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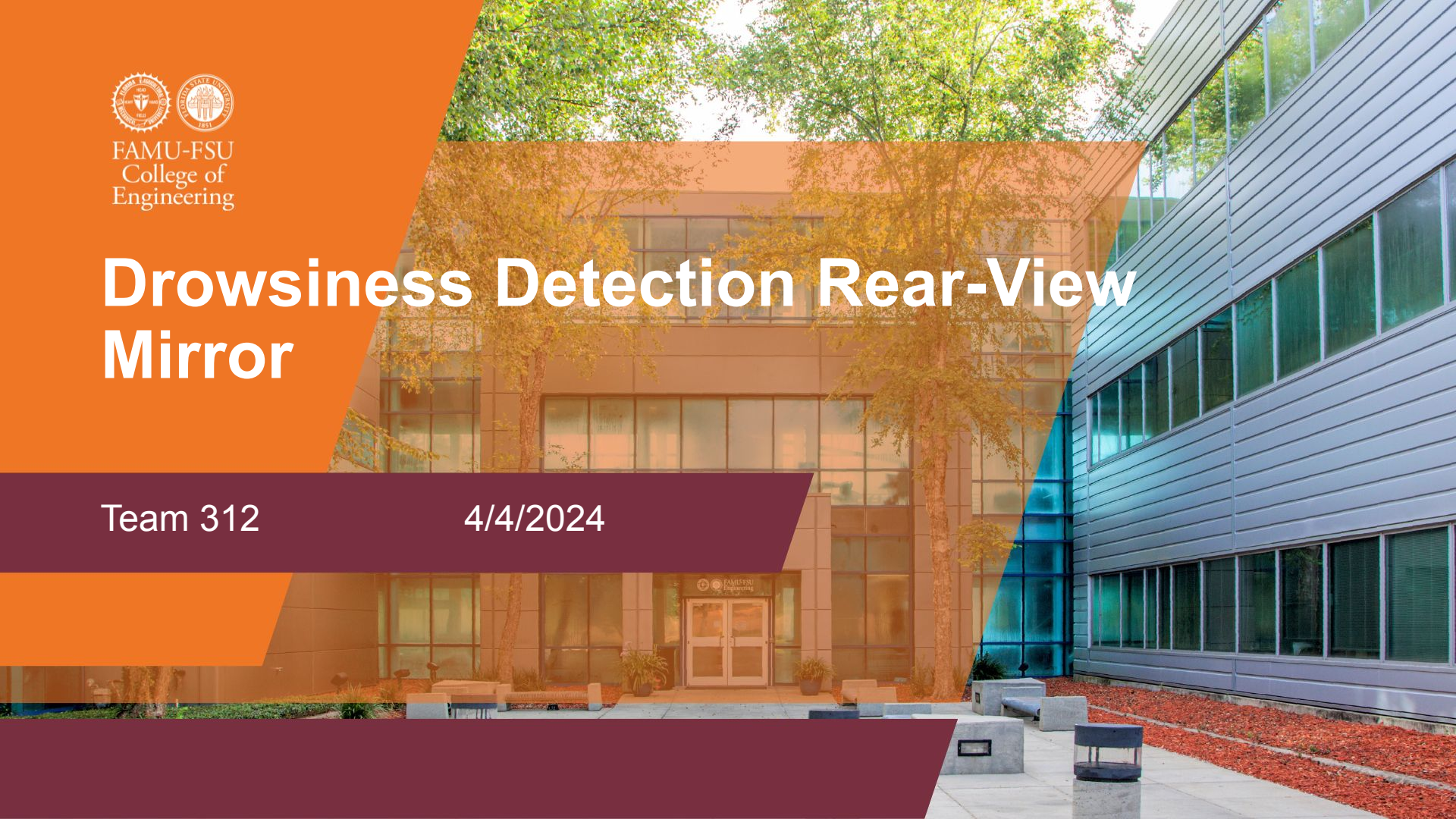
Drowsiness Detection Rear-View Mirror

Team 312

4/4/2024



Team 312

Theodor Owchariw
Team Leader
Embedded Software Engineer

Lucas Torres
Embedded Systems Engineer

Victor Bellera Tovar
Electrical Engineer

Luke Forbis
Structural Design Engineer

Benjamin Covitz
Test Engineer

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Sponsor and Advisors

Sponsor & Academic Advisor
Bayaner Arigong
Ph.D.
Assistant Professor

Academic Advisor
Jonathan Casamayor
Ph.D. Candidate

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Overview

- Problem and Objective
- Code Implementation on MATLAB
- Mirror Housing Design
- Testing and Validation
- Outcomes
- Conclusion

Problem Statement

- Statistics have shown that thousands of deaths are caused by drowsy driving annually.
- How can we monitor the driver's vitals and alert them if they become too drowsy to drive?
- Develop a rear-view mirror to detect when the driver is becoming drowsy.

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Objectives

- Create algorithm that can detect drowsiness about 1/3 of the time.
- Extract head position and breathing rate
- Develop an alert notification system.
- Design housing for required hardware.
- Test design for safety and efficiency.

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Project Budget

	Item Ref #	Description	Part Num.	Quantity	Unit	Unit Cost	Cost	Shipping	Total Cost
Electronics/Hardware	1	Rear View Mirror: Rectangular, Flat	5UWA3	1	1 mirror	$33.85	$33.85	$10.98	$44.83
	2	Medline Soft-Touch Bluetooth Fingertip Pulse Oximeter	HCSM70T	1	1 device	$70.45	$70.45	$0.00	$70.45
	3	PT-2725WQ (Buzzer)	458-1253-ND	3	1 buzzer	$1.81	$5.43	$6.99	$12.42
	4	WP154A4SUREQBFZGC (RGB LED)	754-1615-ND	1	10 pieces	$11.92	$11.92	$6.99	$18.91
	5	3527 (Other RGB LED)	1927-1048-ND	4	1 piece	$0.66	$2.64	$6.99	$9.63
	6	Respiration Belt	GDX-RB	1	1 belt	$109.00	$109.00	$16.93	$125.93
	7	**Total Price**					**$233.29**	**$48.88**	**$282.17**

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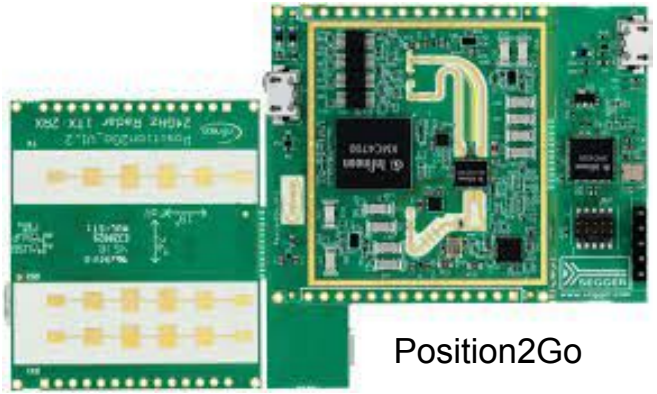
Design Flow

Received signal from driver → Extract Biometrics → Algorithm → Output



Position2Go

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Signal Processing

- Pull raw data from the board
- Data/noise cleaning techniques for accuracy/precision
  - Windowing
  - Filtering
  - Variational Mode Decomposition (VMD)
- Take the fast fourier transform (FFT) of the cleaned data
- Isolation of frequencies

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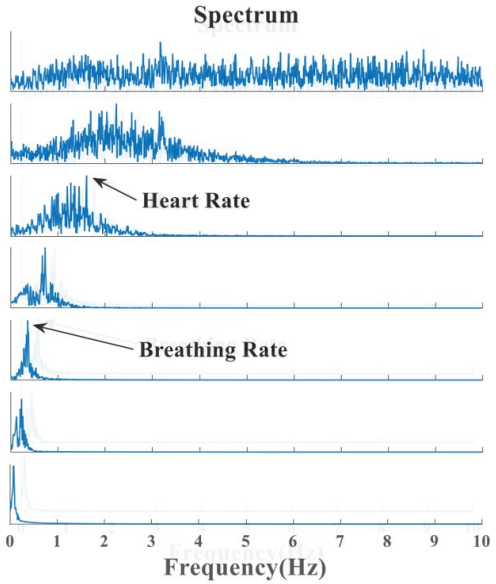
Extracting Biometrics

- Isolation of frequencies is required to extract the biometrics pulled from the radar.
- This data would then be plotted to find patterns in the radar's detected frequencies.
- Observation of the peaks in these plots.



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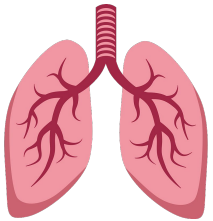
Extracting Biometrics

- Fundamental frequencies to look for:
  - Head: (nodding 2 Hz) [2]
  - Breathing rate: 0.13-0.4 Hz [3]
- The simplest case is to check whether the driver's head is up or down.
  - The frequency will be greater or less depending on the head position.
- Next, breathing rate will be extracted.



