Pedestrian Collision Avoidance System

Software Engineering CSE 435
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Overview and Purpose

Project Overview

Functionality

Embedded system in an automotive vehicle whose primary function is to assist the driver in preventing collisions, injuries, and damages to pedestrians that come in range of the vehicle when it is traveling at speeds of under 50 kph.

Motivation

Autonomous driving is an area of intense interest by the automotive industry and the public. A self-driving vehicle must be able to say in its own lane, brake at intersections, and remain under control during these actions.

Purpose

Primary : Avoid Pedestrian Collisions

Secondary : Lose as Little Time as Possible

Maintain Safety and Security

- Cyber Attacks
- No Injuries

Keep Reasonable

- Cost Analysis
- Achievable Functionality

Features

Radar Sensor

- Can Detect Pedestrian
- Calculate Distance to Pedestrian

Cameras

- Display Environment

Digital User Interface

- Provide Alerts

Features

Manual Override

Autonomous Emergency Braking (AEB) &
Anti-lock Braking System (ABS)

Breakdown of Brake by Wire (BBW)

Domain Research

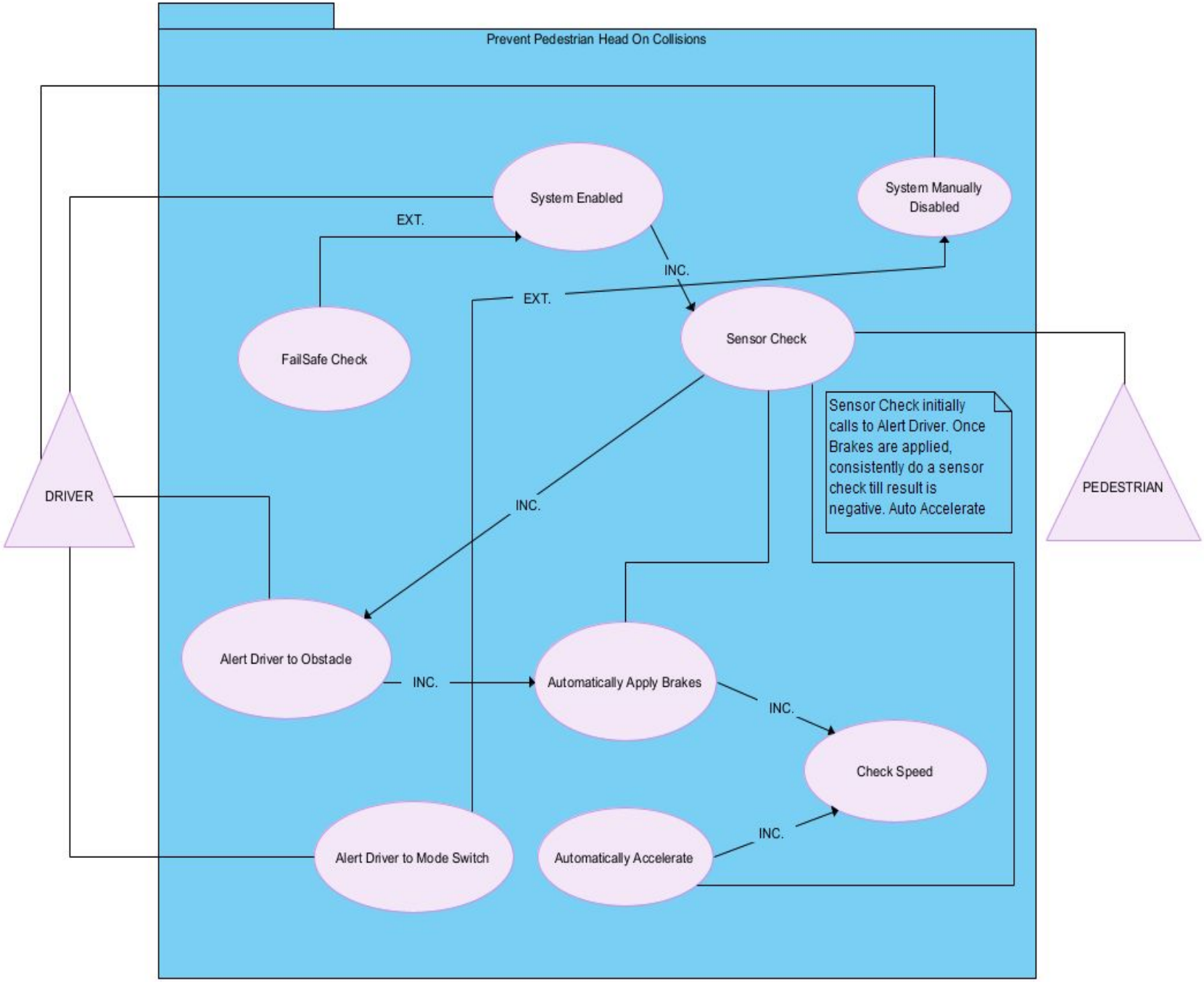
Research & Application

- System Works Only Under 50 kph
- Stopping Distance Buffer of 1.5 m
- Deceleration of 0.7 g, Where 1 g = 9.81 m / s^2

Constraints

- Perfect Environment
- Scenarios as Given
- 0% Chance of Hardware/Software Failure

System Diagram


Prevent Pedestrian Head On Collisions
System Enabled
System Manually Disabled
EXT.
INC.
EXT.
FailSafe Check
Sensor Check
Sensor Check initially calls to Alert Driver. Once Brakes are applied, consistently do a sensor check till result is negative. Auto Accelerate
DRIVER
PEDESTRIAN
INC.
Alert Driver to Obstacle
INC.
Automatically Apply Brakes
INC.
Check Speed
Alert Driver to Mode Switch
Automatically Accelerate
INC.

System Enabled & Manually Disabled

Use Case:	System Enabled
Actors:	Driver (initiator)
