BiseNetV2 – Semantic Segmentation
    - Detail and Semantic Branch
    - Lightweight
    - 9000 Images

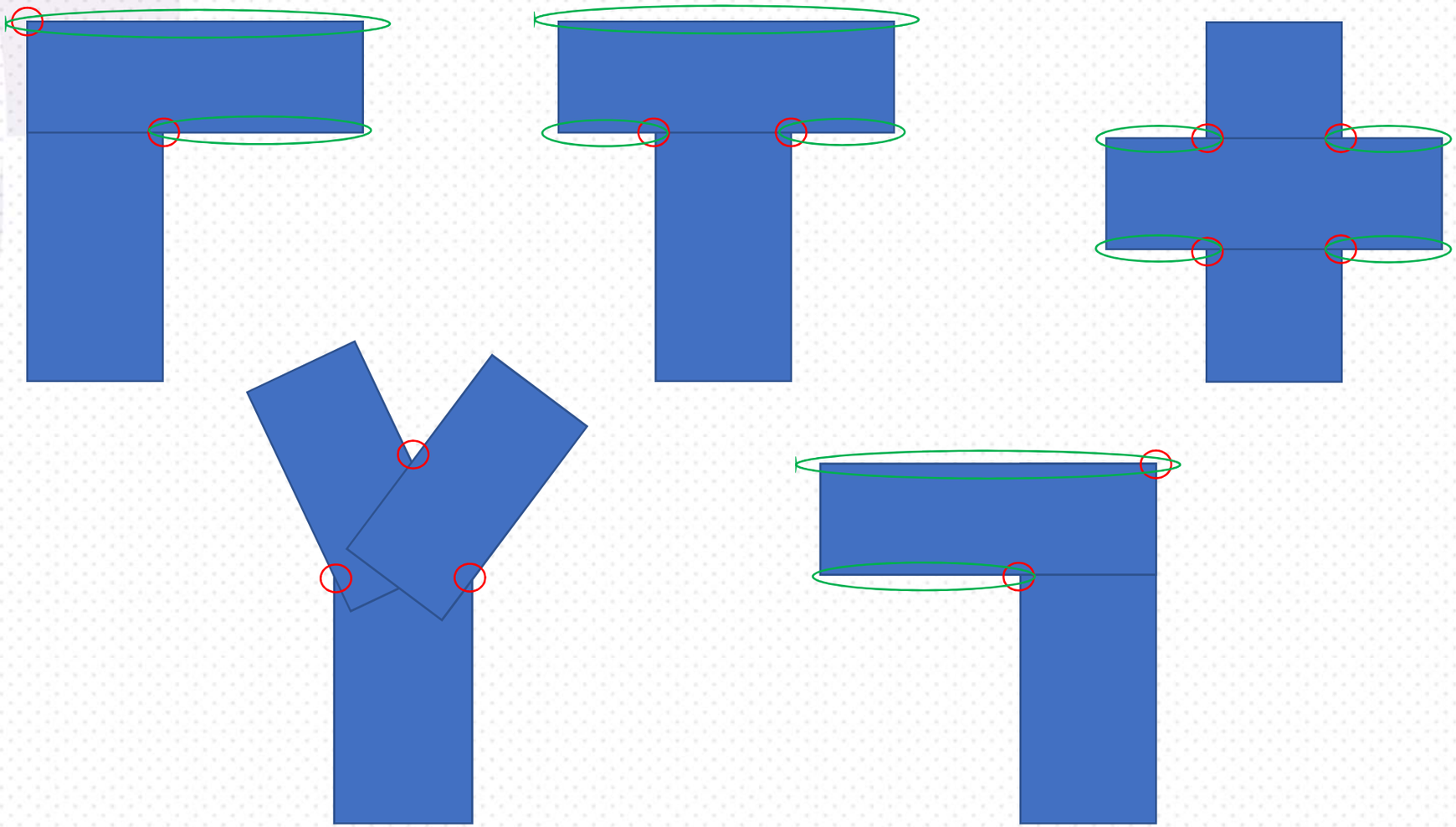


