Software Requirements Specification (SRS)

Project TJA2

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1 Introduction

This document introduces the Traffic Jam Assist (TJA) system, an advanced driver assistance feature that is designed to enhance vehicle control and comfort when in situations where traffic conditions are present. TJA builds upon existing Adaptive Cruise Control (ACC) technology through integration of steering, acceleration, and braking while at low speeds. Using a front-mounted radar, camera sensors, and lane detection modules, TJA assists the driver in maintaining a safe following distance, center the vehicle within the lane, and smoothly start/stop movement as needed based on the flow of traffic. While this system reduces workload in heavy traffic scenarios, it is still a driver-assisted aid, meaning the driver's attention is required at times.

This document details the comprehensive overview of the software requirements, functionality, and the behavior of the TJA system. Throughout the document, we outline the motivations and objectives of the system and identify the functional and non-functional requirements in order to define the operations in which TJA operates. This document details the system architecture, system interaction, dependencies, and any logic that would be considered necessary vehicle behavior in a situation of dense traffic.

1.1 Purpose

The purpose of this Software Requirements Specification (SRS) document is to define any functional, non-functional, and performance requirements related to our TJA system. Through the detailed description of how this system will interact, operate, and integrate with existing systems, we ensure that the TJA system will be developed according to the specifications that support safety, reliability, and comfort of the driver. This document also includes Use Case Diagrams, Object-Oriented Models, Sequence Diagrams, and State Diagrams, with each model providing a different but complementary view of the system. The use case diagrams capture the high-level functional goals of the TJA system, the object-oriented models define its structural components and relationships, the sequence diagrams illustrate step-by-step interactions between system objects during key scenarios, and the state diagrams represent the dynamic behavior and lifecycle of the critical system components. The intended audience of this document are mainly developers and engineers who design, implement, and integrate the software components. Other audiences include the testing and validation teams as well as safety assessors, and stakeholders.

1.2 Scope

The TJA system is a software product developed for the use within modern automotive vehicles that are already equipped with Advanced Driver Assistance Systems (ADAS). The primary objective is to enhance comfort while ensuring safety during low-speed traffic conditions through the automation of control functions such as acceleration, braking, and steering. Our system extends the capabilities of ACC by allowing the vehicle to automatically move, stop, idle, and resume with the traffic flow while maintaining a safe following distance when the speed is below 40 mph[1]. The software executes on the vehicle's ADAS Domain Controller (ADC), which is responsible for processing sensor inputs and coordinating acceleration, braking, and steering commands.

The objective of the development of TJA is to reduce driver workload during dense traffic conditions while increasing safety through consistent spacing and lane positioning. The TJA software will essentially detect vehicles ahead using the radar and camera inputs when maintaining a user-specified following distance and speed limit with the ability to maintain lane centering. TJA will adapt to the acceleration and traffic flow to decide when it is necessary to brake or perform steering adjustments. The system will also alert the driver when manual intervention is necessary and deactivate under specific conditions. One of the limitations of TJA is to operate as a fully autonomous driving system and function outside designated environments or speeds above 40 mph[1]. The second limitation of TJA is that the system will only operate on approved highways.

1.3 Definitions, acronyms, and abbreviations

This section provides clear definitions of the key terms, acronyms, and abbreviations used throughout the SRS to ensure consistent understanding among all readers. These definitions help eliminate ambiguity and ensure accurate interpretation of the functional and non-functional requirements of the TJA system.

ADAS (Advanced Driver Assistance System) : A group of systems that assist drivers via driving and parking functions busting automated technology.

TJA (Traffic Jam Assist) : A driver-assisted feature which automatically controls steering, braking, and acceleration in traffic conditions at low speeds.

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ACC (Adaptive Cruise Control) : A system that automatically adjusts vehicle speed based on vehicles in front of the driver in order to maintain a safe distance.

ABS (Anti-lock Braking System) : Wheel lock prevention during the action of braking and is used by TJA for controlled deceleration.

Radar Sensor: A forward-facing sensor used to measure distance and speed of objects that are positioned in front of the vehicle.

Camera Sensor: An optical device used to detect lane markings, other vehicles, pedestrians, and other objects.

ECU (Electric Control Unit) : A microcontroller responsible for processing sensor data and managing vehicle control systems.

Target Vehicle: The vehicle that is directly ahead which TJA uses as a reference for calculating distance and speed.

Driver Override: A driver controlled action that temporarily disables TJA.

Closing Rate: The rate at which the distance between driver vehicle and target vehicle decreases over time and is used to determine whether to accelerate/brake.

GPS (Global Positioning System) : A satellite based navigation system used to access and confirm approved freeway operations.

OTA (Over-the-Air) : Remote software and map updates to the vehicle system.

1.4 Organization

The remainder of this document is structured as follows. Section 2 introduces the reader to the product perspective, the main functions of the software, the characteristics of the users, and any possible constraints that could affect development of the system. Section 3 enumerates and categorizes all of the functional, non-functional, and security requirements required in our TJA system. Section 4 presents various diagrams and models that depict the structure and operation of our system. These include the use case diagram, domain model, sequence diagrams, and state diagrams. Section 5 describes how to access and run the prototype, outlines any configuration requirements necessary, and any sample scenarios for the vital use cases related to our system's core features. Section 6 lists all sources used throughout this document to describe the system design. Lastly, section 7 provides the project instructor's contact information for any further information related to this project.

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2 Overall Description

The following sections describe at a high level how the TJA works. Section 2.1 contains the context and constraints of the system as well its connection to the bigger system. Section 2.2 summarizes the main functions that the software will perform. Section 2.3 contains the expectations and assumptions of the user. Section 2.4 dives deeper into the system constraints. In section 2.5, key assumptions and dependencies of the system will be addressed. Lastly in section 2.6, apportioning of requirements will be addressed.

2.1 Product Perspective

TJA system is based on the ACC system present in most modern vehicles. It's a level 2 driver assistance that combines ACC and lane centering technologies. TJA works by allowing, on a limited number of highways, the ability to adjust to the vehicle in front when it stops or slows down. If the vehicle in front starts again, then the vehicle with TJA will also start up and follow, controlling the closing rate.

From the user's perspective, all of the interactions and communication with the system are done through the steering wheel and the dashboard. The driver can engage the TJA system by pressing the ACC switch on the steering wheel, which is also used to set speed and, in some cases, the closing distance for TJA. All of the alerts from the system are shown in the dashboard, including set speed, distance, and alerts when the system will disengage.

Regarding the interface of the system, TJA interacts with different subsystems such as acceleration, braking and the ACC system, which allows the vehicle to cruise at a set speed on a highway. It communicates with the braking system to apply controlled deceleration and overrides its system when a collision is imminent. TJA communicates with the steering wheel system to allow lane centering assist. The system is heavily integrated with different systems of the vehicle, on a high level TJA utilizes front facing radars, as well as a front facing camera located underneath the rearview mirror. Front radar helps the vehicle computer determine the speed and distance of the vehicle ahead, while the camera assists to identify lane markings[1]. The TJA system also requires a GPS sourced from the server but that caches data locally to determine whether the vehicle is on an acceptable road for TJA. Updates on the GPS are delivered through OTA.