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Concepts Signal Processing

- Filters:
  - Clutter Filter
  - Bandpass Filter
  - Butterworth Filter
  - Low-pass filter
- Signal Transforms:
  - Hilbert Transform
  - FFT
  - Phase Unwrapping
- Isolation:
  - Machine Learning
  - Cross correlation
  - Doppler Processing
  - VMD

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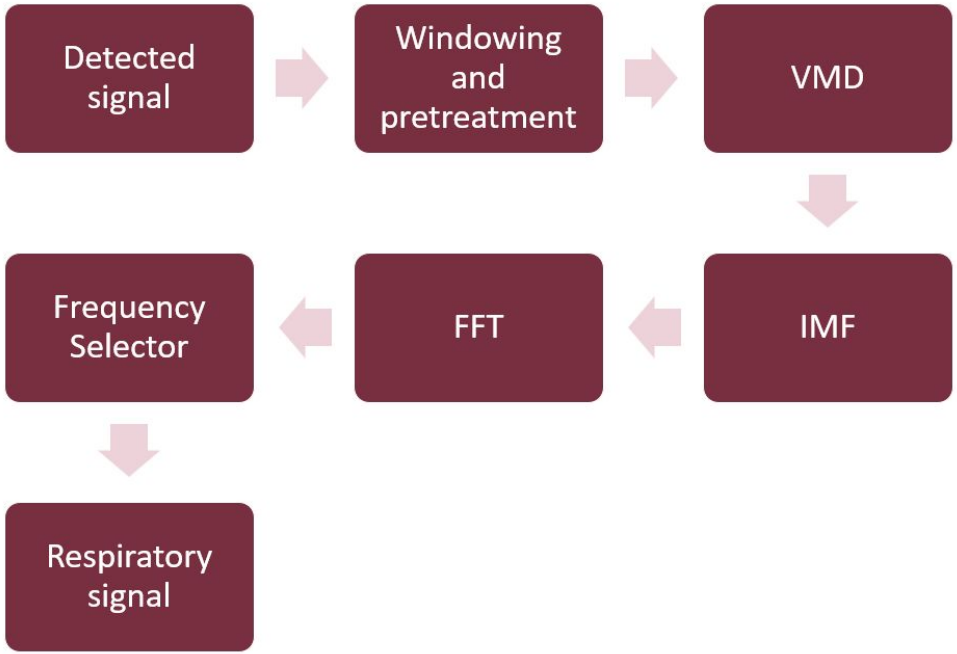
Signal Processing Flowchart



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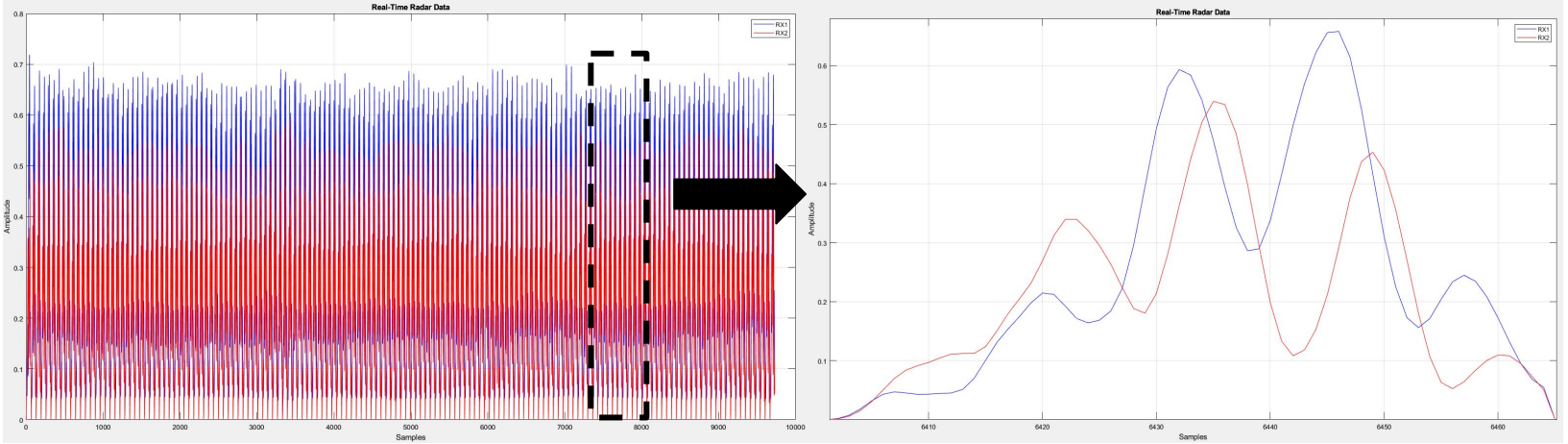
Windowing



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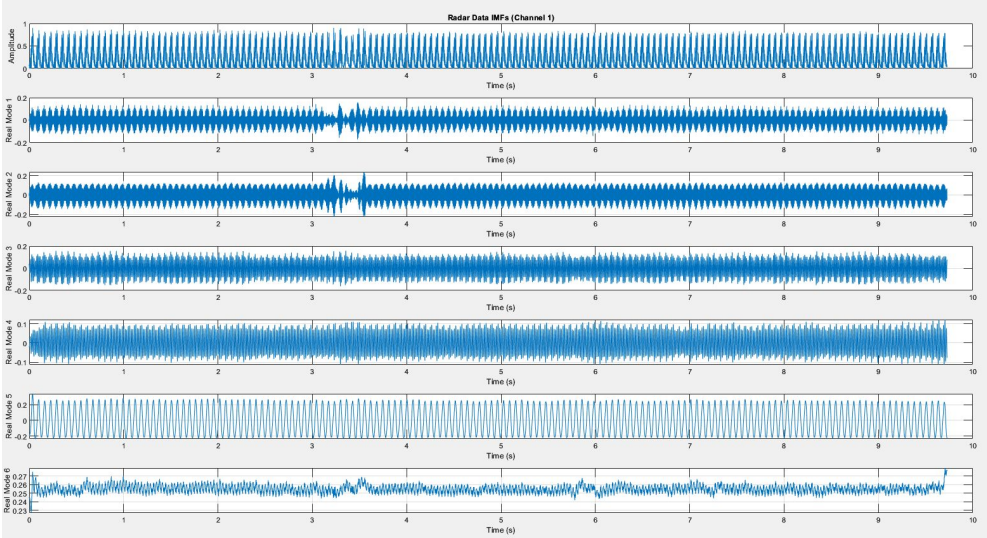
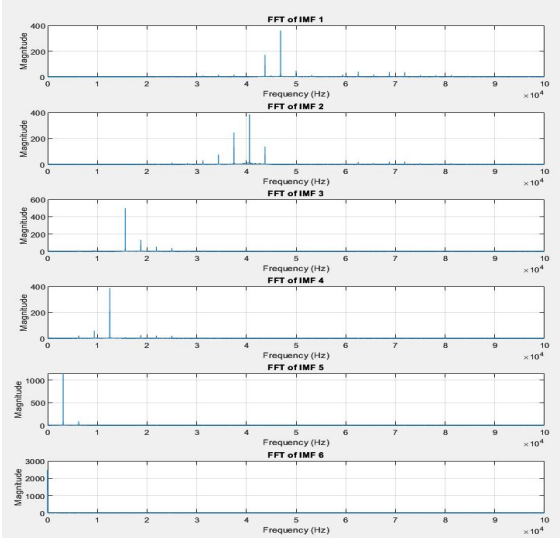
IMFs FFT





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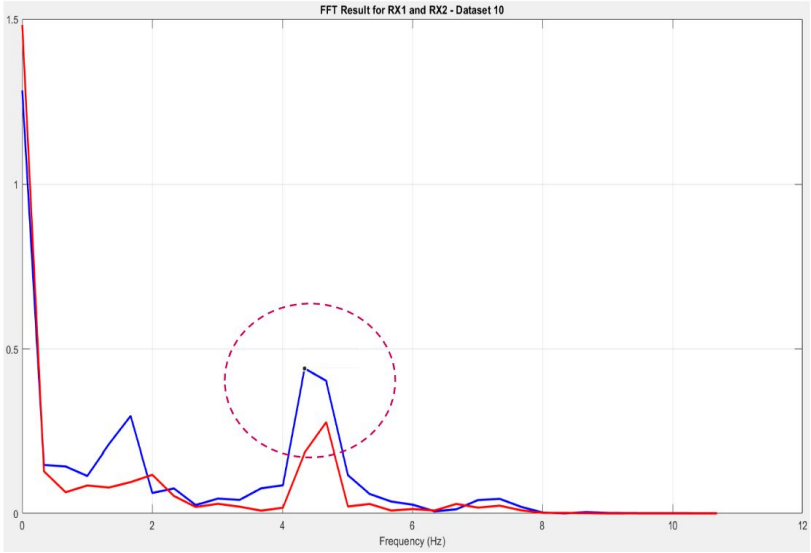
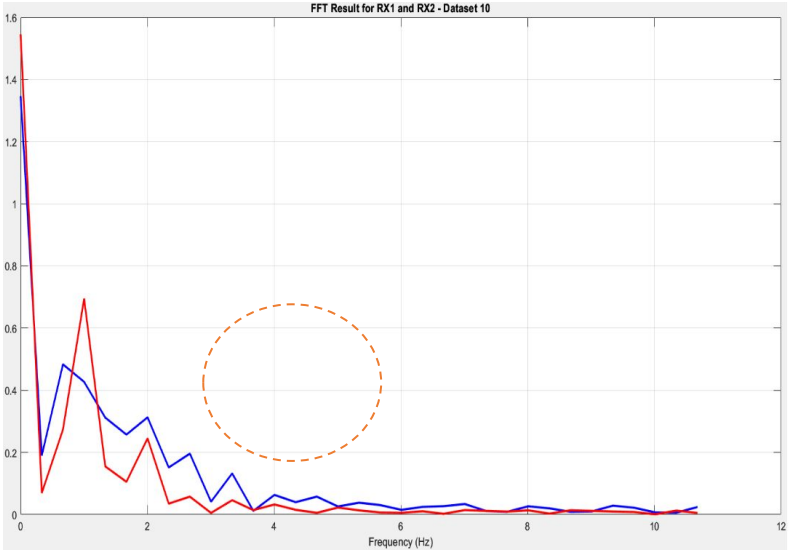
Frequency Isolation on MATLAB