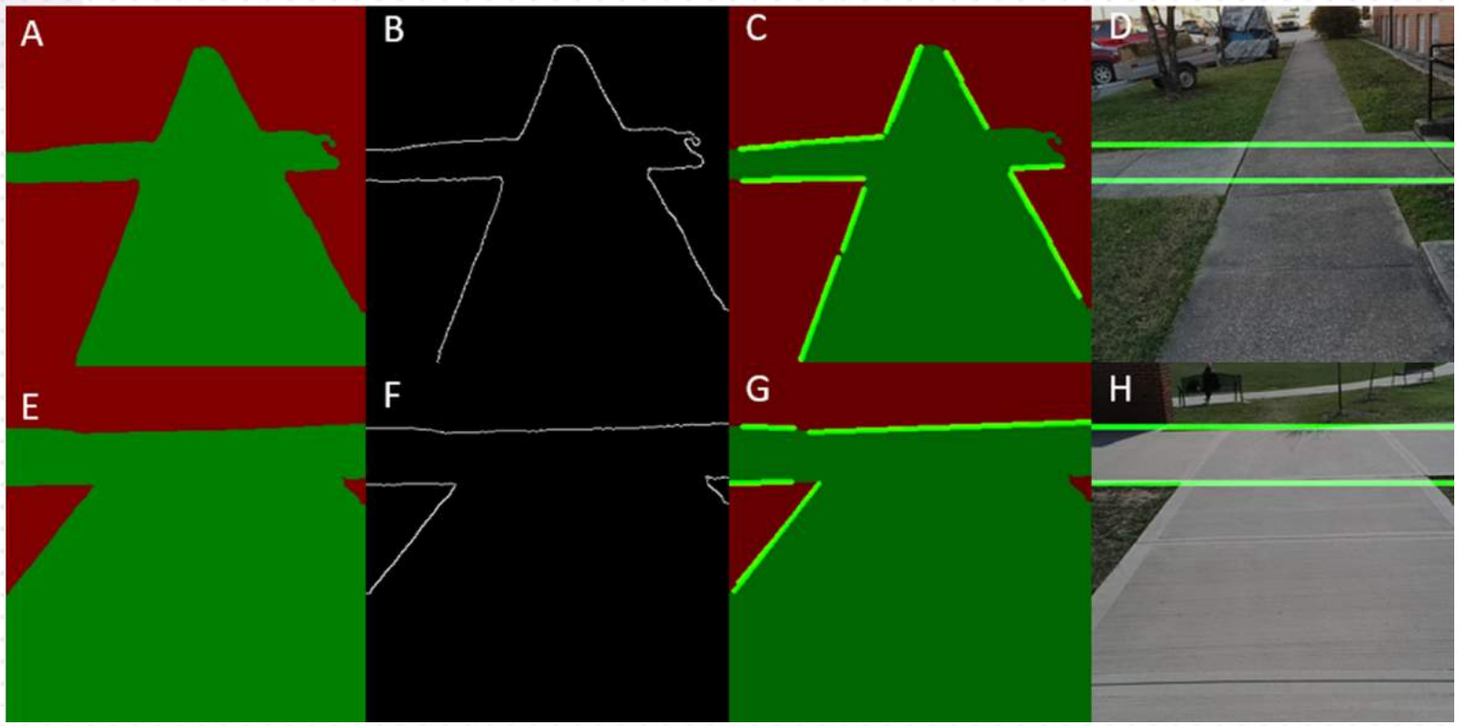


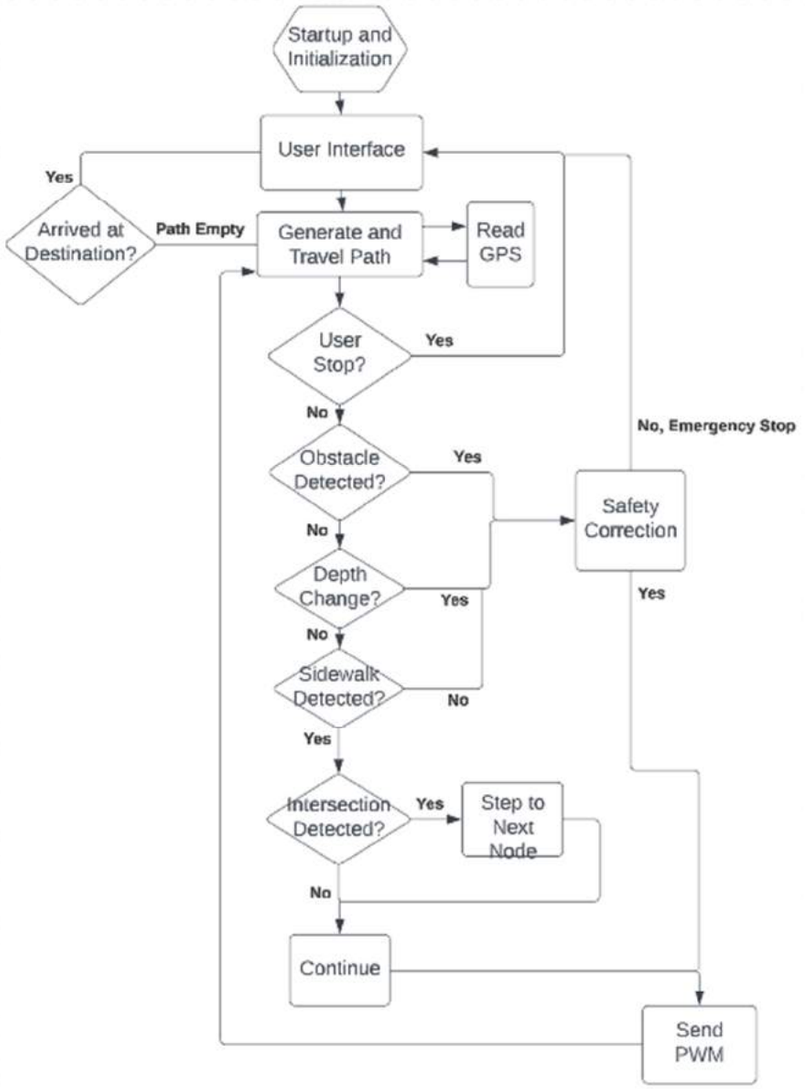
- BiseNetV2 Performance

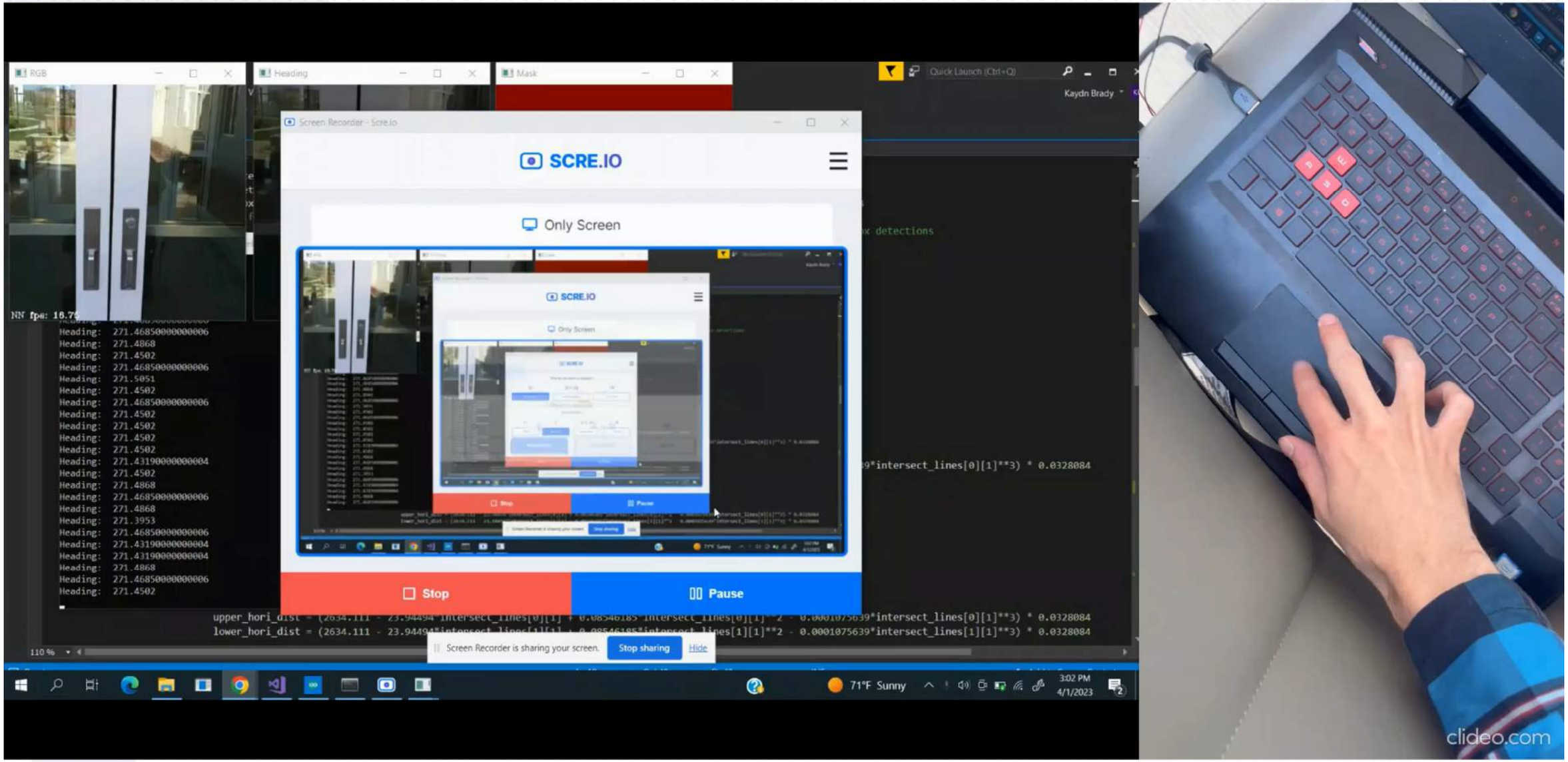


- Sidewalk Intersection




A
B
C
D
E
F
G
H


Startup and Initialization
User Interface
Yes
Arrived at Destination?
Path Empty
Generate and Travel Path
Read GPS
User Stop?
Yes
No
No, Emergency Stop
Obstacle Detected?
Yes
No
Safety Correction
Depth Change?
Yes
Yes
No
Sidewalk Detected?
No
Yes
Intersection Detected?
Yes
Step to Next Node
No
Continue
Send PWM