TJA utilizes the inputs gathered for ACC and expands the use to allow more automation. While ACC allows high speeds, TJA is limited to 40mph[1] and when the driver brakes, it will shut off not only TJA but also ACC. Another system heavily used for TJA is the Lane Assist System. Typically, the Lane Assist uses side mounted radar to identify the lane markings and warns and corrects the driver if the vehicle starts to drift.

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2.2 Product Functions

The high level goal of the TJA system is to assist the driver on highways to operate the vehicle at slow speeds during traffic jams. The system assists the driver by changing the speed according to the traffic flow and the vehicle in front.

During typical use, the vehicle relies on GPS to determine whether it is traveling on an approved highway, and if so, after pressing the button on the steering wheel TJA will be active. Once active, the system uses its sensors and cameras to detect lane markings and identify vehicles ahead. If the vehicle in front slows down, TJA will activate the braking system and reduce speed to maintain the selected closing distance. When traffic begins moving again, the system will resume to speed up to the maximum set limit as long as the vehicle in front allows. When TJA is engaged, lane assist will keep the vehicle centered and will correct the steering wheel if the vehicle is drifting unless turning lights are on.

The diagram below illustrates the high level goal and functions of the TJA system. The oval represents the goal of the system, the rectangles show the 3 main functions needed to achieve the goal. Under each rectangle, the downward arrows list the detailed steps for each sub-function.

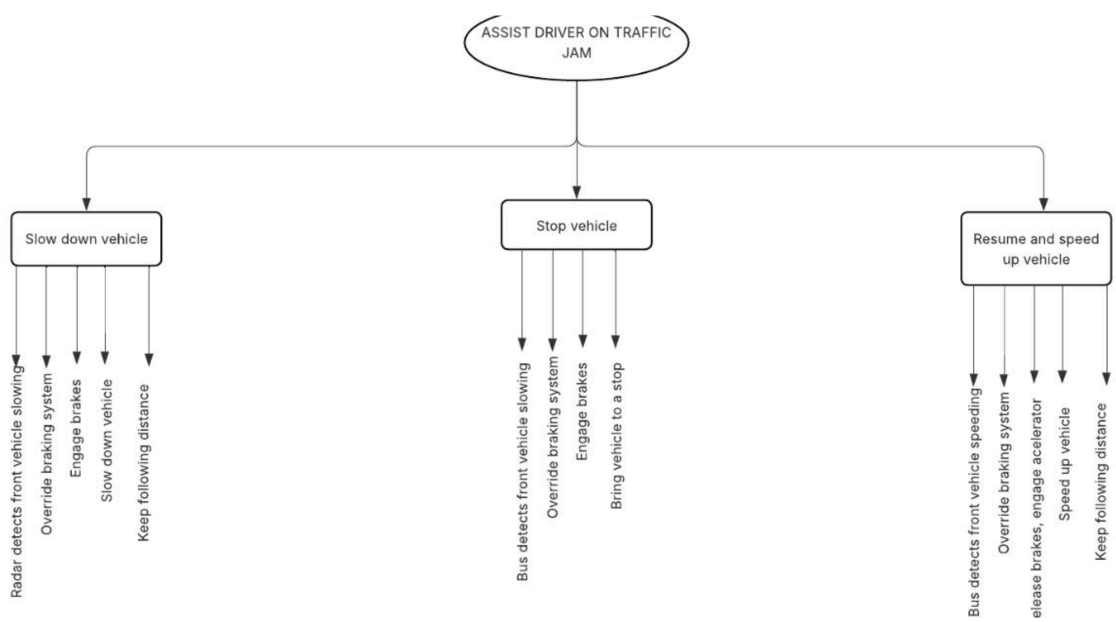

Figure 1: High level goal diagram

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2.3 User Characteristics

The driver is the main user of the system and does not require extensive knowledge of it. Although the system provides assistance, the driver maintains control over the vehicle. Drivers should be licensed and should drive following laws of their area. The user must be able to read street signs, and if required, the driver can have aids like glasses. The user is expected to understand that the system does not make the vehicle drive autonomously and is only an aid for the driver. As a result, the driver must remain alert and ready to take control of the vehicle.

2.4 Constraints

The following are some general constraints for the TJA system. Country regulations (ie. NHTSA requirements for the United States), limitations for hardware dependencies such as radar and camera. The system must take into consideration possible limitations of the hardware, like visibility of camera and radar under tough weather conditions. The TJA system should not be used on tough weather conditions such as rain, snow and hail.

Other constraints for the TJA system involve ADAS calibration. The sensors for the vehicle must be properly calibrated to ensure accuracy of the TJA system. Failure in calibration of these means the system will not be able to operate correctly and might cause false positives and/or false negatives which can both lead to accidents[1].

Regarding safety-critical properties for the system and the vehicle. The primary features are working airbags, a working anti lock braking system, electronic stability control system and a forward collision warning system as well as working sensors and camera. All of the properties mentioned above are crucial for the system to work properly, and if under any circumstances these properties are violated, TJA will immediately deactivate and alert the driver.

2.5 Assumptions and Dependencies

For the TJA system, the vehicle is assumed to have a working analogue braking system and acceleration. The system must also have the following sensors and hardware: a rear view camera, lane dividing camera, throttle position sensor, wheel speed sensors, and an Electric Control Unit (ECU) responsible for processing speed sensor information and cycling brake pressure[2]. It is also assumed that the vehicle's GPS is up to date on the roads that allow TJA and that the system follows NHTSA vehicle safety guidelines, which emphasize system safety, operational design domain, object and event detection response, validation methods, and vehicle cybersecurity[4].

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2.6 Apportioning of Requirements

In the future, the TJA system may evolve to include requirements left out of this prototype to prevent the scope of the project from growing out of hand. Later versions can incorporate AI capabilities into the system. If the vehicle is equipped with a front view camera, AI can allow for target recognition and enhanced lane verification. AI can also be used to recognize street signs. Future versions of TJA can also support driver monitoring features to make sure the driver is engaged at all times. This feature can include eye-tracking sensors and randomized steering wheel interaction checks to ensure that the driver is alert, and ready to take control when needed. The system may also evolve to support use on non highway roads and eventually enable fully autonomous driving.

3 Specific Requirements

1. The Traffic Jam Assist system shall activate when the TJA ON button is pressed
   1.1. When the system is activated, the dashboard shall indicate to the driver that the system is on by displaying a TJA ON icon
2. The system shall by default set the maximum vehicle speed to be the current speed and set the maximum following distance to be the shortest of the three options (short, medium, and long)
   2.1. The vehicle shall not surpass the speed set by the driver at any time
3. The TJA system shall be deactivated when the TJA button on the steering wheel is pressed while the TJA system is activated, or when the brake pedal is pressed.
4. The maximum vehicle speed and the maximum following distance shall be able to be adjusted with buttons on the steering wheel
5. The Traffic Jam Assist system shall use the vehicle’s front-facing camera to keep the vehicle centered in its lane.
   5.1. If the vehicle drifts away from the center line of the lane, a visual alert shall be displayed on the console and Traffic Jam Assist system shall recenter the vehicle by manipulating the steering wheel.
      5.1.1. The TJA system shall induce a 20N force on the steering wheel when aiding the driver in steering, unless the turn signal is activated
6. If the target vehicle is within the set following distance and is not moving forward, the vehicle shall come to a stop.
7. If the target vehicle is moving slower than the vehicle, the vehicle shall slow only as much as is needed to maintain the set following distance from the target vehicle.
8. If the target vehicle is not moving forward and then begins moving forward, the vehicle shall accelerate as much as possible while maintaining the set following distance from the target vehicle.
9. A visual alert shall be displayed on the console if the Traffic Jam Assist system detects that lanes are not visible
10. The Traffic Jam Assist system shall only activate on approved highways.