HEAD UP



HEAD DOWN



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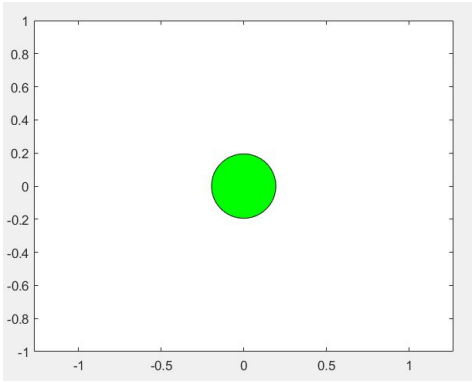
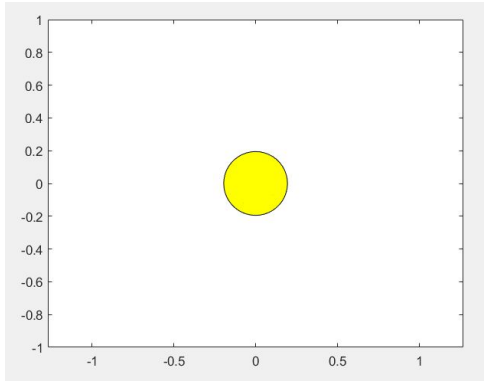
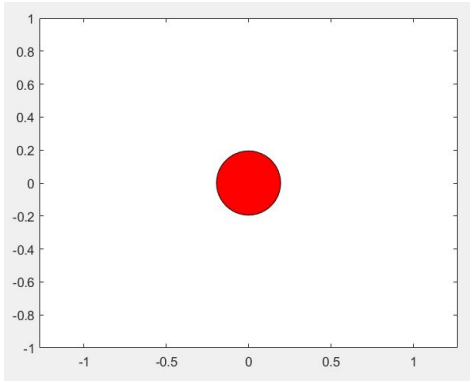
Algorithm Concepts

- Algorithm:
  - Neural network to employ training data
  - Create cases for different drowsiness state
- Outputs:
  - Visual Indicator
  - Audio Indicator
  - Audio/Visual Combo







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Algorithm Implementation

- Inputs:
  - Breathing rate
  - Head position
  - Driving time

- Hard-coded probability table.
  - Values for these probabilities are assumed
  - Derived from basic driving assumptions
  - Would like to find research-backed values for future utilization

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Conditional Probability Table

Head State	Breathing State	Drive Length	P(Drowsy)
UP	Low	Short	0.2
UP	Low	Medium	0.4
UP	Low	Long	0.6
UP	Normal	Short	0.1
UP	Normal	Medium	0.2
UP	Normal	Long	0.4
UP	High	Short	0.05
UP	High	Medium	0.1
UP	High	Long	0.2

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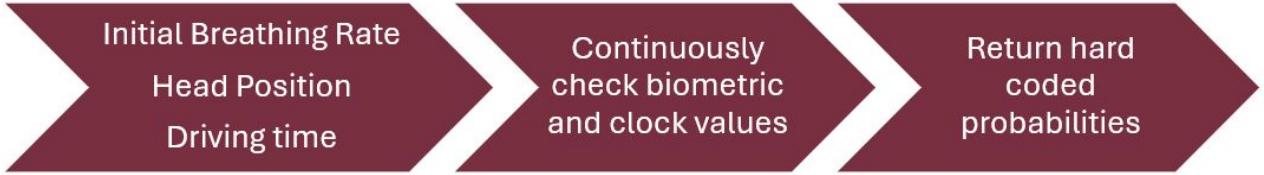
Further Analysis of Algorithm



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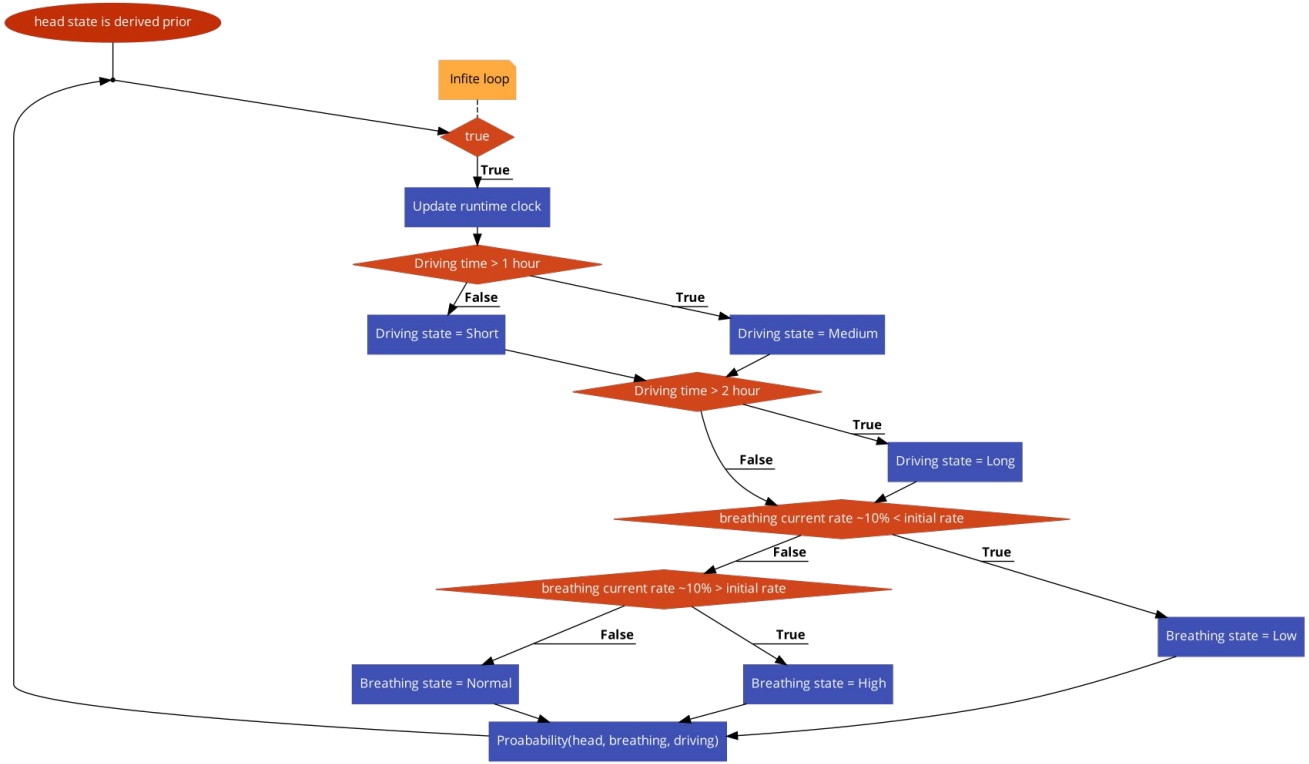
Further Analysis of Algorithm



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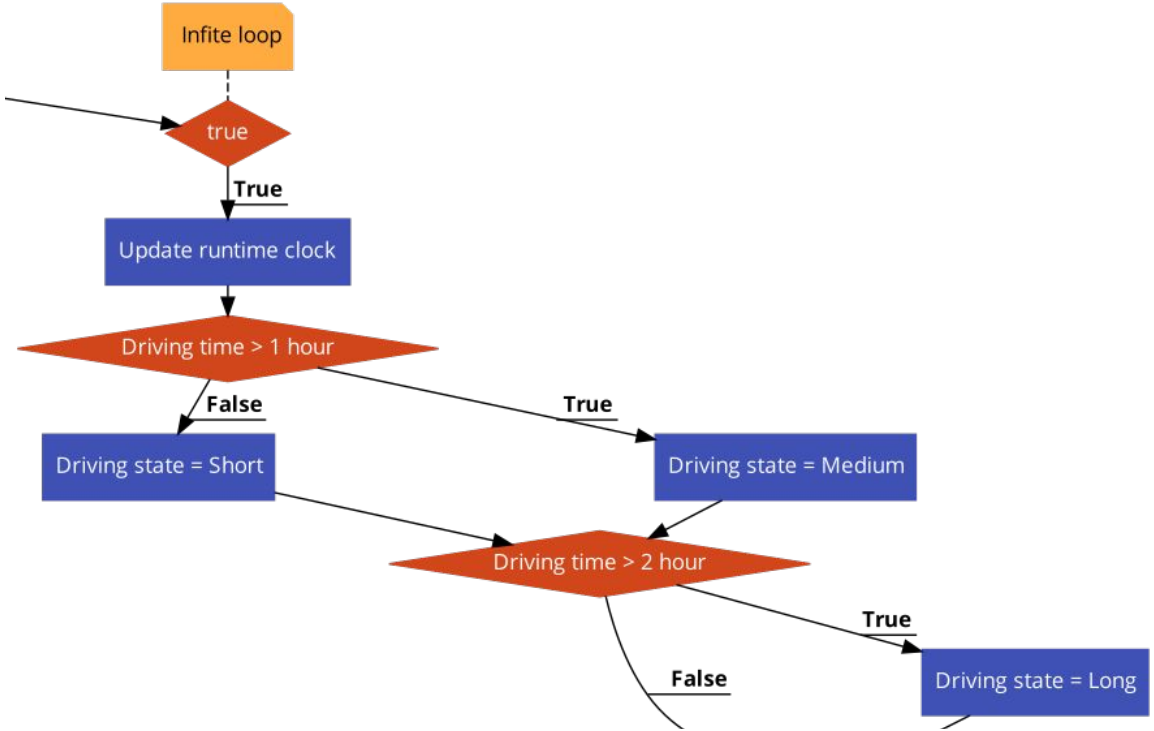

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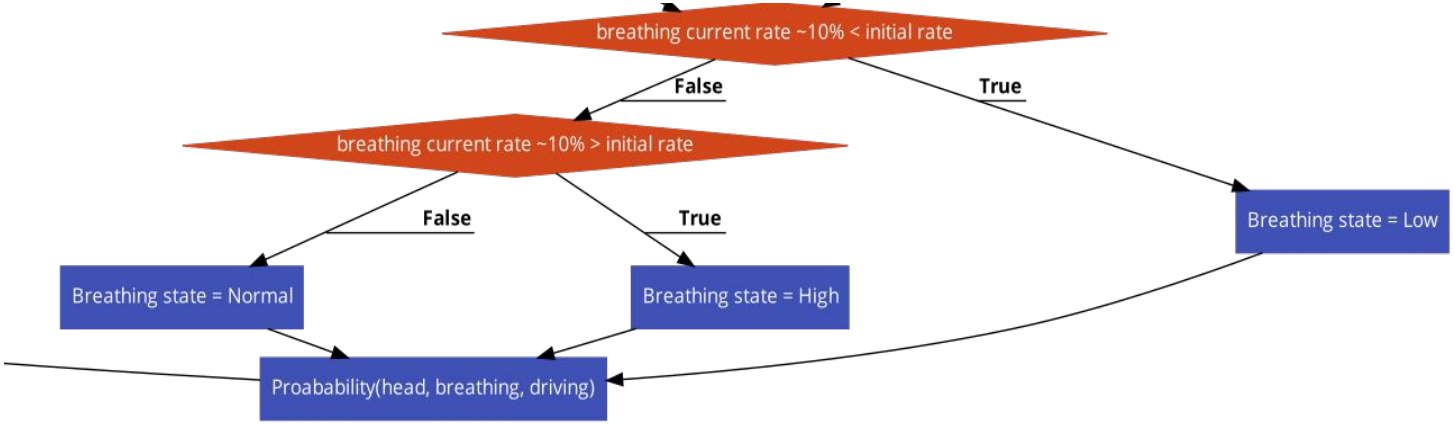
Further Analysis of Algorithm