RGB
Heading
Mask
Screen Recorder - Scre.io
SCRE.IO
Only Screen
Stop
Pause
Screen Recorder is sharing your screen.
Stop sharing
Hide
Kaydn Brady
Quick Launch (Ctrl+Q)
NN fps: 16.75
Heading: 271.46850000000006
Heading: 271.4868
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Heading: 271.5051
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Heading: 271.4502
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Heading: 271.46850000000006
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Heading: 271.4868
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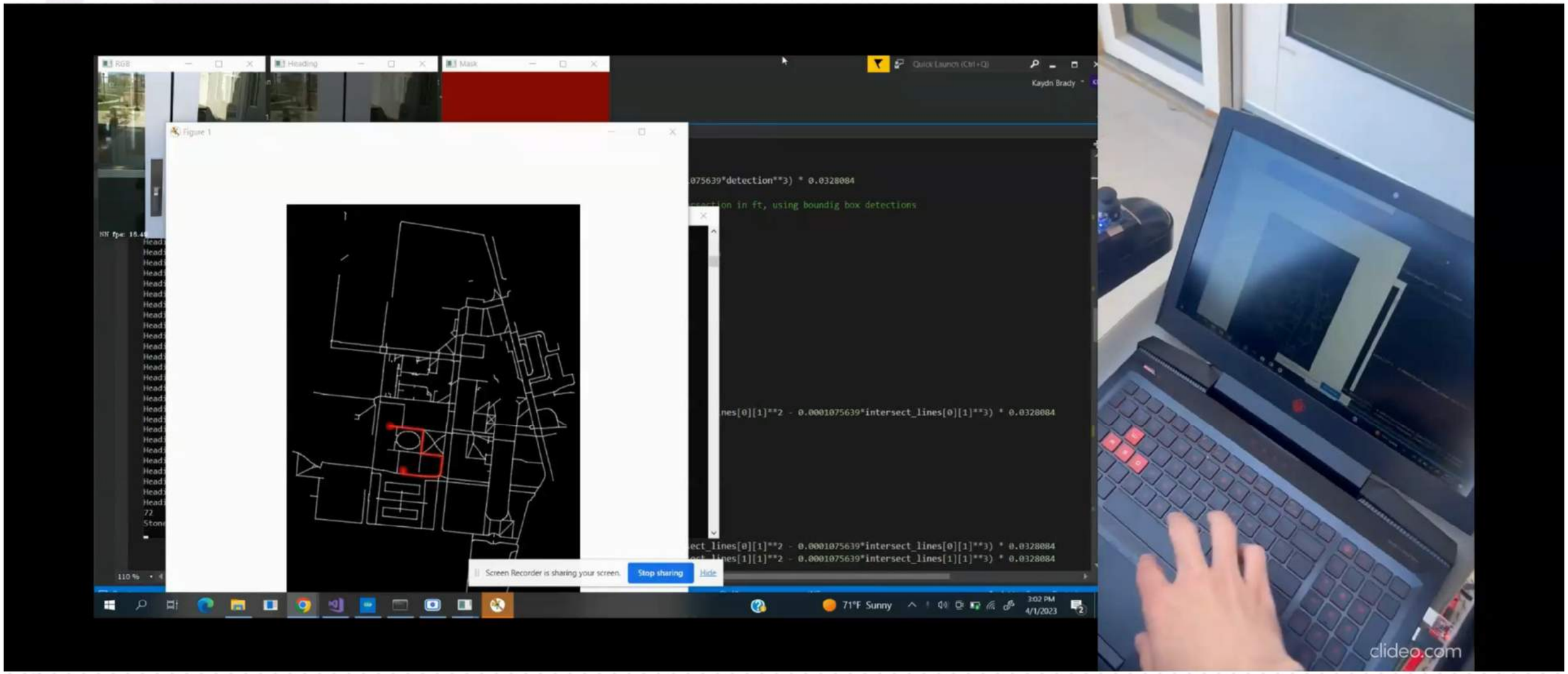
Heading: 271.4502
x detections
9*intersect_lines[0][1]**3) * 0.0328084
upper_hori_dist = (2634.111 - 23.94494*intersect_lines[0][1] + 0.08546185*intersect_lines[0][1]**2 - 0.0001075639*intersect_lines[0][1]**3) * 0.0328084
lower_hori_dist = (2634.111 - 23.94494*intersect_lines[1][1] + 0.08546185*intersect_lines[1][1]**2 - 0.0001075639*intersect_lines[1][1]**3) * 0.0328084
110 %
71°F Sunny
3:02 PM
4/1/2023
clideo.com


RGB
Heading
Mask
Figure 1
Quick Launch (Ctrl+Q)
Kaydn Brady
075639*detection**3) * 0.0328084
ection in ft, using boundig box detections
nes[0][1]**2 - 0.0001075639*intersect_lines[0][1]**3) * 0.0328084
ect_lines[0][1]**2 - 0.0001075639*intersect_lines[0][1]**3) * 0.0328084
ect_lines[1][1]**2 - 0.0001075639*intersect_lines[1][1]**3) * 0.0328084
Screen Recorder is sharing your screen.
Stop sharing
Hide
71°F Sunny
3:02 PM
4/1/2023
clideo.com


AUTONOMOUS WHEELCHAIR
A LOT OF THINGS, INCLUDING
captions settings
captions off
subtitles (en)
cc1 CC

Conclusions

- Designed and developed and add on autonomous control and navigation system to accommodate physically and mentally challenged people
- Alert system when driver is lost due to dimentia
- Affordable solution
- Preliminary successful testing

Future Work

- Extensive on campus testing
- Add safety features
- Extend human machine interface
- Test the system using people with dementia
- Add safe road crossing capability
- Road/public places testing
- Potential commercilization