10.1. If the Traffic Jam Assist system is active when the vehicle enters a non-approved area, visual and audio alerts shall be given to the driver and then the Traffic Jam Assist system shall deactivate.

11. Provide status on the overhead dash and enable/disable alerts for vehicles when TJA is active.

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4 Modeling Requirements

This section outlines multiple models which describe the TJA system. This includes Use Case Diagrams, Object Oriented Models, Sequence Diagrams, and State Diagrams. Each diagram is described in detail and uses Unified Modeling Language notation.

4.1 Use Case Diagram

The use case diagram below describes all the major use cases in our system. The actors include driver, road, and the vehicle in front that are shown in the diagram as stick figures. The actors are placed outside of the blue system boundary. Each actor plays a role in the system and has use cases that interact with other actors. Use cases are connected using dotted arrows. Below the diagram is a series of tables which further describes each use case and their relationships.

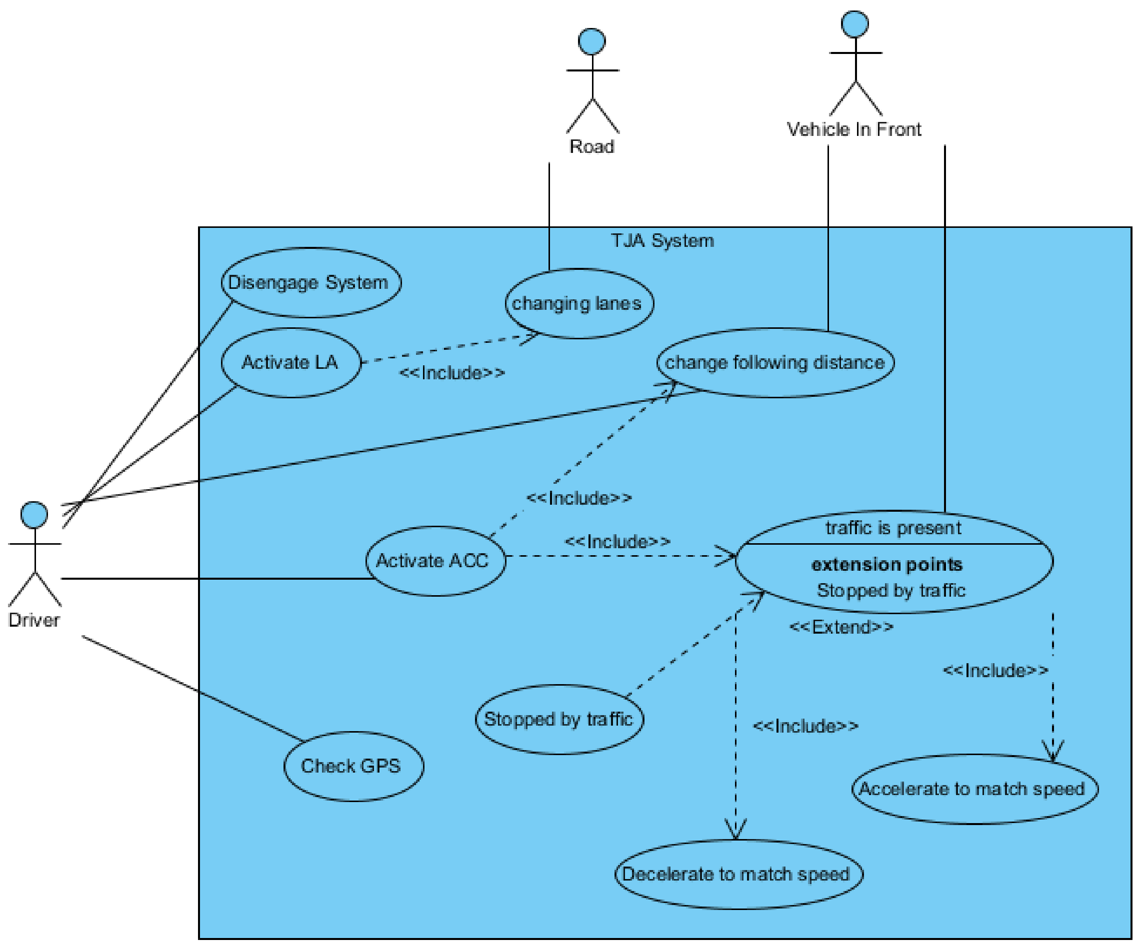

Figure 2: Use Case Diagram

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Use Case:	Activate LA
Actors:	Driver
Description	The driver turns on TJA and the lane assist turns on. The system then keeps the vehicle centered in the lane
Type:	Primary (essential)
Includes:	Changing lanes
Extends:	
Cross-refs:	5, 5.1, 5.1.1
Use cases:	Changing lanes

Use Case:	Disengage system
Actors:	Driver
Description	When the driver signals the system to shut off, the system will turn off and defer control back to the driver
Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	3
Use cases:	

Use Case:	Changing Lanes
Actors:	Driver, Road
Description	Changes the lane when turn signal is activated

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Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	5.1
Use cases:	Changing lanes

Use Case:	Activate ACC
Actors:	Driver
Description	When the driver activates the TJA system the ACC will engage and the speed will be set to the current speed and the distance is set to the max
Type:	Primary (essential)
Includes:	Change following distance, traffic is present
Extends:	
Cross-refs:	2, 2.1
Use cases:	Vehicle Slowing Down Due to Traffic, changing speed

Use Case:	Check GPS
Actors:	Driver
Description	When the driver activates the TJA system the GPS will ensure the vehicle is on an accepted freeway.
Type:	Primary (essential)
Includes:	

Extends:	
Cross-refs:	10, 10.1
Use cases:	Driving off approved freeway

Use Case:	Change following distance
Actors:	Driver, vehicle in front
Description	When the driver activates the TJA system the ACC will engage and the speed will be set to the current speed and the distance is set to the max. The driver can press one of the different following distance buttons changing how far away the vehicle is from the vehicle in front
Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	2, 4
Use cases:	Changing speed

Use Case:	Vehicle in front has fluctuating speed
Actors:	Vehicle in front
Description	The vehicle in front slows down due to traffic
Type:	Primary (essential)
Includes:	Decelerate to match speed, Accelerate to match speed
Extends:	Stopped by traffic

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Cross-refs:	6, 7, 8
Use cases:	Vehicle Slowing Down Due to Traffic

Use Case:	Stopped by traffic
Actors:	System
Description	The vehicle stops due to traffic stopping
Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	6
Use cases:	Vehicle Slowing Down Due to Traffic