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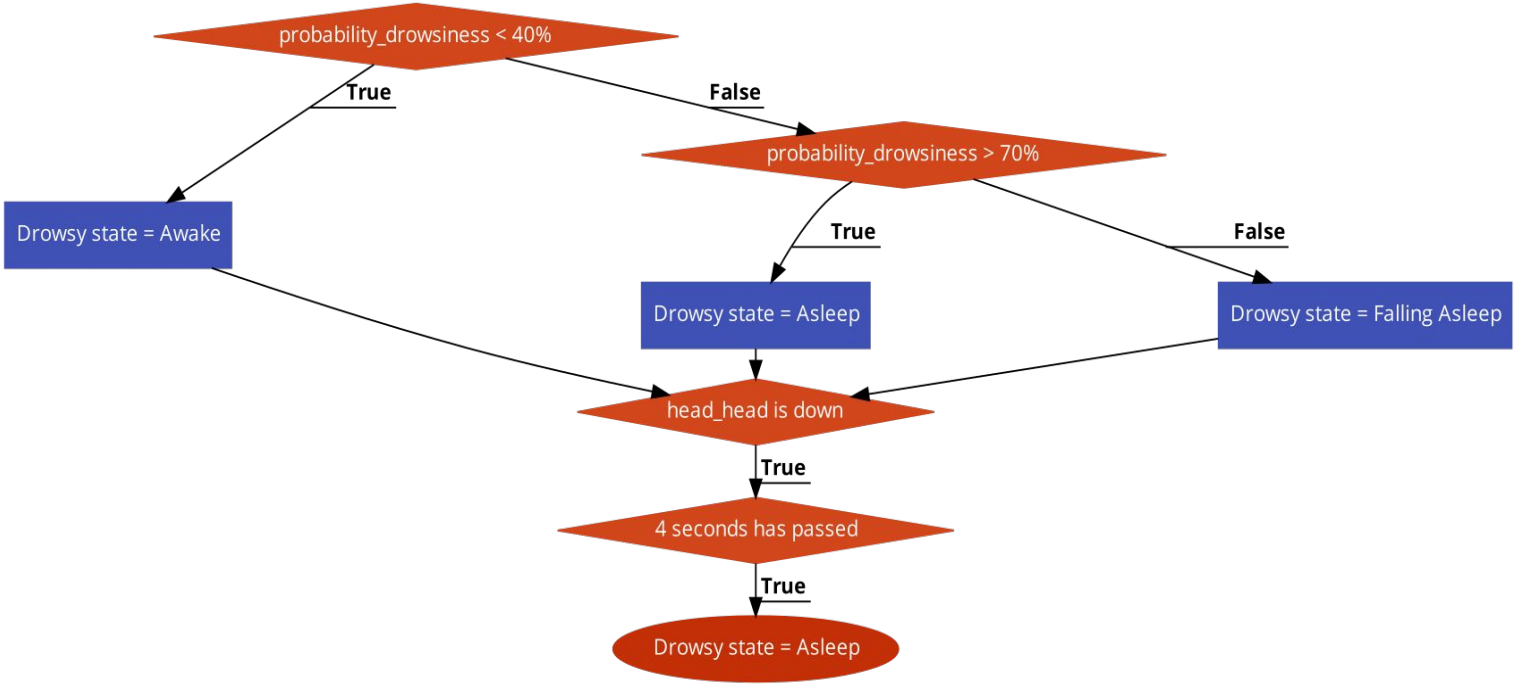

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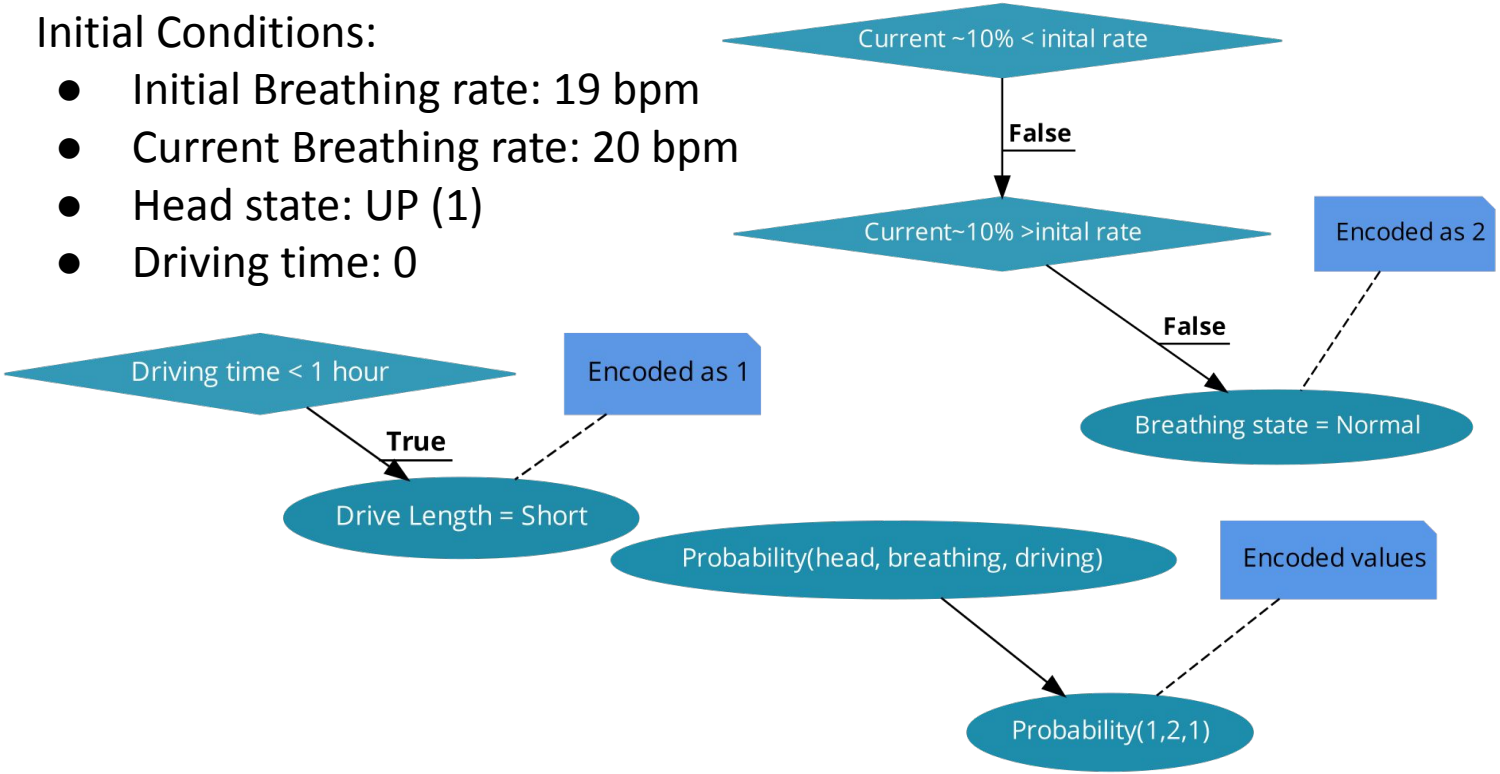
Example Case

Initial Conditions:

- Initial Breathing rate: 19 bpm
- Current Breathing rate: 20 bpm
- Head state: UP (1)
- Driving time: 0



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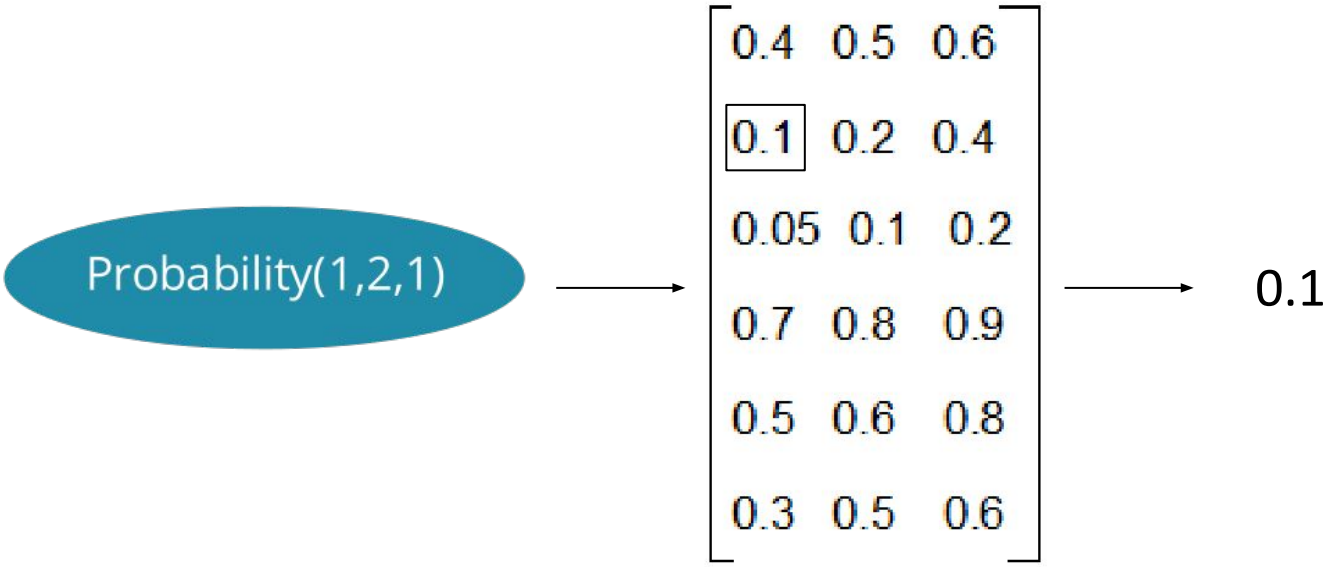
Example Case



