Software Requirements Specification (SRS)
Project APA3

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1 Introduction

Active Parking Assist (APA) is a system that adds a capability to vehicles to be able to identify a nearby valid parking location and successfully park the vehicle in the location identified within a general time frame without the assistance of the driver. APA makes use of sensors to analyze its surroundings and use this information to park the car as well as adapt to any situation that occurs during the parking process.

To achieve this, there will be many important topics that must be covered such as the requirements, functionality, dependencies, and constraints of the system to be able to show all of the required parts of creating an APA system. Various models and diagrams will be included to allow for more detailed insight into what must be done to create a working APA system as well as a prototype to put a visual on how it should behave and adapt to certain situations. The APA system contains sensors that control and communicate with the vehicle in a way that allows for it to be successfully parked without assistance of the driver.

1.1 Purpose

The purpose of the document is to provide specifications for the APA system in both visual and written form in a way such that it is easily understandable and also satisfies the customer's requirements. The document will serve as a clear guide for designing and implementing the system. The document is intended for both developers and stakeholders alike. Developers will be able to fully understand the APA system before beginning to design and implement the system while the stakeholders will be able to understand all of the aspects of the system in an easy to digest format.

1.2 Scope

APA is a system that is embedded in an automotive vehicle and its primary objective is to successfully park the vehicle. However, while doing this it will also avoid/prevent collisions, damages, and injuries to anyone or anything surrounding the vehicle while parking. The APA system will adapt to any situation that occurs while the vehicle is parking and will prevent any form of collision or damages from occurring while using this feature, however this is what the system is limited to, as it won't undo the parking of the car or do anything else related to driving the vehicle.

1.3 Definitions

- **APA:** Active Parking Assist
- **Obstacle:** Anything the vehicle can collide with while performing the parking process. Examples of this include cars, pedestrians, buildings, and more.
- **Sensor:** Cameras that scan the surrounding area of the vehicle, allowing it to perform the parking process in the correct location while avoiding any form of collision or damage.
- **HMI:** The Human-Machine Interface in the car that allows the driver to interact with the APA system
- **MPH:** Miles per hour

1.4 Organization

The remainder of the document is organized as follows. Section 2 describes the APA system as well as how it functions and the characteristics of the system. Next, section 3 lists the specific requirements for the APA system and details everything that will be needed in order for the system to successfully park. Section 4 includes diagrams and models for the APA system and descriptions that show the system in more detail. Section 5 demonstrates the APA system in a more visual and functional manner by utilizing a prototype created in unity. Section 6 contains references used to create the document as well as links to the group website which also contains the prototype. Lastly, section 7 contains the contact information for the instructor of the course for which this document is being created.

2 Overall Description

This section describes the APA system in detail. Section 2.1 will introduce the product perspective describing the context of the APA system and identify any constraints within the system. Section 2.2 will outline the product functions by summarizing the major functions the APA system will perform. Section 2.3 will focus on the user characteristics specifying expectations about the user. Section 2.4 elaborates more on constraints within the system. Section 2.5 will focus on the assumptions and dependencies, predominantly the assumptions made about the hardware, software, environment, and user interactions. Lastly, section 2.6 will conclude with a proportioning of requirements.

2.1 Product Perspective

The APA system's main goal is to eliminate the stress the driver endures when parking their vehicle. The system also aims to eliminate driver error and ensure that the vehicle desired maneuvers can be carried out in an accurate and safe manner. The system implements autonomous driving by using pre-existing technology already available to the vehicle. The system allows the vehicle to automatically park itself in either a parallel or perpendicular parking space. The APA system is a safety critical system and every design choice keeps this in mind.

The APA system cannot exist independently as its a subsystem of the vehicle relying on a number of other subsystems. The Human Machine Interface (HMI) system accepts input from the driver, displaying the camera feed with additional information, and handles telltales/warnings. Information gathered from the HMI system is accepted by the Park Control Subsystem (PCS) which masters the APA system.The PCS accepts information from the Brake Control Subsystem (BCS), Steering Control Subsystem (SCS), and Powertrain Management Subsystem (PMS) to aid the APA system with parking maneuvers. The PCS also uses the Vehicles Positioning Subsystem (VPS) to verify vehicle position throughout the duration of a parking event. The VPS processes data from the vehicles camera and radar hardware to calculate the vehicle’s current trajectory. The driver is also allowed to control the parking maneuver remotely via the Ford Pass application.