Use Case:	Accelerate to match speed
Actors:	System
Description	Engage the engine to match a speed faster than the speed the car is currently moving
Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	8
Use cases:	Vehicle Slowing Down Due to Traffic, changing speed

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Use Case:	TJA is activated and deactivated
Actors:	Driver
Description	The driver presses the TJA button on an approved freeway and then presses the same button again providing visual and audio alerts
Type:	Primary (essential)
Includes:	
Extends:	
Cross-refs:	1, 1.1, 3, 10, 11
Use cases:	Vehicle Slowing Down Due to Traffic

4.2 Domain Model

Figure 3 below shows an object-oriented model, or domain model, for our Traffic Jam Assist system. It uses UML class diagram notation for operations and attributes. For example, the ACC class has attributes such as engaged and operations such as closingRate(). The diagram shows various relationships between classes. Lines with hollow diamonds indicate aggregation relationships, where one class contains others as parts. For instance, the TJA system aggregates components like the ACC, LA, and On/Off Button. Simple lines between classes represent associations, indicating communication and interaction between components. The Camera associates with LA to keep the vehicle centered in the lane, while the ACC associates with both the Accelerator and ABS for vehicle control. Each class in the diagram is detailed in the accompanying data dictionary, which comprehensively describes the class's purpose, attributes, operations, and relationships.

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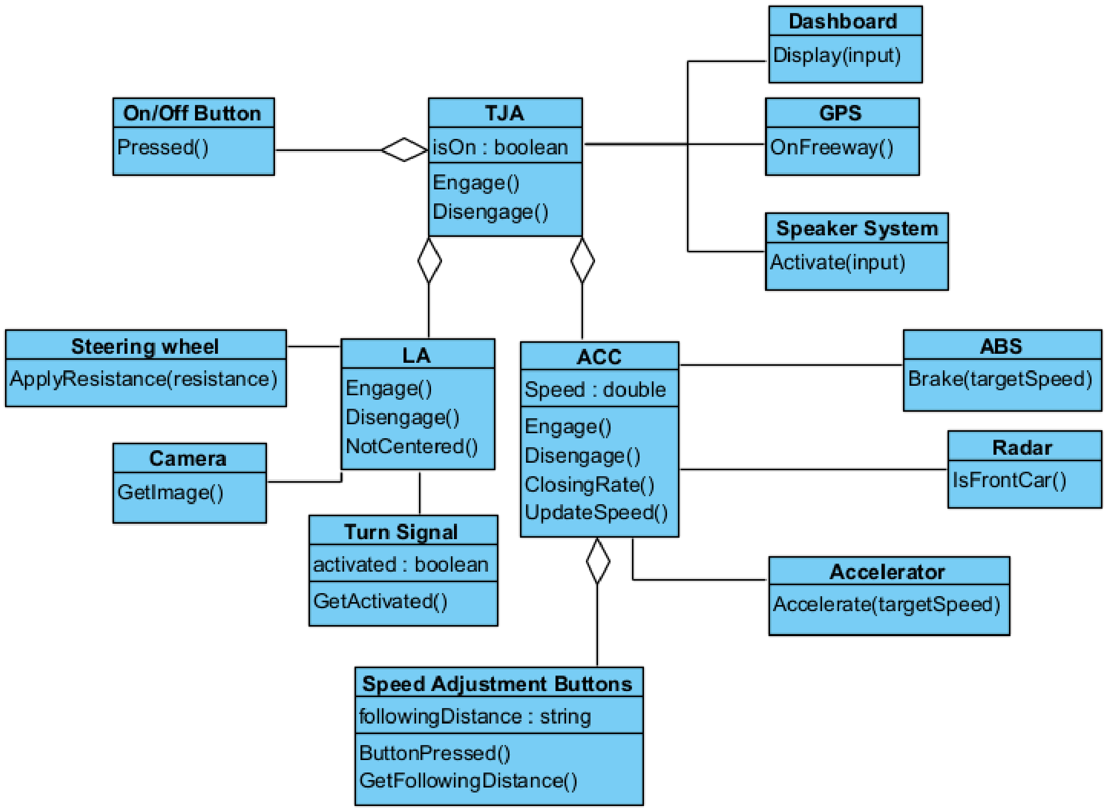

Figure 3: Domain Model for TJA System

Element Name		Description
ABS		Activates the brakes in the vehicle when pressed by the operator. Also disengages the TJA System for the vehicle when pressed
Attributes		
Operations		
	Brake(targetSpeed)	Activates the brakes until the car reaches its desired speed
Relationships	ACC: Association, the ABS system is activated by the ACC system	
UML Extensions		

Element Name		Description
ACC		Controlls the Accelerator and the ABS systems based upon the information from the Radar and Speed Adjustment Buttons
Attributes		
	Speed:double	Current speed of the vehicle
Operations		
	ClosingRate()	Calculates the closing rate to the vehicle ahead
	Disengage()	Deactivates the system
	Engage()	Activates the system
	UpdateSpeed()	Updates the speed of the vehicle
Relationships	ABS: Association, the ACC system activates the ABS system	
	Accelerator: Association, provides the Accelerator with the target speed	
	Radar: Association, radar provides information about the vehicle ahead to ACC	
	Speed Adjustment Buttons(SAB): Aggregation, the SAB provides the ACC with the current desired following distance from the vehicle ahead	
	TJA: Aggregation, The TJA system engages and disengages the ACC system	
UML Extensions		

Element Name		Description
Accelerator		Increases the speed of the vehicle
Attributes		
Operations		
	Accelerate(targetSpeed)	Accelerates the vehicle until the vehicle reaches the target speed
Relationships	ACC: Association, the Accelerator system is activated by the ACC system	
UML Extensions		

Element Name		Description
Camera		Obtains an image of the road ahead
Attributes		
Operations		
	GetImage()	Obtains an image of the road ahead
Relationships	LA: Assocation, Provides the LA system with the image for processing lane centering	
UML Extensions		

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Element Name		Description
Dashboard		Displays given inputs to the driver on a screen above the steering wheel
Attributes		
Operations		
	Display(input)	Displays the input to the driver
Relationships	TJA: Association, The TJA provides input to the Dashboard	
UML Extensions		

Element Name		Description
GPS		Finds the vehicle's location
Attributes		
Operations		
	OnFreeway()	Determine's if the vehicle is on an approved freeway
Relationships	TJA: Association, The GPS indicates if the vehicle is on an approved freeway. If true the TJA system can then activate	
UML Extensions		

Element Name		Description
LA		Aids the driver in keeping the vehicle within the center of the lane
Attributes		
Operations		
	Disengage()	deactivates the system
	Engage()	activates the system
	NotCentered()	Using an image obtained from the Camera GetImage() the LA will call ApplyResistance(resistance) in steering wheel unless Turn Signal GetActivated() returns True
Relationships	Camera: Association, LA obtains the image for lane centering using GetImage()	
	Steering wheel: Association, LA calls ApplyResistance(resistance) when attempting to center within the lane	
	TJA: Aggregation, LA is activated and owned by the TJA system	
	Turn Signal: Association, LA uses GetActivated() to determine whether or not to apply resistance to the steering wheel	
UML Extensions		