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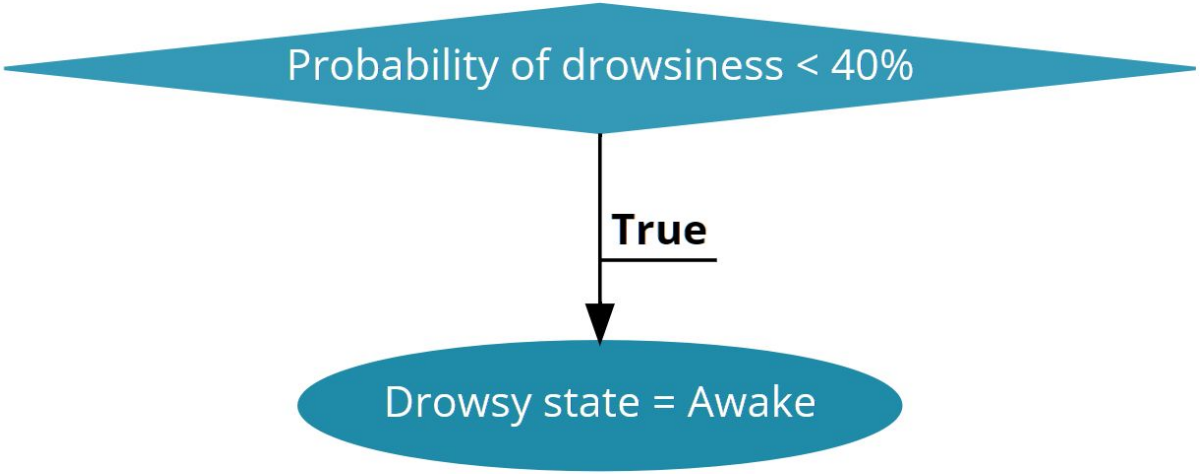
Example Case



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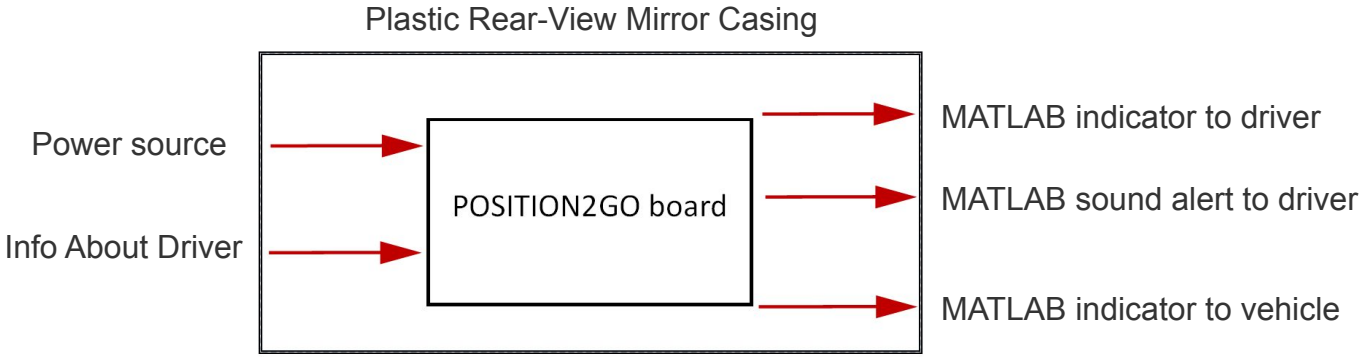
Component Breakdown



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Mirror Housing Concepts

- Top choices for material to create mirror casing
  - 3D filament
  - Clear plastic
  - Hard rubber
  - Soft rubber
  - Variation of material with rubber stabilizers for the radar

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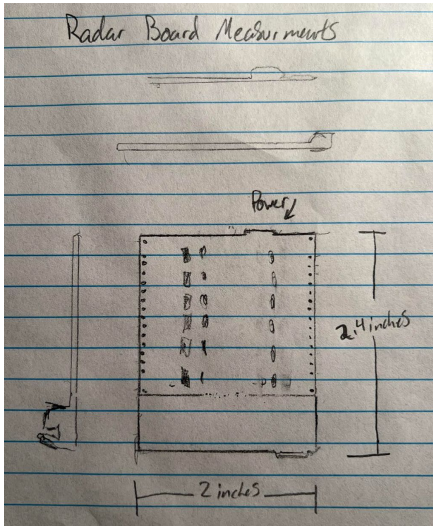
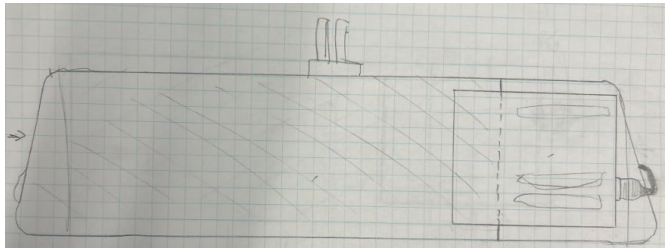
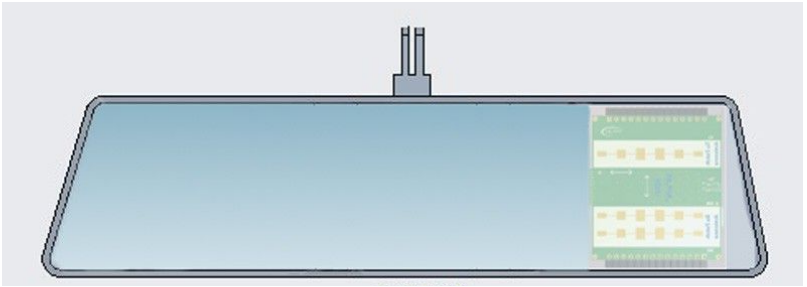
Finalized Design Sketch

- Measurements taken of the mirror and board for sketch
- Merged sketches of the Postition2GO boar and mirror housing







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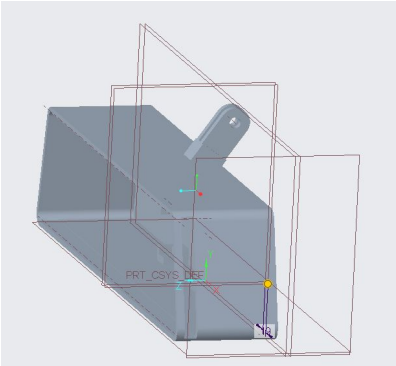
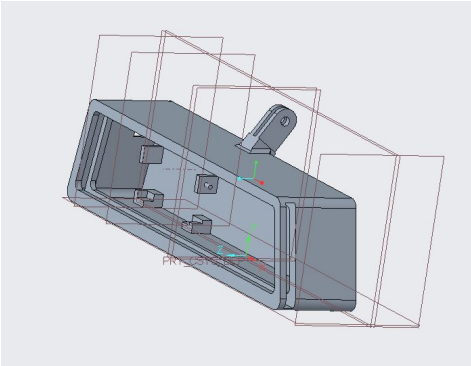
Mirror Housing Revision

- Remodeled in Creo
- Corrected mount design
- Improved slot to securely hold glass





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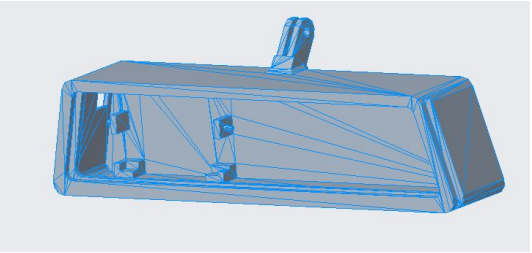
Printing Mirror Housing

- Creo modeling software
- 3D printed at the Innovation Hub
- Secure hold of the Position2Go board