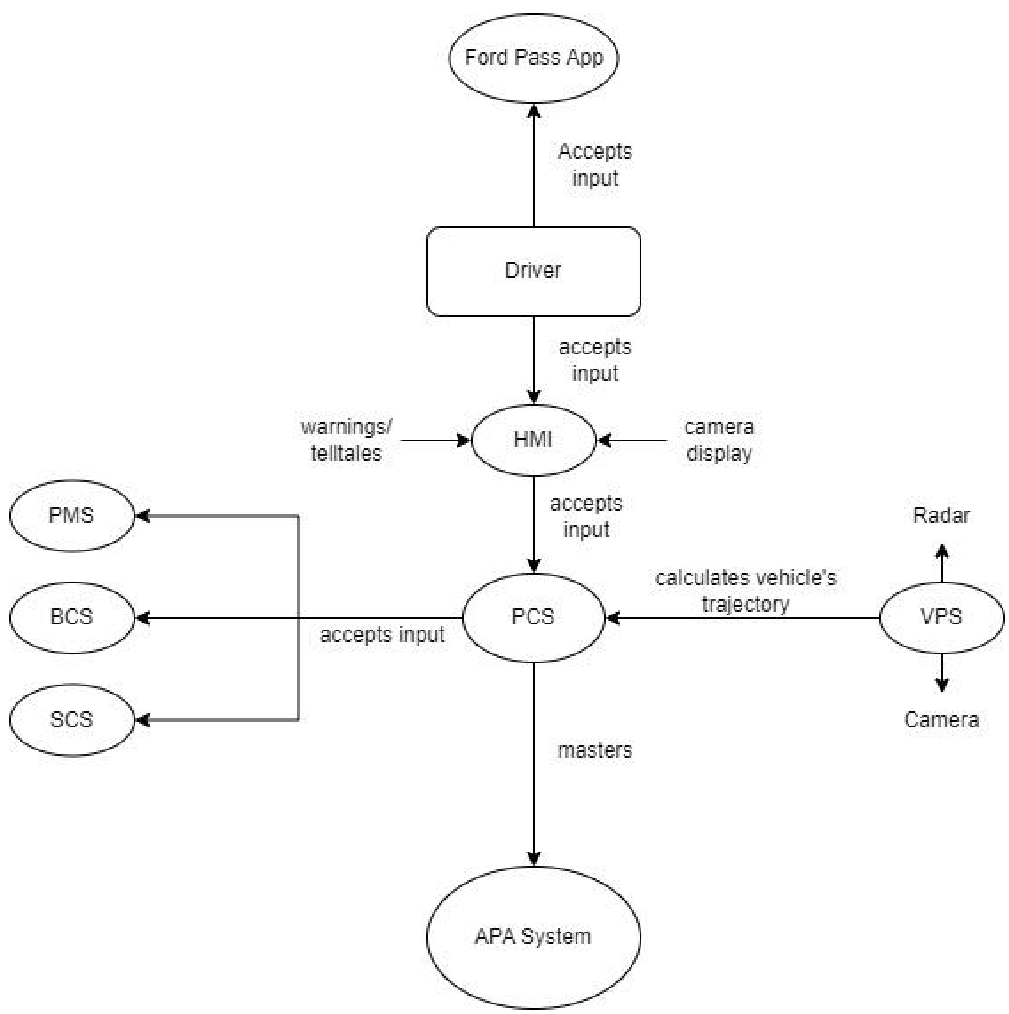

Figure 1 Diagram for subsystems associated with APA System

2.2 Product Functions

The Active Parking Assist system is utilized to help the driver park their vehicle autonomously. Before parking the vehicle, the driver is given the option to park via the APA system controls. These options are displayed on the vehicle's HMI system which also displays camera information. The system scans for available parking spots either parallel or perpendicular parking, all based on the driver's desired inputs. Both front and rear cameras are available to be used to identify the parking spot. Ultrasonic sensors, mounted on the side of the vehicle, will be used to measure the available spaces between vehicles in a parallel parking situation, to identify spots that are large enough to fit into. Upon identifying a valid parking space, the HMI will prompt the driver to verify the selection. After choosing the desired parking space, the APA system automatically turns on, eliminating the need of user dependent driving. The driver will still be able to override the APA system's autonomous driving through use of the brakes or steering wheel, gaining access to all normal driving controls such as brakes, transmission, and engine control.