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Element Name		Description
On/Off Button		A button, when pressed, will activate or deactivate the TJA system
Attributes		
Operations		
	Pressed()	Activated by the driver and will activate the TJA system if it is deactivated and will deactiavte the TJA system if it is activated
Relationships	TJA: Aggregation, On/Off Button activates and deactivates the TJA system	
UML Extensions		

Element Name		Description
Radar		Obtains information about the vehicle ahead if there is one
Attributes		
Operations		
	IsFrontCar()	Determines if there is a car ahead and what the following distance is
Relationships	ACC: Association, Provides the ACC system with the information collected	
UML Extensions		

Element Name		Description
Speaker System		Makes sounds based upon a provided input
Attributes		
Operations		
	Activate(input)	Makes the sound of the given input
Relationships	TJA: Association, TJA system provideds the Speaker system with inputs	
UML Extensions		

Element Name		Description
Speed Adjustment Buttons		Allows the driver to adjust the speed of the vehicle and the following distance of the vehicle
Attributes		
	followingDistance:string	the current following distance from the vehicle ahead
Operations		
	ButtonPressed()	Determines what button the driver pressed and follows out that action
	GetFollowingDistance()	Outputs the current set following distance
Relationships	ACC: Aggregation, Speed Adjustment Buttons is owned by the ACC system and provides it with the information about the buttons that were pressed	
UML Extensions		

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Element Name		Description
Steering wheel		Controls the direction in which the vehicle will move
Attributes		
Operations		
	ApplyResistance(resistance)	Applies the given resistence to the steering wheel in degrees based upon the vertical axis, Left being negative and right being positive
Relationships	LA: Association, the LA system calls the ApplyResistance(resistance) function	
UML Extensions		

Element Name		Description
TJA		TJA system aids the driver in high traffic situations on approved freeways by allowing the usage of the ACC and LA systems under their minimum speed requirement of 25mph
Attributes		
	isOn:boolean	returns True if activated and False if deactivated
Operations		
	Engage()	Activates the system and the LA and ACC system
	Disengage()	Deactivates the system and the LA and ACC systems
Relationships	ACC: Aggregation, ACC is owned by TJA and relies on it to activate and deactivate	
	Dashboard: Association, TJA calls the Display(input) function in Dashboard	
	GPS: Association, GPS allows TJA to be activated if on an approved freeway	
	LA: Aggregation, LA is owned by TJA and relies on it to activate and deactivate	
	On/Off Button: Aggregation, TJA owns this class and the class provides information on whether to activate or deactivate	
	Speaker System: Association, TJA calls Activate(input) to notify the driver	
UML Extensions		

Element Name		Description
Turn Signal		Indicates that the vehicle will be turning or changing lanes
Attributes		
	activated:boolean	True if the turn signal is activated and False if not
Operations		
	GetActivated()	Getter for the activated boolean
Relationships	LA: Association, LA uses the GetActivated() function	
UML Extensions		

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4.3 Sequence Diagrams

In this section, many sequence diagrams will be presented to further describe how certain scenarios are handled within our system. The large blue boxes with dotted lines are objects in our system and their life lines. The arrows between the dotted lines represent messages between objects in order in which they occur, most recently being the highest on the diagram. Loops are shown by boxes around messages and messages may have guards, shown in brackets, which are conditions which must be checked before continuing.

Figure 4 describes a scenario where the driver adjusts the following distance of the vehicle causing the ACC to accelerate or decelerate. The driver initially presses a button decreasing the following distance, but increasing the speed. Then the driver presses the a button increasing the following distance, which decreases the speed of the vehicle.

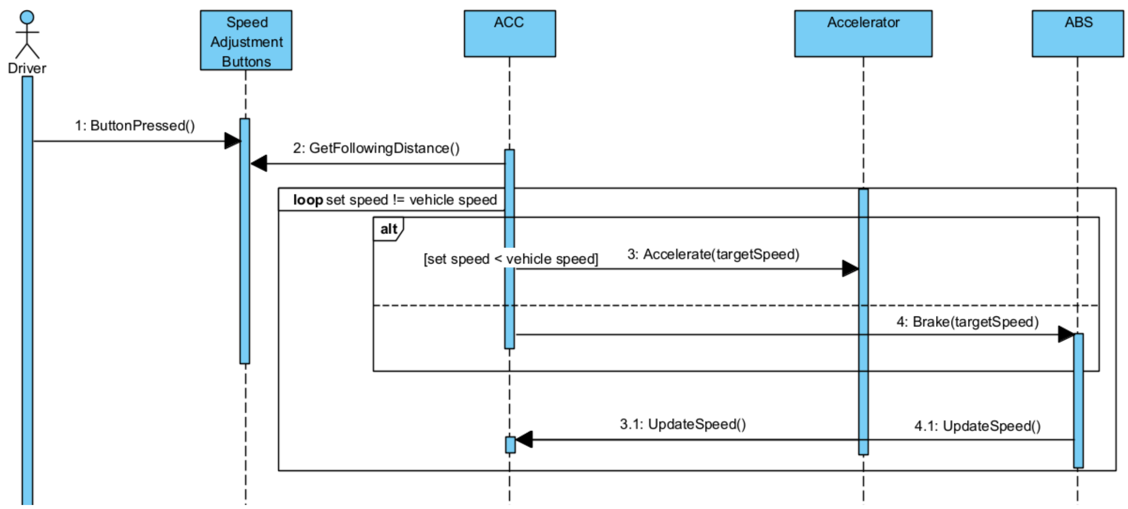

Figure 4: Sequence Diagram for following distance adjustment

Figure 5 describes a scenario where a crash is unavoidable. When the radar detects that the target vehicle is closing rapidly, it will read the speed and distance and cut the throttle and engage the brakes. The vehicle will slow down as fast as possible while TJA is disabled for driver control until vehicle speed is updated.

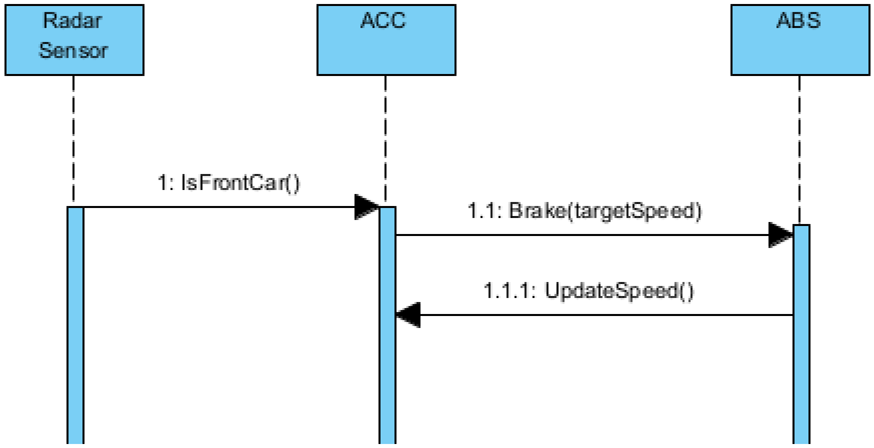

Figure 5: Sequence Diagram for an Unavoidable Crash

Figure 6 describes how the system would act when the vehicle changes lanes. When the driver changes lanes, the camera notifies Lane Assist. Lane Assist checks if turning lights are on. If they are on, the steering wheel will have no resistance. If turning lights are off the steering wheel will have resistance.