Prusa Mk3s+

Stl file “this format is needed to send to the 3D printer



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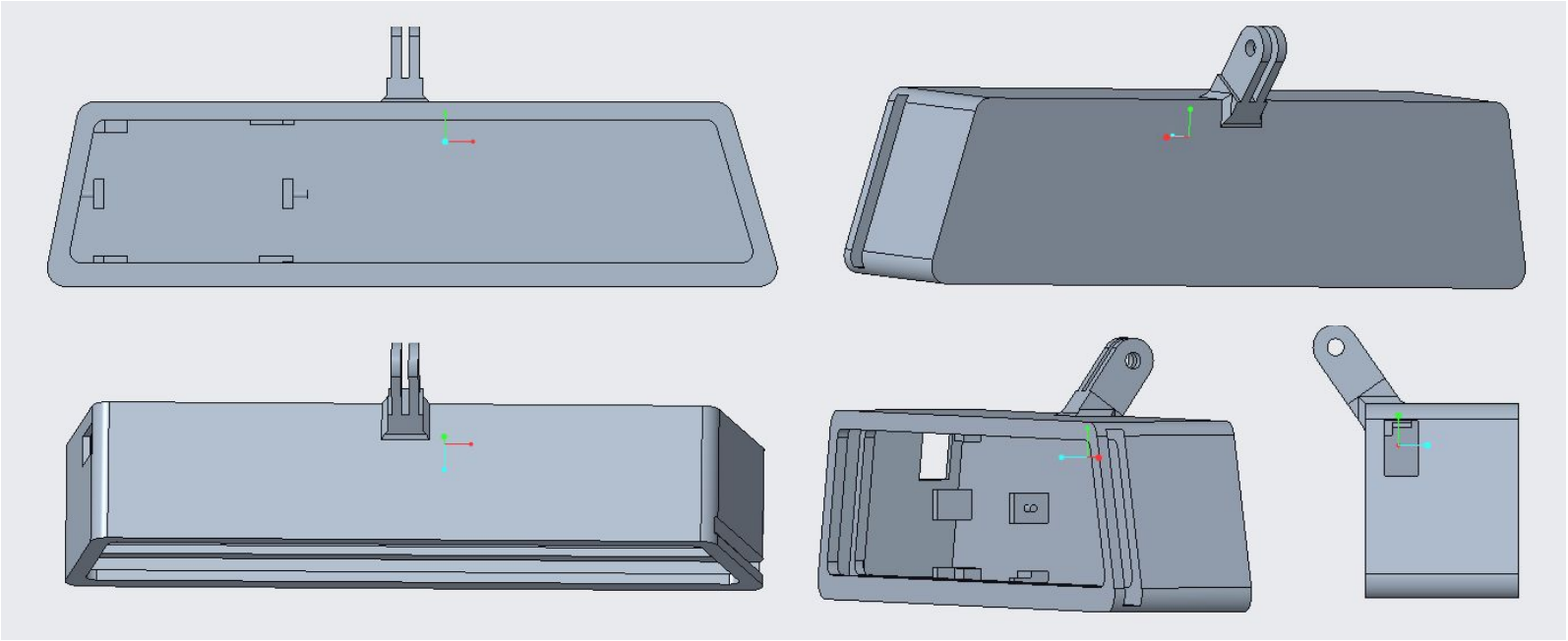
Multidirectional View



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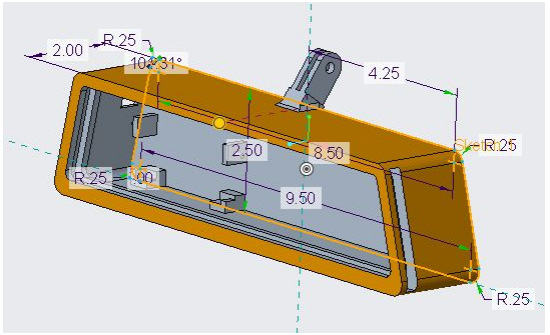
Mirror Housing Visuals

Dimensional view



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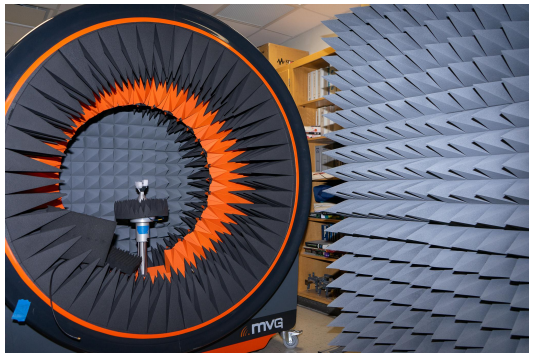
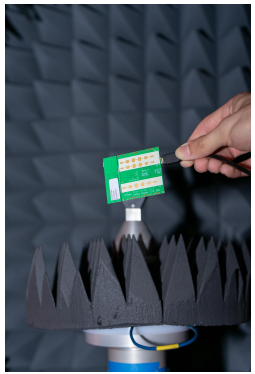
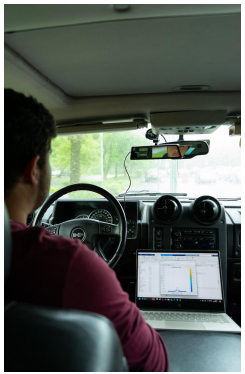
Testing

- Anechoic chamber used to get a reliable range measurement
- Lack of reliable data available online
- Team members mimicked drowsy behavior to obtain more testing data
- A Go Direct® Respiration Belt was used to record breathing rate during the experiment







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Experiment

- Setup
  - Stationary car
  - Respiration belt
  - Device connected to laptop running Matlab script
- Procedure
  1. Calibration of driver's head position and breathing rate
  2. Driver mimics behavior of scenario x
  3. Measure performance of algorithm using accuracy and precision metrics

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Algorithm Testing

- Test subjects for several different scenarios (example cases below)

No.	Head position	Breathing rate	Drive time	Expected Output	Actual Output
1	UP	HIGH	LONG	AWAKE	AWAKE
2	DOWN	LOW	SHORT	FALLING ASLEEP	FALLING ASLEEP
3	DOWN	LOW	MEDIUM	ASLEEP	ASLEEP
4	DOWN	LOW	LONG	ASLEEP	ASLEEP
5	DOWN	LOW	SHORT	FALLING ASLEEP	FALLING ASLEEP

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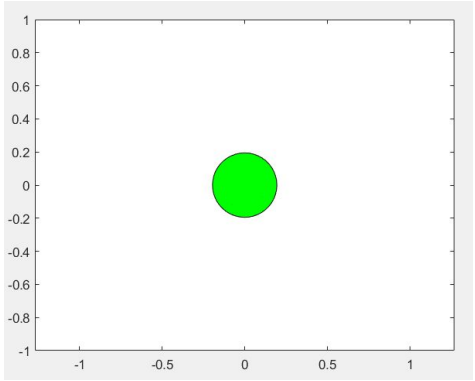
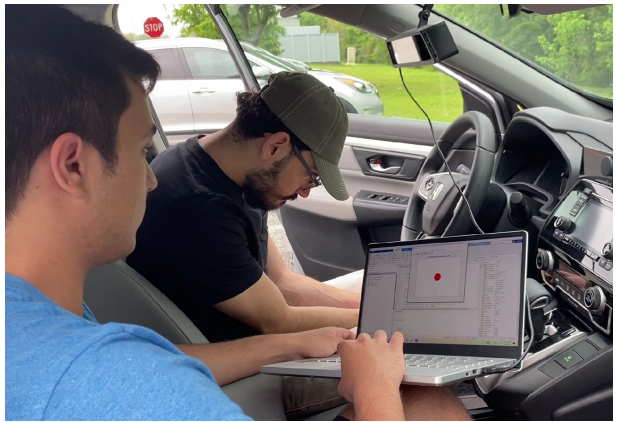
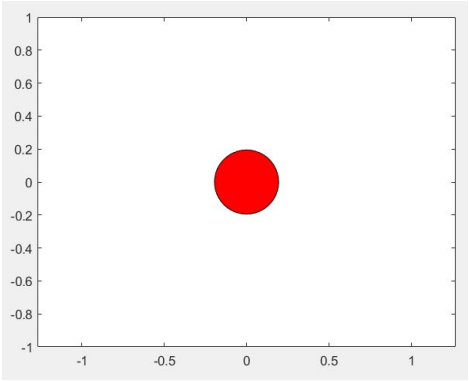
Testing Example







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Outcomes

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Initial Testing Results

- Obtained an accuracy of 88.9%
- Precision score of 83.3%
- Further testing to include
  - Breathing rate implementation
  - More scenarios to include head nodding

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Lessons Learned

- Emphasize learning the board documentation in beginning stages of project
- Replace Position2Go board with up-to-date radar system
- Use a camera system and neural network model instead
- Prioritize individual work over group work

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Review

- Outlined project objectives and key goals
- Discussed features of implemented design
  - Extracting biometrics using MATLAB
  - Decision-making algorithm with Pseudocode
  - Rear view mirror housing
- Prototype testing procedure and results
- Discussed outcomes and lessons learned

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References

[1] B. Warwick, N. Symons, X. Chen and K. Xiong, "Detecting Driver Drowsiness Using Wireless Wearables," 2015 IEEE 12th International Conference on Mobile Ad Hoc and Sensor Systems, Dallas, TX, USA, 2015, pp. 585-588, doi: 10.1109/MASS.2015.22.

[2] D. Dacova, “Ride comfort in road vehicles: a literature review.” Available: https://stumejournals.com/journals/tm/2021/2/65.full.pdf

[3] A. Sapra, A. Malik, and P. Bhandari, “Vital sign assessment,” National Library of Medicine, May 01, 2023. https://www.ncbi.nlm.nih.gov/books/NBK553213/

[4] F. D. Enggar, A. M. Muthiah, O. D. Winarko, O. N. Samijayani and S. Rahmatia, "Performance comparison of various windowing On FMCW radar signal processing," 2016 International Symposium on Electronics and Smart Devices (ISESD), Bandung, Indonesia, 2016, pp. 326-330, doi: 10.1109/ISESD.2016.7886743

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Questions?

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Project Background

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Frequency isolation on MATLAB

- Taking the Fast Fourier Transform enables us to find patterns in the the frequency changes of head movement.
- This demonstrates a difference in initial readings, to current readings which can be used to predict head positioning.
- Using a similar process we were able to show a faster/slower breathing rate.