During activation the APA system utilizes other subsystems within the vehicle, the primary one being the Park Control Subsystem which sends information to the APA system to perform autonomous parking in a safe and efficient manner. The system will shift the automatic transmission into the appropriate range and will accelerate, brake, and steer the vehicle as necessary into the parking spot. During the parking maneuver, radar and camera systems will monitor vehicle position to guarantee that the vehicle does not bump into any of the other parked vehicles. At the end of the parking maneuver, the Active Park Assist system will put the automatic transmission into the Park position, and indicate to the driver that the parking process has been completed. At that point, the feature is inactive and the driver takes over the control of the vehicle. The driver may also transfer control to the FordPass app on their smartphone. In which case, the vehicle's speed and position will be controlled remotely, with the driver still able to activate the brakes from the app.

2.3 User Characteristics

The expectations of the user who will be utilizing the system are described as follows. The user should be able to validate their ability of operating a motor vehicle by either possessing a valid drivers license or learners permit. Also the user should be able to identify any possible hazards or safety concerns unseen by the system by quickly reacting and taking control of the vehicle.

2.4 Constraints

The APA system has a number of constraints that must be kept in mind during development. These vary from basic functionality of the system to handling of exceptional cases, all of which must be specifically developed for.

Some of these constraints are intended for only the cases when the APA has total control of the vehicle itself, the most important of which being a max speed of 5 miles per hour, while the system has control it should constantly monitor current speed, controlling the brakes and accelerator appropriately to maintain this requirement, while still performing the desired parking maneuver accurately and in a reasonable time. Along the same lines, the system should never be capable of applying both the acceleration and braking systems simultaneously as this could cause damage to the vehicle. This means that if the system ever attempts to apply the brakes or accelerator, it must release the other if it can.

The only other constraints on basic functionality of the APA system have to do with identifying a valid parking space. First, the measured space must fit the relative length or width to fit the vehicle, otherwise the space should not be offered to the driver as an option. In addition it is important to keep in mind that the ultrasonic sensors on the vehicle have a very limited range; only about 10 feet, any further and the readings may not be accurate enough to base decisions on.

Other than these there are exceptions to adhere to, although they are not as likely to come up, they are important to plan for. One common exception, which is more common than the others, is if the APA system is activated through a smartphone, using the FordPass app, there must be a means of confirming the driver, or someone else registered with the vehicle, is the one creating the request. The system must confirm that the smartphone that has made the request has previously been linked with the vehicle via bluetooth using the HMI. Another exception is if a sensor which is vital to the completion of the parking maneuver is faulty. The APA system should be able to detect this, and cancel the request if it is deemed unsafe to proceed without the faulty sensor. Lastly is the topic of collision avoidance. This system is not designed to avoid a collision in any greater capacity than applying the brakes when one is imminent, and therefore should not make any attempts to, except for stopping the vehicle if an obstacle is in its path.

2.5 Assumptions and Dependencies

There are certain assumptions that must be made about features outside of the APA system that have an impact on how it would be developed. For example, there is existing software that should allow for relatively simple integration of this system. Along with all subsystems that are necessary for the APA to function, there is software which manages the APA system and all others within Ford vehicles, this must function properly in order for the system to work. In addition, there is the existing FordPass app, this app should already be capable of connecting to the vehicle as well as have a variety of control options that can be adapted to enable the APA system remotely with relative simplicity.

Other than this there are assumptions about the hardware and physical environment that are vital to the proper functioning of the APA system. In terms of hardware, there is a predetermined number of cameras and sensors on all compatible vehicles that will be programmed for, any change in this will require adapting the software as well. Other than this, we need to make assumptions about the parking space outside of the system. First, based on the limitations of the system's sensors, the parking space must be in close proximity to the vehicle, about 10 feet; any others cannot be detected. In addition to this, the parking space must be enclosed, something on either side, presumably other parked cars, that indicate the available space, and confirm that the location is indeed a parking space.

2.6 Apportioning of Requirements

There are other features of the APA system that could be implemented in the future, and as such the system should be designed with them in mind. The first is the capability to park in handicap spaces. Due to the way the system determines if a parking space is valid, it is not prepared to handle if a space is significantly wider than anticipated, as it would be for a handicap parking space. This could be accounted for as an additional input to the HMI. Another future improvement would be to increase security by ensuring that the APA system will not be activated through the HMI and FordPass app simultaneously. One method to accomplish this is using pre-existing weight sensors in the driver's seat to determine if a driver is present when the system is activated through the FordPass app, and confirming the request is from the driver through the HMI. Another possible solution would be to disable activation through the HMI or FordPass app altogether if activated through the other.

3 Specific Requirements

The following section highlights the global invariant requirements, general requirements, subsystem requirements, and safety requirements pertaining to the APA system in hierarchical order. Requirements are associated with respected use cases in section 4.