Description:	*Turns on the system. This is only the case if several things are true. 1) The vehicle in question is turned on, and 2) the system has not been manually turned off. No other use cases should ever engage or be valid so long as this is not true. It should immediately perform a check for obstacles after this.*
Type:	Primary and Essential
Includes:	*Sensor Check*
Extends:	*Failsafe Check*

Use Case:	System Manually Disabled
Actors:	Driver (initiator)
Description:	*This will override the system but must be done manually by the operator, in this case the driver.*
Type:	Primary and Essential
Extends:	*Alert Driver to Mode Switch*

System Enabled & Manually Disabled

No Other Use Case Works if Not Enabled

Always Enable Unless Manually Disabled

The Physical Driver Initiates These Use Cases

Failsafe Check is Performed

Sensor Check

Use Case:	Sensor Check
Actors:	System (initiator), Pedestrian
Description:	*After the system is enabled and at every moment following activation, this reports if a pedestrian is detected or not, and at what distance they are from the center-front of the vehicle. Based on this, determines whether to accelerate, decelerate, or take no action.*
Type:	Secondary and Essential
Includes:	*Alert Driver to Obstacle, Automatically Apply Brakes, Automatically Accelerate*
Use cases:	Must have completed the Systems Enabled use case. Must have completed the Failsafe Check use case.

Sensor Check

Reports True/False Pedestrian Detected

Sends Data of How Far Pedestrian is From Vehicle

Calls to Alert the Driver

Alert Driver

Use Case:	Alert Driver To Obstacle
Actors:	System (initiator), Driver
Description:	*Provides an alert to the driver after detecting a pedestrian within 30 meters of the vehicle. This alert is both visual and auditory. Emits an auditory beep to warn the driver, as well as provides an alert on the dashboard that a pedestrian has been detected. After the initial alert,* ***it will not continually provide an alert.*** *It will only alert an additional time if a new pedestrian is detected.*
Type:	Secondary and Essential
Includes:	*Automatically Apply Brakes*
Use cases:	Must have completed the Systems Enabled use case. Must have completed the Failsafe Check use case. Must have completed the Sensor Check use case.