3D Model and glass cut

We custom cut glass to make glass fit

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Slide Headline

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- Try to put as few words as possible on the slide if you're using for a presentation.
- Mix and match the backgrounds as shown in this template or just use one throughout.
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- This is 10-point
- This is 15–point Times
- This is 20–point
- This is 25–point
- This is 30–point
- This is 35–point
- This is 40–point
- This is 50–point
- This is 60–point

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College of Engineering Color Palette

Pantone: PMS 195 C

RGB: 120, 47, 64
Hex: #782F40

CMYK:19, 90, 50, 55

Garnet

Pantone: Black C

RGB: 0, 0, 0
Hex: #000000

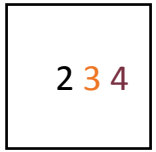
CMYK:0, 0, 0, 100

Black

RGB: 238, 118, 36
Hex: #EE7624

CMYK:2, 66, 99, 0

Fang Orange



Pantone: PMS 000C

RGB: 255, 255, 255
Hex: #FFFFFF

CMYK: 0, 0, 0, 0

White

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Accent Color Palette

RGB: 0, 59, 111
Hex: #003B6F

CMYK:

Tardis Blue

RGB: 251, 236, 93
Hex: #FBEC5D

CMYK:

Corn

RGB: 219, 215, 210
Hex: #DBD7D2

CMYK:

Timberwolf

RGB: 206, 0, 88
Hex: #CE0058

CMYK: 0, 100, 43, 12

Rubine Red

RGB: 104, 40, 96
Hex: #682860

CMYK:

Imperial

RGB: 220, 220, 220
Hex: #DCDCDC

CMYK:

Gainsboro

RGB: 72, 146, 155
Hex: #48929b

CMYK:

Asagi-iro

RGB: 64, 224, 208
Hex: #40E0D0

CMYK:

Turquoise

RGB: 255, 139, 0
Hex: #FF8B00

CMYK:

American Orange

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Analogous	F7AB19	D67F15	EE7624	D64615	F73119
Monochromatic	6E3610	F0A16C	EE7624	6E4931	BA5B1C
Triad	A14508	4BED3B	EE7624	250CED	2010A1
Complementary	A1470C	FF8C40	EE7624	0098A1	24E2ED
Split Complementary	28A164	2FED8D	EE7624	0848A1	1871ED
Double Split Complementary	EDAC2F	3BED93	EE7624	0C6AED	ED2F18
Square	ED660C	C7ED3B	EE7624	0CE1ED	A418ED
Compound	BA7E09	87724A	EE7624	60EFCF	09BA61
Shades	AD551A	6E3610	EE7624	FA7625	D46820

or.adobe.
e/color-w

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Analogous	85412D	8F3831	782f40	8F3176	792D85
Monochromatic	C44D69	8E626D	782F40	C48796	451B25
Triad	C43959	78743B	782F40	236178	43A2C4
Complementary	C43959	C46078	782F40	25C43D	2F783A
Split Complementary	93C460	577835	782F40	39C49D	297861
Double Split Complementary	784435	5A783B	782F40	237860	6E2978
Square	782337	78683b	782F40	237830	293978
Compound	AB4D32	DEBAAF	782F40	5D8555	70AB32
Shades	38161E	C44D69	782F40	853447	5E2532

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e/color-w

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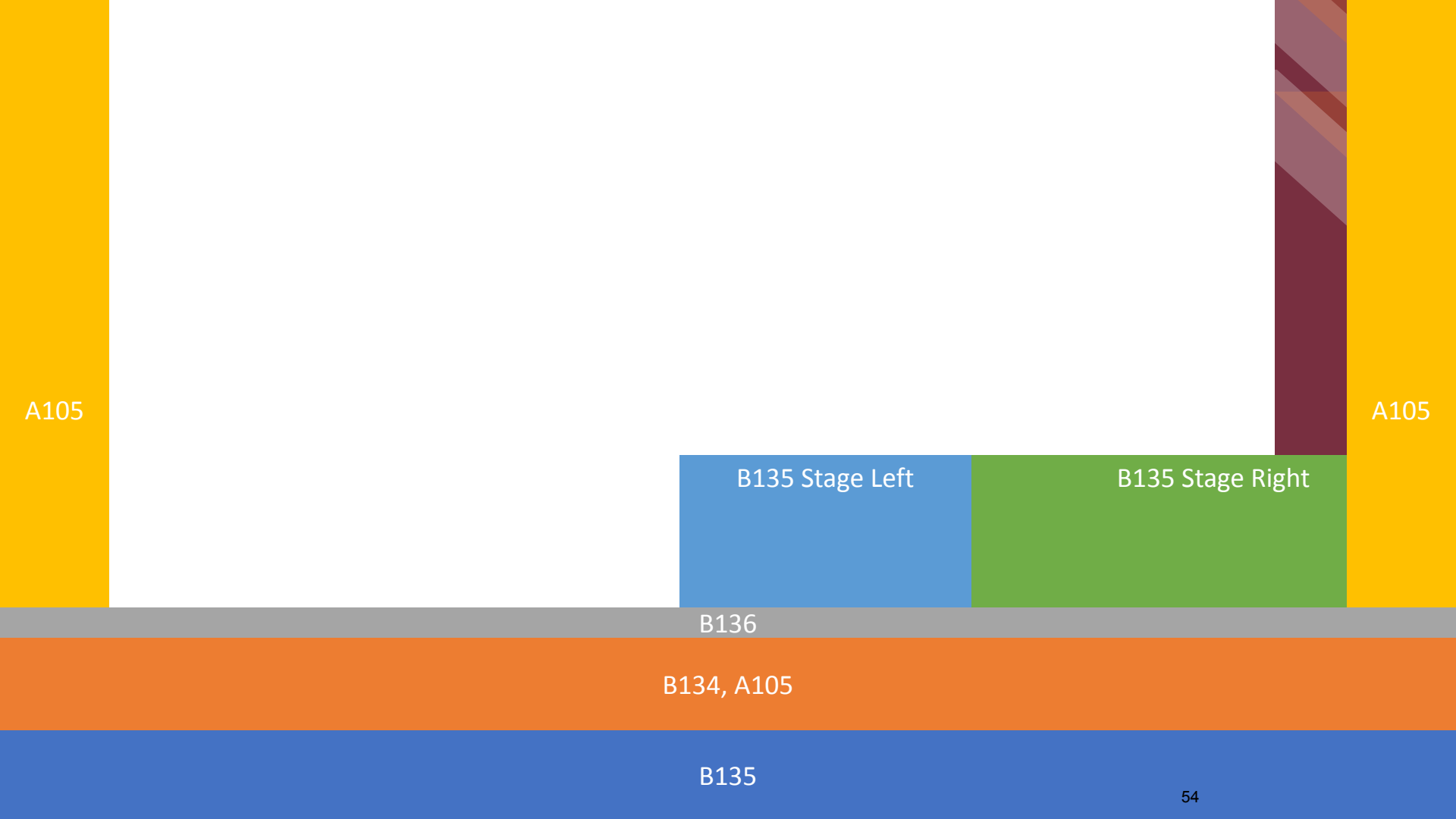
A105
A105
B135 Stage Left
B135 Stage Right
B136
B134, A105
B135

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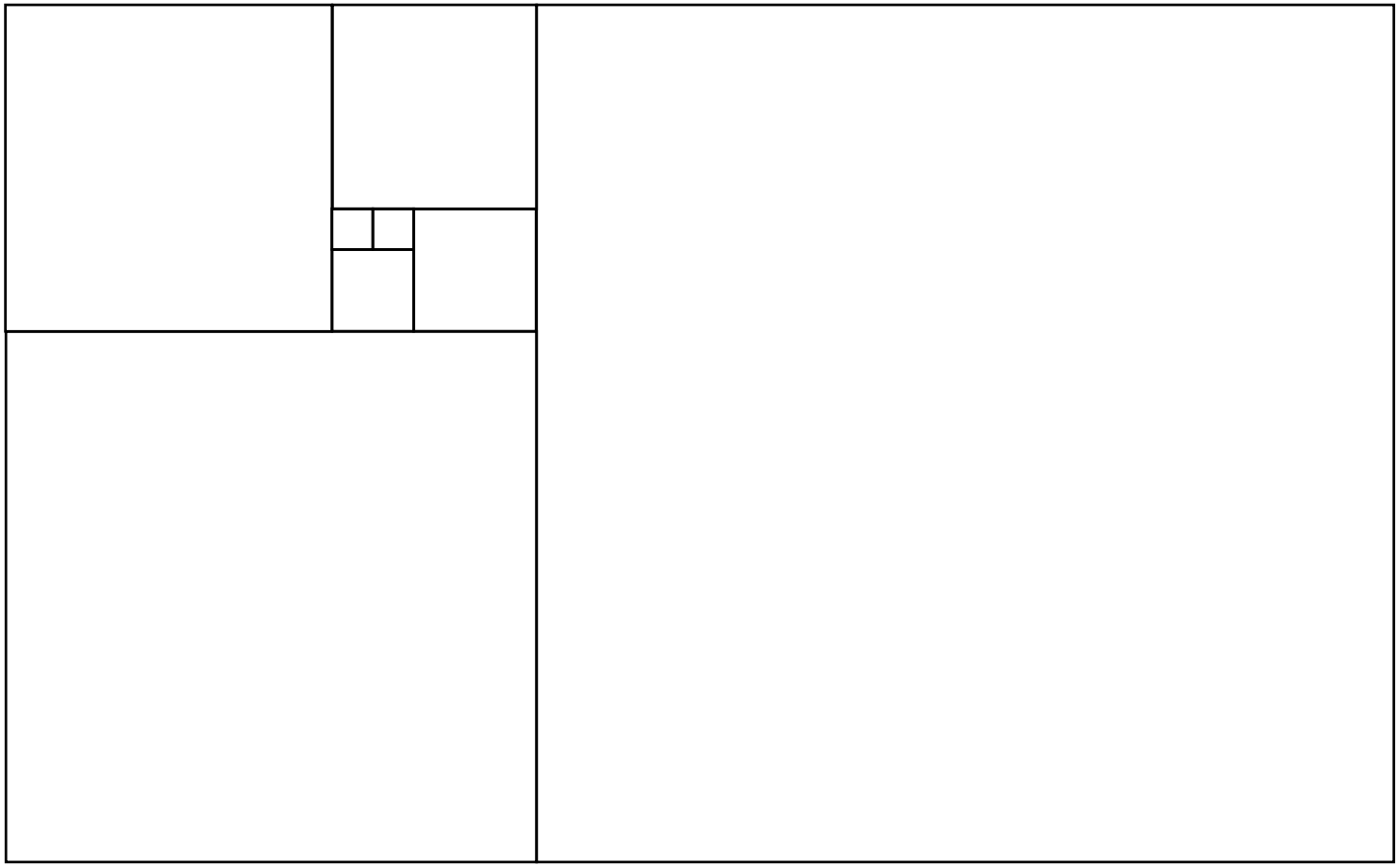