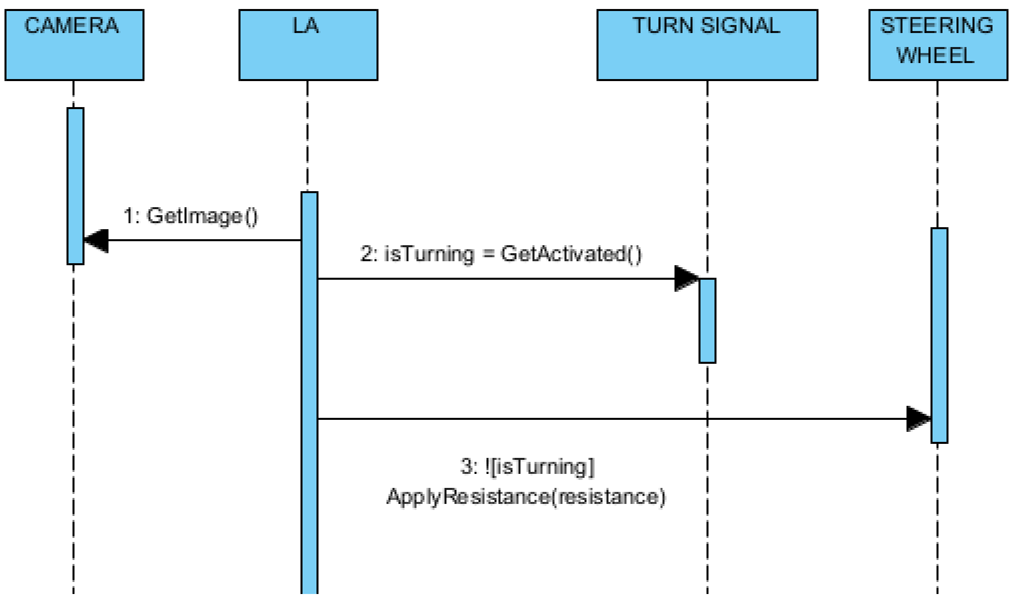

Figure 6: Sequence Diagram for Changing Lanes

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at msu.edu)

Figure 7 describes a scenario where TJA is activated and there is a vehicle in front. The system calculates the closing rate and slows down due to the vehicle in front speed being slower than the vehicle's speed.

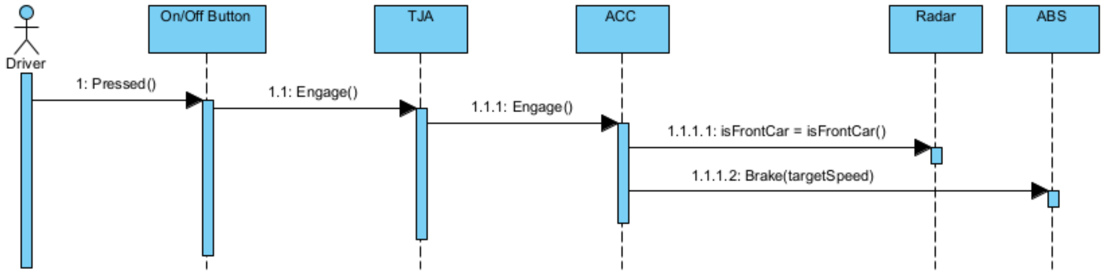

Figure 7: Sequence Diagram for Vehicle Slowing Down Due to Traffic

Figure 8 describes a scenario where the driver activates the TJA and drives off the highway disengaging the system. The scenarios include the display and sound notification for engaging and disengaging the system.

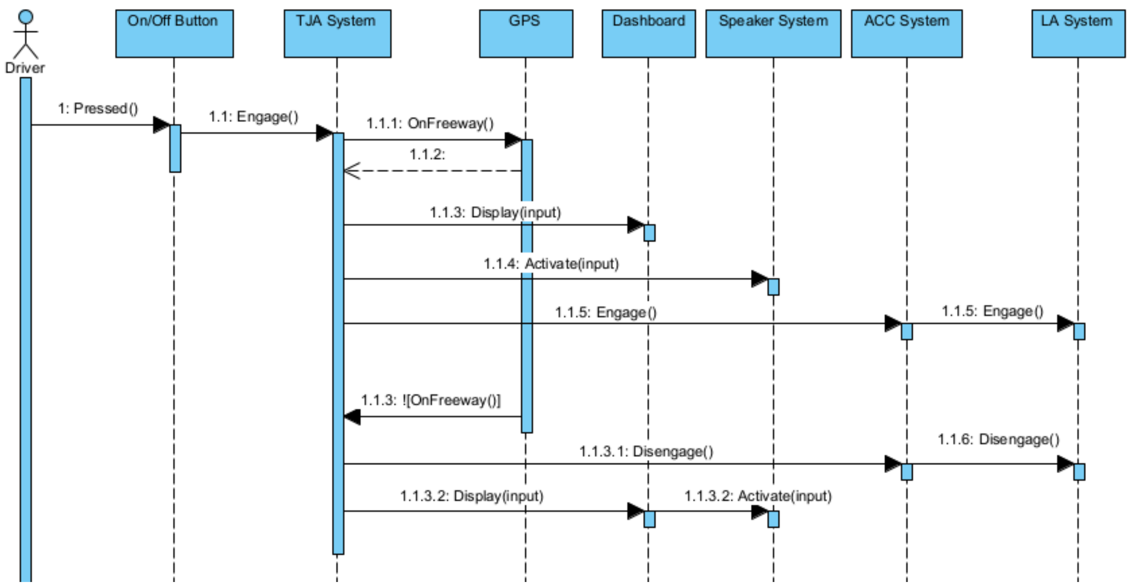

Figure 8: Sequence Diagram for TJA disengage due to leaving approved freeway

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at msu.edu)

4.4 State Diagram

This section will contain state diagrams which describe how different components of our system move from state to state. In the following state diagrams, states are represented by the blue rectangles and transitions between states are denoted by arrows. The text on the arrows is the trigger that causes states to change.

In figure 9, the GPS system notifies the TJA system that the vehicle has left an approved freeway causing the TJA system to shut down. The system is idle until pressed on. The GPS checks if the vehicle is on an approved freeway. When so, TJA is activated and continues following the vehicle ahead. Once the vehicle changes lanes the GPS is checked again and if the vehicle leaves the approved freeway the TJA system disengages.