Alert Driver

Not Continuous

Alerts Again if New Pedestrian Detected

Provides Audible and Visual Alert

Automatically Brake

Use Case:	Automatically Apply Brakes
Actors:	System (initiator)
Description:	*When initially called, take note of the current speed of the vehicle (this will be the **steady state speed**. Apply brakes and decelerate as needed from the current speed. This will not occur if the vehicle exceeds the system speed limit (50 kph.)*
Type:	Secondary and Essential
Includes:	*Check Speed*
Use cases:	Must have completed the Systems Enabled use case. Must have completed the Failsafe Check use case. Must have completed the Sensor Check use case.

Automatically Brake

Use Sensors to Tell if Pedestrian is in Path

Apply the Brakes

Does Not Work Above 50 kph

Take Note of Pre-Deceleration Speed

Automatically Accelerate

Use Case:	Automatically Accelerates
Actors:	System (initiator)
Description:	*Accelerate the vehicle until the current speed matches the speed that was indicated from Automatically Apply Brakes as the* ***steady state speed****.*
Type:	Secondary and Essential
Includes:	*Check Speed*
Use cases:	Must have completed the Systems Enabled use case. Must have completed the Failsafe Check use case. Must have completed the Sensor Check use case. Must have performed and no longer be performing the Automatically Apply Brakes use case.