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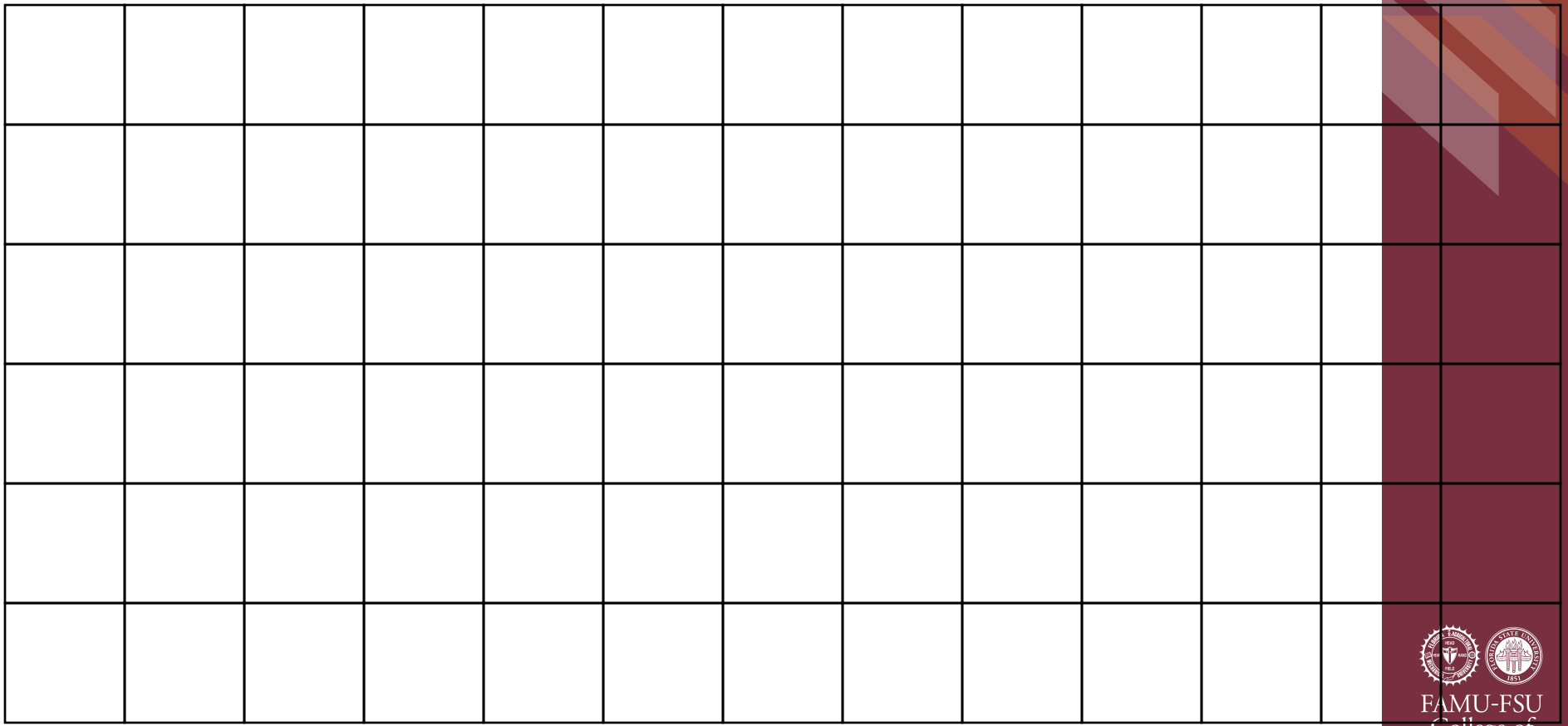

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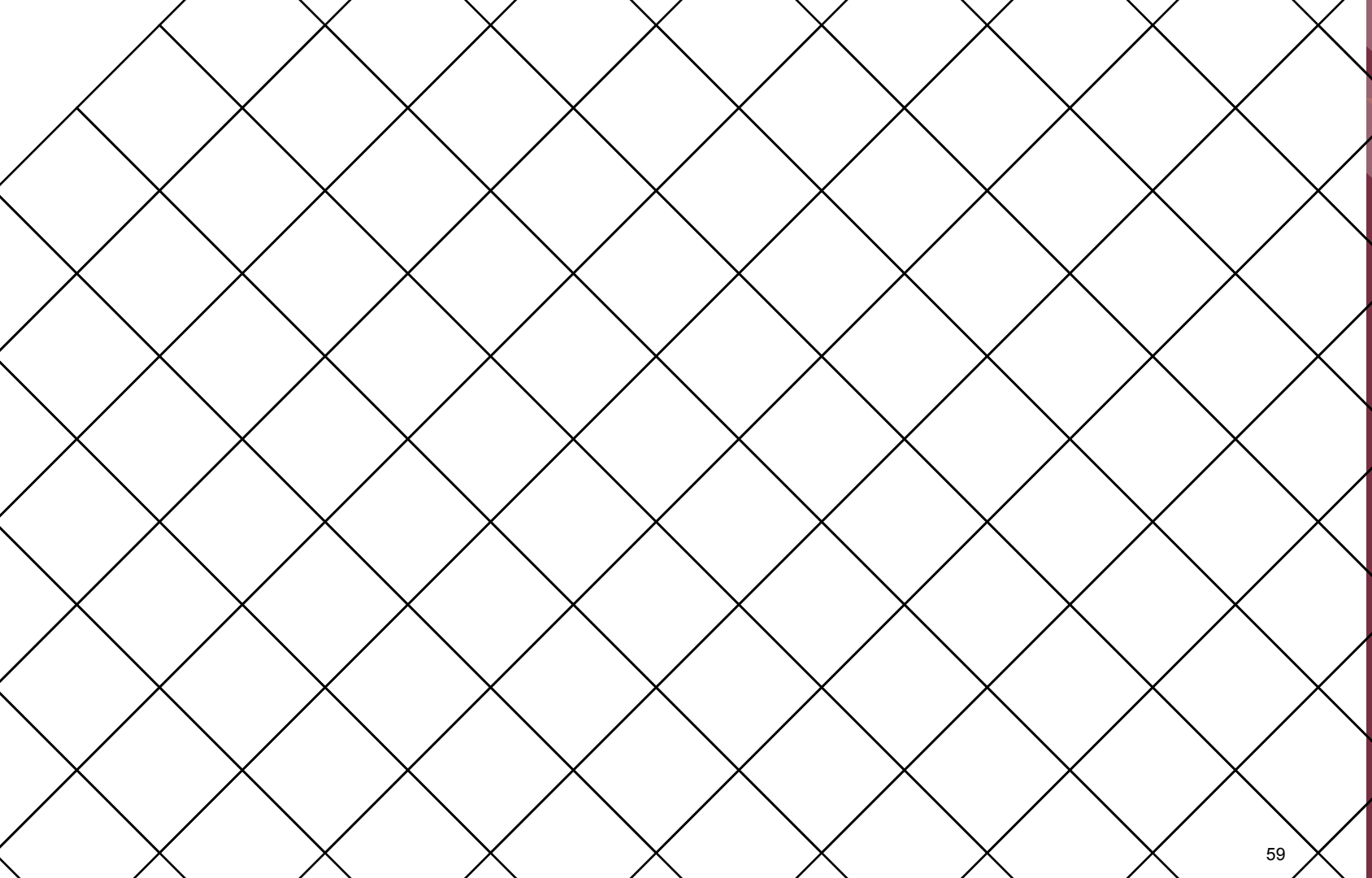
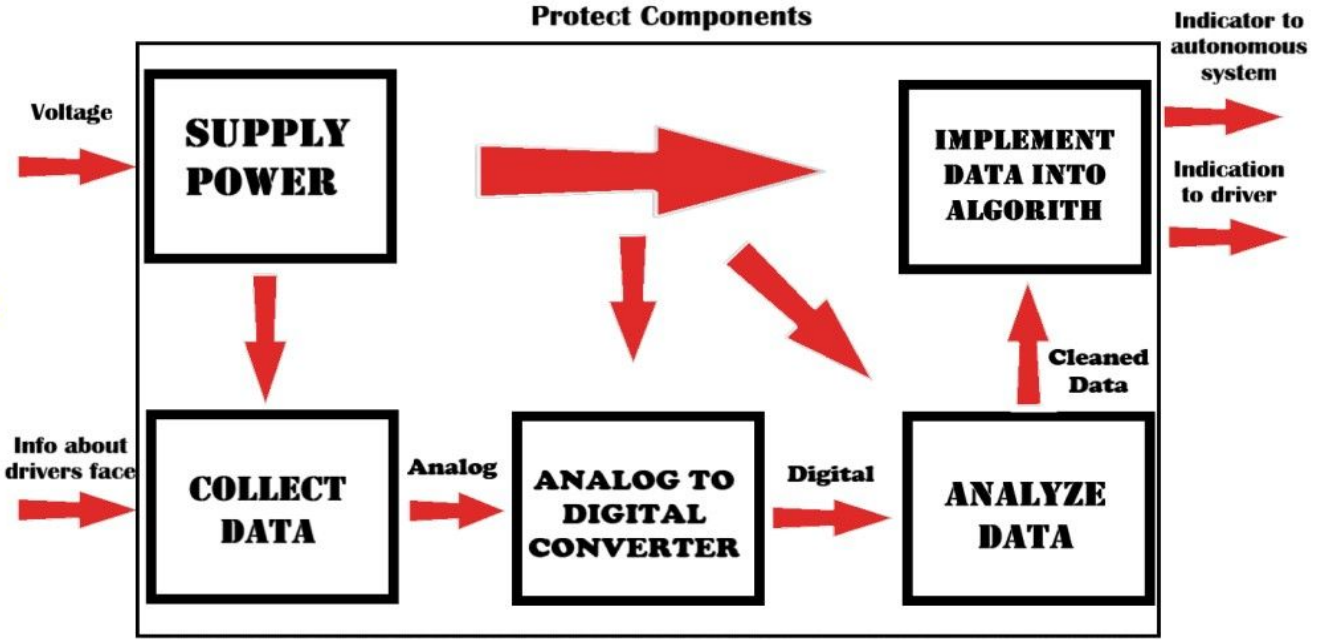


L0

L1



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Concept Generation

Concept Selection

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Detailed Design

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Implementation

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Testing and Validation

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