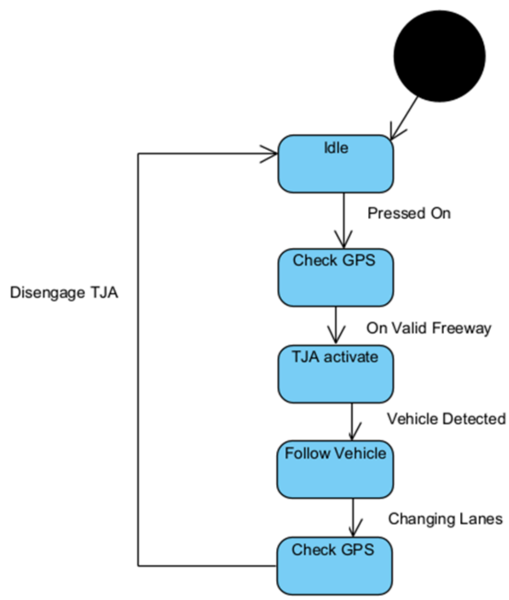

Figure 9: State Diagram for TJA disengage due to leaving approved freeway

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at msu.edu)

In figure 10, it describes how the braking system works when there is an unavoidable crash. The TJA system is activated and detects a vehicle rapidly approaching. Then the ABS system is engaged braking and giving the driver more control over the vehicle.

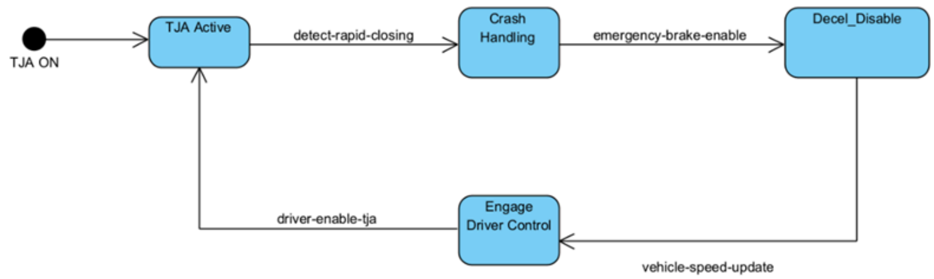

Figure 10: Sequence Diagram for an imminent crash

In figure 11, it describes how the system reacts to speed changes. After the target speed is set the system determines if the speed is at the target speed, if not the vehicle will accelerate or decelerate. When the target speed is reached the end state is achieved.

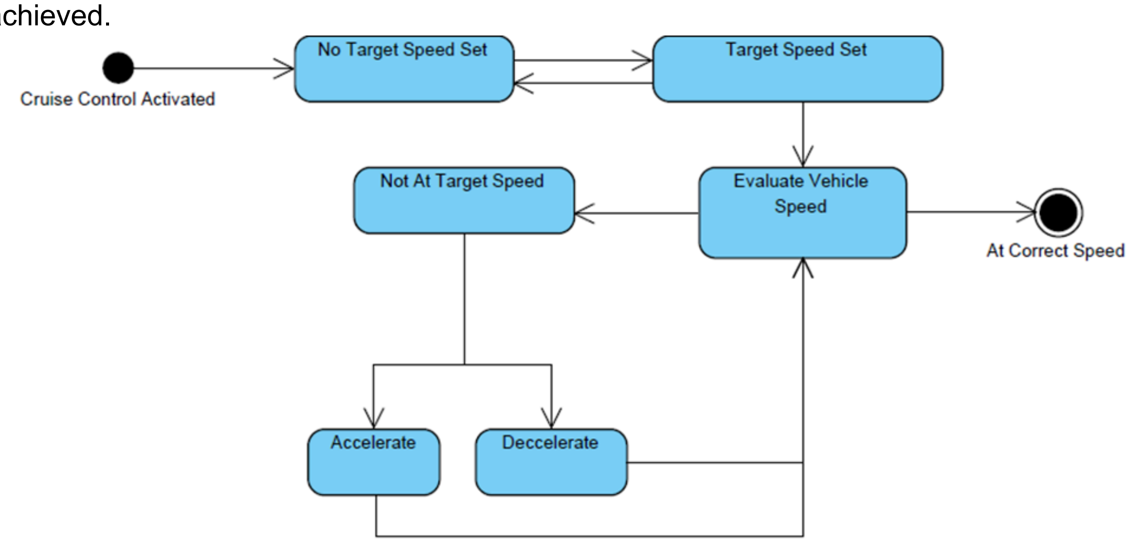

Figure 11: State Diagram for speed changes

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In figure 12, it describes lane changing using the LA system. Once the driver starts changing lanes, if the driver activates the turn signal the system will allow the lane change, but if the turn signal is not activated the system will apply an opposing force onto the steering wheel.

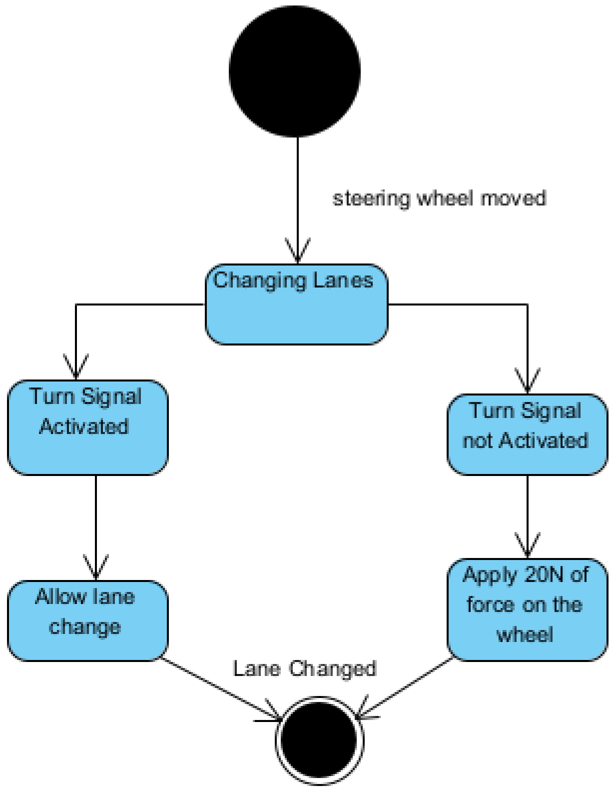

Figure 12: State diagram for changing lanes

5 Prototype

Our prototype is a WebGL build of a Unity application that allows users to control a vehicle in third person and travel along multi-lane road scenes that showcase several use cases of the TJA2 system. Users are able to signal lane changes and toggle lane assist, as well as toggle and adjust cruise control. In addition, the following three distances for the ACC subsystem are able to be set. These are all visible on a mock dashboard UI.