Automatically Accelerate

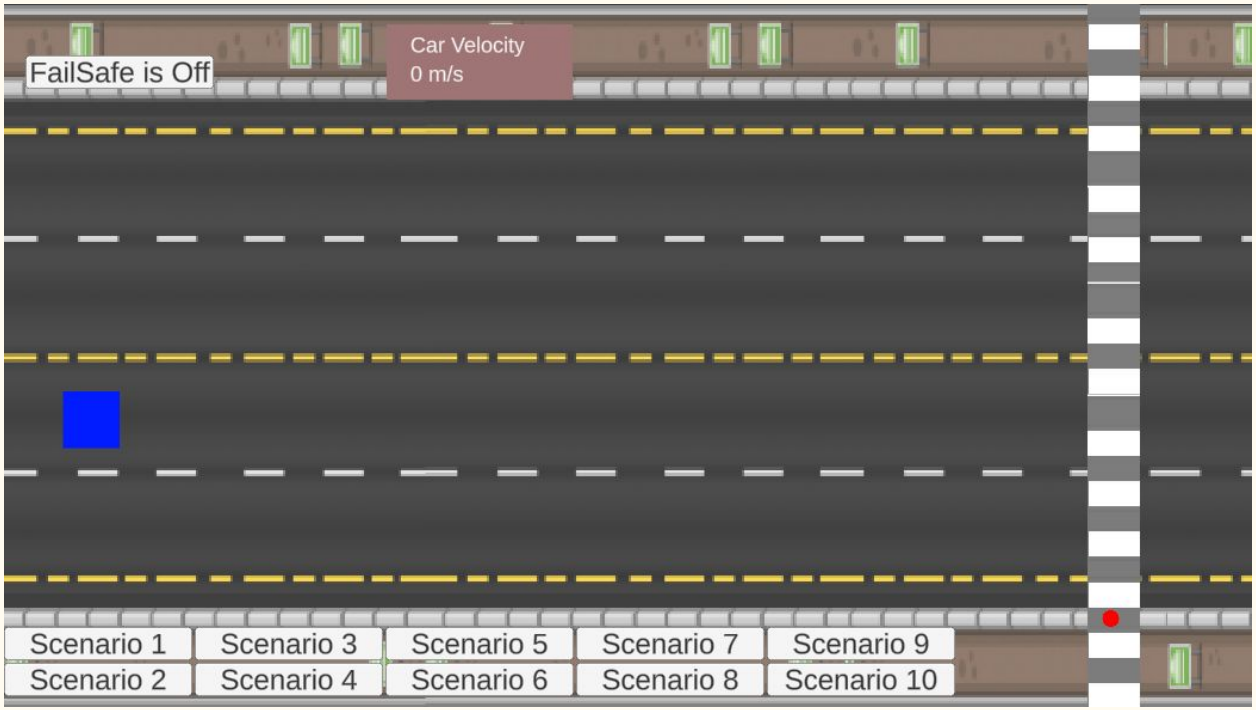
Accelerate to Steady State Speed

Use Sensors to Tell if Pedestrian is Not in Path

Prototype Breakdown

Demonstration

david-khankin.itch.io/executable-435



Scenario Explanation

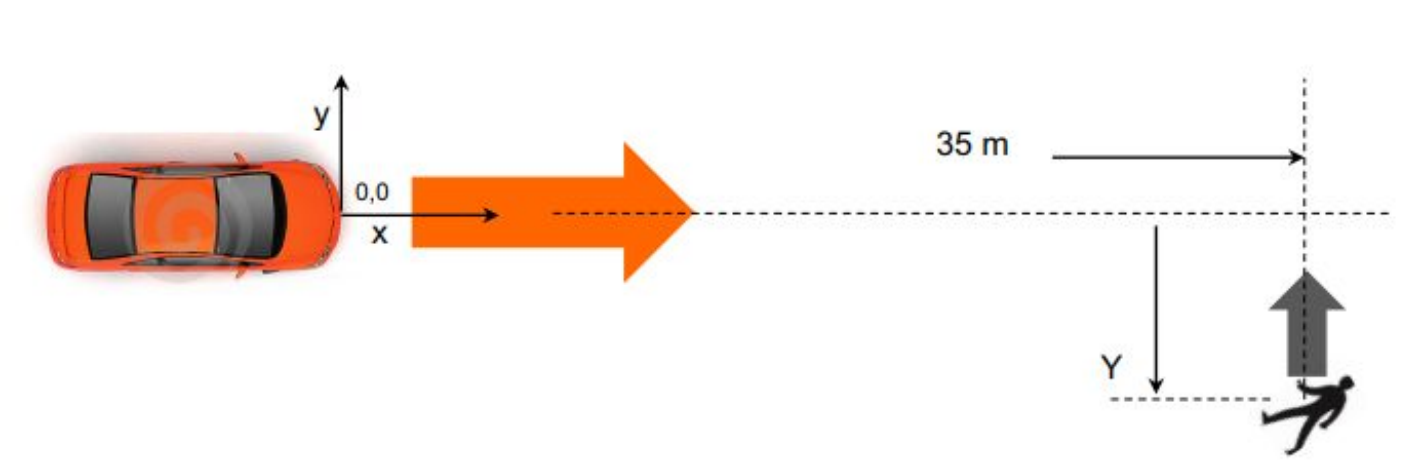
Vehicle at x = 0 m , y = 0 m

Pedestrian at x = 35 m, y varies

Vehicle has width of 2m, 1m in either direction from origin

Length of vehicle is irrelevant for these scenarios

Stops 1.5 m away from Pedestrian



How it Works

Braking and Accelerating Constraints:

Deceleration has an Accuracy of +/- 2%

Response Time of System to Brake is 200 ms, and 900 ms in Failsafe Mode

Acceleration is 0.25 g, where 1 g = 9.81 m / s^2

Deceleration is 0.7 g, where 1 g = 9.81 m / s^2

How it Works

Reality Constraints:

Pedestrian has Infinite Acceleration

Pedestrian is Always Moving at Either 0 kph or 10 kph

Pedestrian Can Only Move at a Right Angle to Vehicle Path

How it Works

Positioning and Scaling

- Given Values from Customer

Assumptions

- x, y coordinate system
- Vehicle does not swerve
- System will always work

Calculations

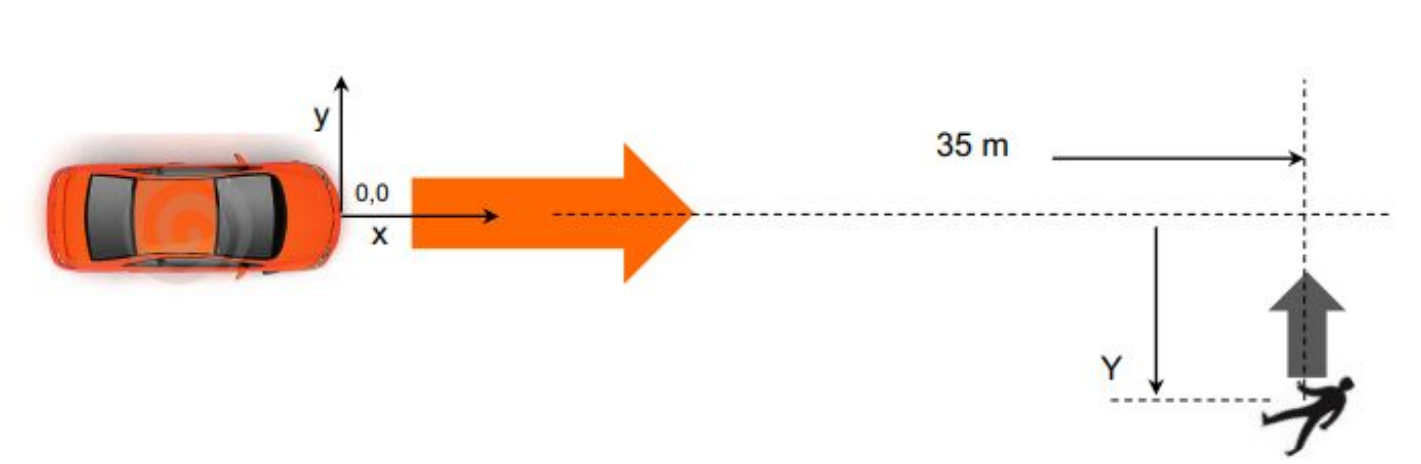
- Determine Potential Collisions
- Decelerate if Collision Possible
- Accelerate to Steady State if Collision Not Possible

How it Works

Two Factors for Potential Collision

Can the Pedestrian Move into the Vehicle Intercept Point

Can the Vehicle Stop Before Reaching the Area a Pedestrian Could be in



How it Works

Pseudo Code:

How Long for Vehicle to Fully Stop

Distance Vehicle and Pedestrian can Travel in this Time

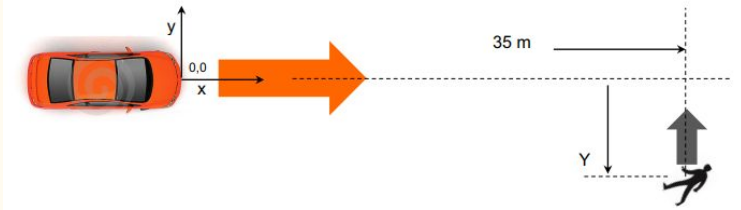
Can Pedestrian Move into Vehicle Path within Stopping Time

Can Vehicle End up at Intercept Point if Decelerate to Full Stop

If Both of These are Yes, Decelerate Until Either is No

If Either is No, and the Vehicle is Not at its Steady State Speed, Accelerate

Scenarios



Moving Then Stopped Pedestrian				
Scen #	Initial Position, Yi	End Position, Yf	Initial Speed	Final Speed
	(m)	(m)	(kph)	(kph)
1	-7	0	10	0
2	-7	-2	10	0
3	-7	-3	10	0
4	-7	-5	10	0

Static then Moving Pedestrian				
Scen #	Initial Position, Yi	Delay Before Moving	Initial Speed	Final Speed
	(m)	(s)	(kph)	(kph)
5	0	1.5	0	10
6	-2	1.8	0	10
7	-4	1.1	0	10

Static Pedestrian	
	(m)
8	0
9	-2
10	-4

Scenario 1 Failsafe Off:
Pedestrian Moves and Stops in Vehicle Path

Scen #	Initial Position, Yi	End Position, Yf	Initial Speed	Final Speed
	(m)	(m)	(kph)	(kph)
1	-7	0	10	0