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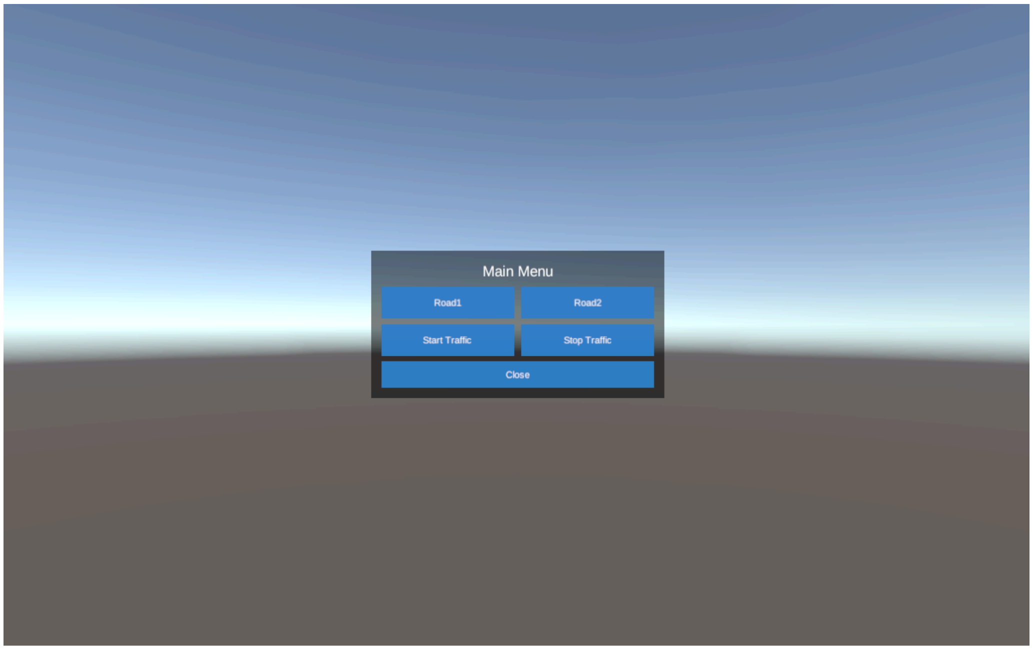

Figure 13: Prototype Main Menu

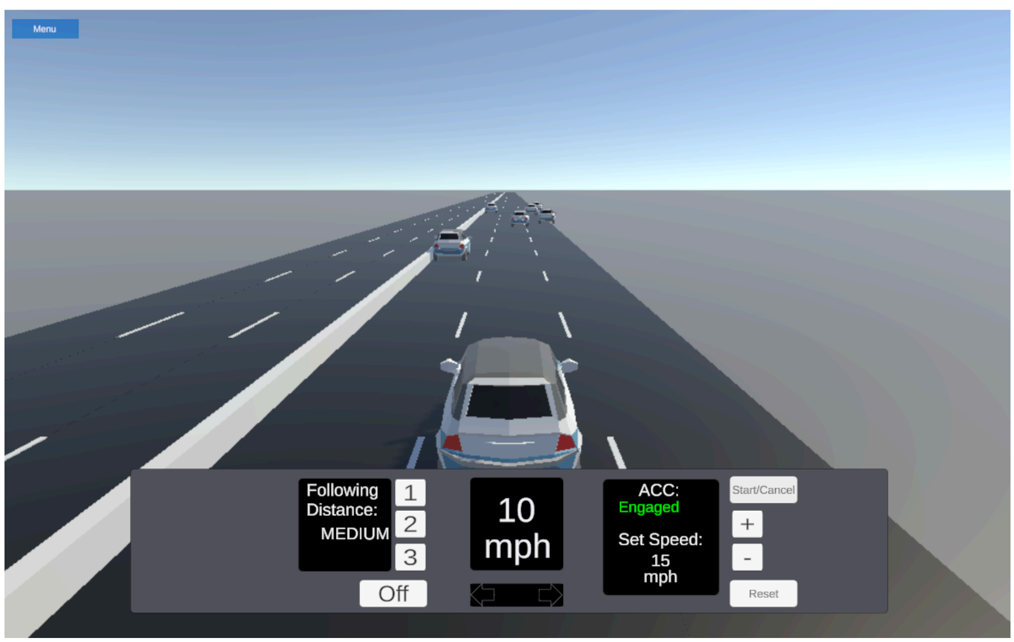

Figure 14: Using TJA2 in moving traffic

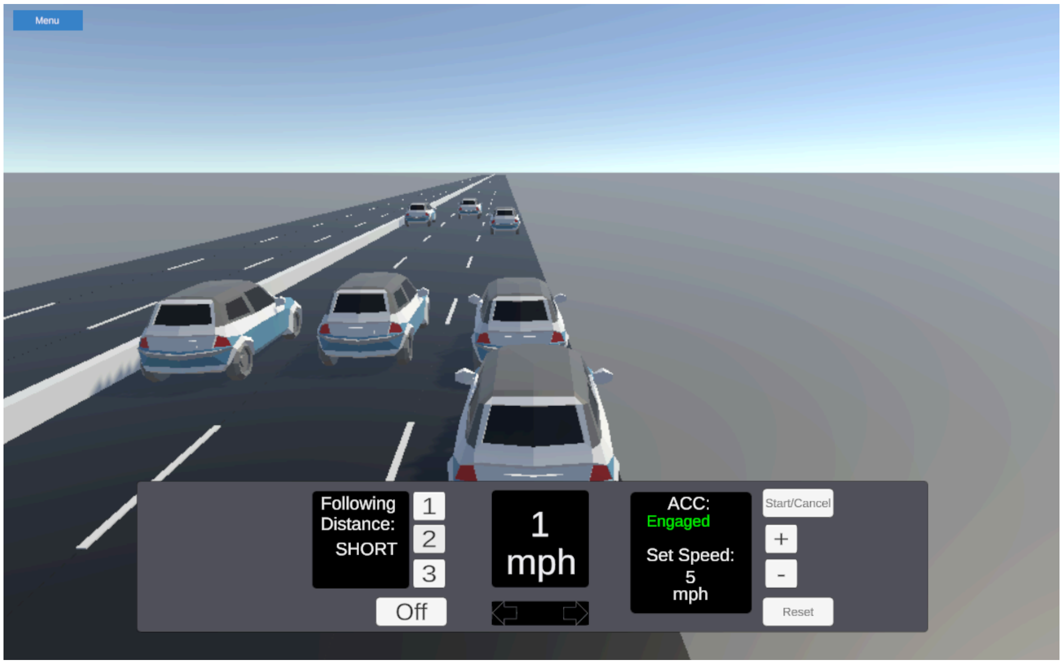

Figure 15: Using TJA2 in stopped traffic

5.1 How to Run Prototype

The prototype is embedded and hosted on our TJA2 website, and must be accessed on a recent desktop version of Firefox, Chrome, Edge, or Safari. The most recent prototype is available at the following URL: https://www.egr.msu.edu/cse435/tja2/prototype/.

It may take longer to load on devices with lower amounts of RAM, showing a black screen until properly loaded. Users can accelerate and decelerate with the "W" and "S" keys, respectively, and steer with the "A" and "D" keys. Turn signals can be activated with the "Q" and "E" keys. All dashboard modules can be interacted with via mouse clicks and shall function as specified in project requirements.

5.2 Sample Scenarios

The sample scenarios shown by the prototype will show the vital use cases of the TJA2 software. These consist of getting stopped in traffic, driving through normal traffic, and reacting to an imminent crash. They will include the implementation of established systems like ACC and lane assist.

6 References

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[2] Hawley, Dustin. "What Is a Front Wheel Speed Sensor?" *Jdpower.com*, J.D. Power, 2023, www.jdpower.com/cars/shopping-guides/what-is-a-front-wheel-speed-sensor.

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7 Point of Contact

For further information regarding this document and project, please contact **Prof. Betty H.C. Cheng** at Michigan State University (chengb at msu.edu). All materials in this document have been sanitized for proprietary data. The students and the instructor gratefully acknowledge the participation of our industrial collaborators.