Scenario 5 Failsafe On:
Pedestrian Starts Static and Moves Out of Vehicle Path

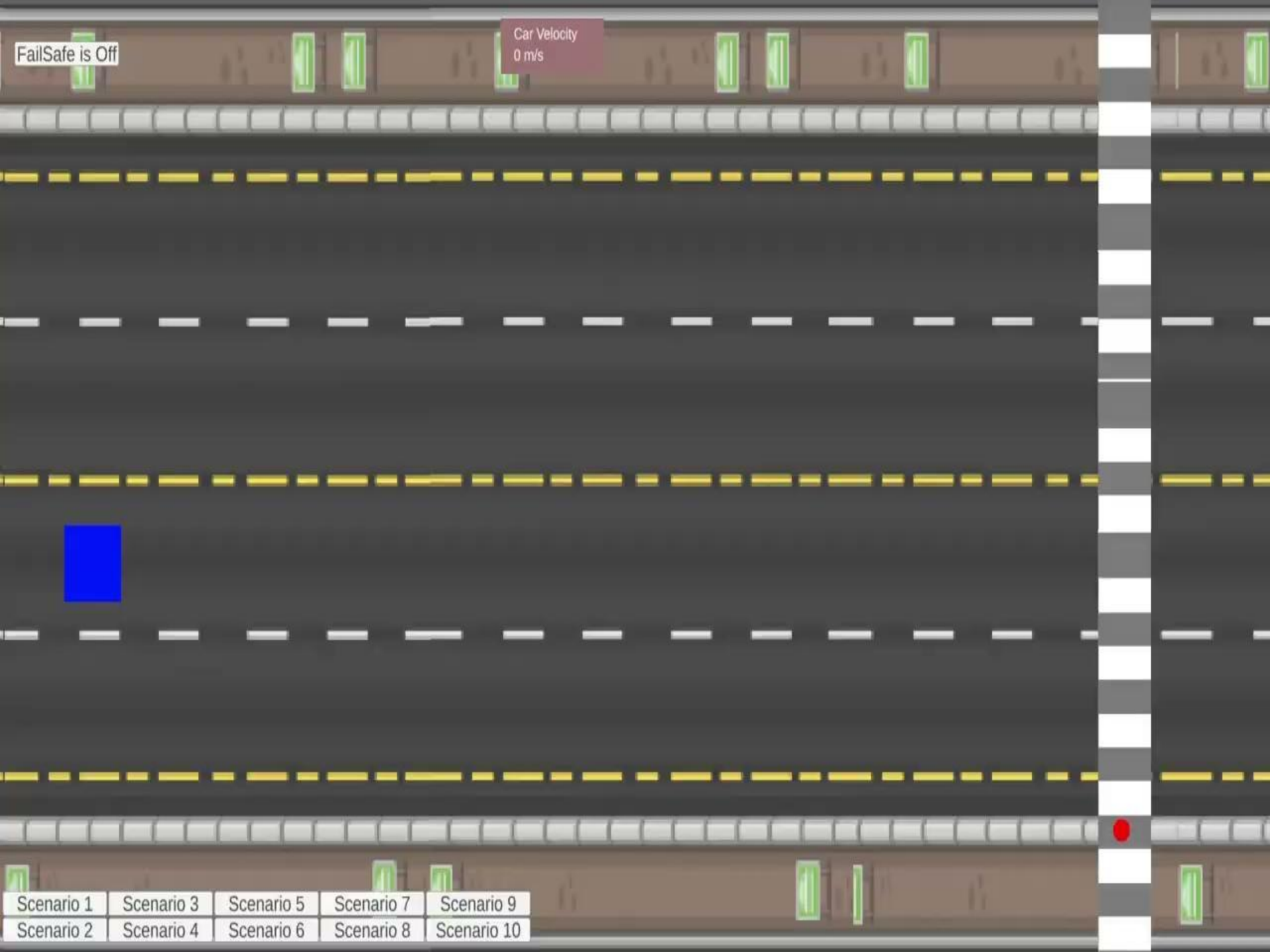
Scen #	Initial Position, Yi	Delay Before Moving	Initial Speed	Final Speed
	(m)	(m)	(kph)	(kph)
5	0	1.5	0	10

Scenario 9 Failsafe On:
Pedestrian Stays Just Out of Vehicle Path

Scen #	Position
	(m)
9	-2

Scenario 10 Failsafe Off:
Pedestrian Stays Out of Vehicle Path

Scen #	Position
	(m)
10	-4


FailSafe is Off
Car Velocity
0 m/s
Scenario 1
Scenario 3
Scenario 5
Scenario 7
Scenario 9
Scenario 2
Scenario 4
Scenario 6
Scenario 8
Scenario 10

Acknowledgements

We express our sincere gratitude and appreciation to our customer, Mr. Chris Capaldi, from Dataspeed Inc.
Thank you!