1. **Global Invariants requirements**
    - 1.1. The system will prevent injuries
    - 1.2. When system is in control, the vehicle will not exceed 5 mph
    - 1.3. The system can only activate when the car is at a complete stop.
    - 1.4. The system should be able to recognize faults in the sensors and controllers and determine if it is safe to continue
    - 1.5. The driver may override the vehicle's speed control with the brake pedal, canceling the system and slowing the car to a stop.

2. **General Requirements**
    - 2.1. Upon activation by the driver through the HMI or FordPass app, the system will scan for available parking spots - either via parallel or perpendicular parking based on driver input.
        - 2.1.1. This system should support being enabled entirely through a companion app, all necessary HMI features should be replicated in the app.
        - 2.1.2. Using front, rear, and side cameras and ultrasound sensors, the system will search for surrounding vehicles with space in between, if the space is at least 1.2x the length of the car being parked in parallel, it is considered valid.
    - 2.2. The HMI system or FordPass app should display all valid parking spots and allow the driver to select the one they desire

2.2.1. Upon selection, the system should activate the car's turn signal in the direction of the selected space until the maneuver is completed.

2.3. Once a valid parking spot has been selected, the system should position for one of 3 standard procedures

2.3.1. Parallel Parking - the system will line up the back of the parking car with the back of the car positioned ahead of the available parking space

2.3.2. Perpendicular Parking, forward - the system will position the car behind the available parking space with enough room between to drive into

2.3.3. Perpendicular Parking, reverse - the system will position the car ahead of the available parking space with enough room between to reverse into

2.4. Once in position the system will set the vehicle in the appropriate transmission range, and begin adjusting the steering system, pointing it toward the parking space.

2.4.1. If parallel parking, the system will reverse the car until it is at a 45° to the parking space, then adjust the steering control in the opposite direction while reversing until the car is parallel to the space, and directly behind the car initially positioned against.

2.4.2. If perpendicular parking, the system will reverse or drive as appropriate toward the desired space until the car is aligned with neighboring cars, at which point the steering control will straighten the car and the car will slowly move forward until fully parked.

2.4.3. In either case, parking should take no longer than one minute in ideal conditions

2.4.4. Camera feed should display in the HMI or FordPass app through the entirety of the parking maneuver

2.5. Once entirely in the desired parking space, the system will set the car to park and relinquish control to the driver or turn off the engine if activated from the app.

2.5.1. The driver will be notified through the HMI or app that the maneuver has been completed

3. Subsystem Requirements

3.1. Park Control Subsystem (PCS) masters the APA feature. It accepts the customer input from the HMI subsystem, calculates the vehicle trajectory based on information from the Vehicle Position Subsystem, and issues commands to the other subsystems.

3.2. Powertrain Management Subsystem (PMS) accepts inputs from the Park Control Subsystem to accelerate the vehicle and select the gear lever position in order to meet the required trajectory

3.3. Human Machine Interface (HMI) subsystem accepts customer inputs, displays camera information, and handles telltales / warnings.

3.4. Brake Control Subsystem (BCS) accepts inputs from the Park Control Subsystem to brake the vehicle in order to meet the required trajectory.

3.5. Steering Control Subsystem (SCS) accepts inputs from the Park Control Subsystem to steer the vehicle in order to meet the required trajectory

3.6. Vehicle Position Subsystem(VPS) processes data from the vehicle's cameras / radar in order to identify parking spots and verify vehicle position throughout the duration of a parking event.

3.7. Ford Pass application allows the customer to control the parking maneuver remotely

4. Safety requirements

4.1. If system control is via companion applicaiton There must be a security measure in place to confirm the user of the companion app is the driver of the car

4.2. While the system has control over the vehicle's movement, there will be exceptional cases to monitor for in order to avoid collisions

4.2.1. If any moving obstacle is detected in the path of the car while the system is controlling it, the car will begin to slow down and stop if necessary

4.2.2. If an obstacle is determined to be inside the desired parking space after the maneuver has started, the car will stop and prompt the driver to either abort, reverse the actions made and set the car back to its position before beginning to park, or take over control of the vehicle.

4 Modeling Requirements

This section contains a variety of models relevant to the APA system, describing the system itself and its many applications. All of the models are developed using UML.

4.1 Use Case Diagram

Figure 2 below details a use case diagram for the APA system. It illustrates the many interactions the customer may have with the system and how these interactions are involved with a number of other external actors. Use cases are represented as ovals within the system boundary, associations between these and actors are indicated by a solid line connecting the two, and dotted arrows indicate either an inclusion or extension between use cases. An include relationship means the functionality of the case being pointed to is present in the other, while an extend relationship represents an exceptional case of the use case where the arrow originates.

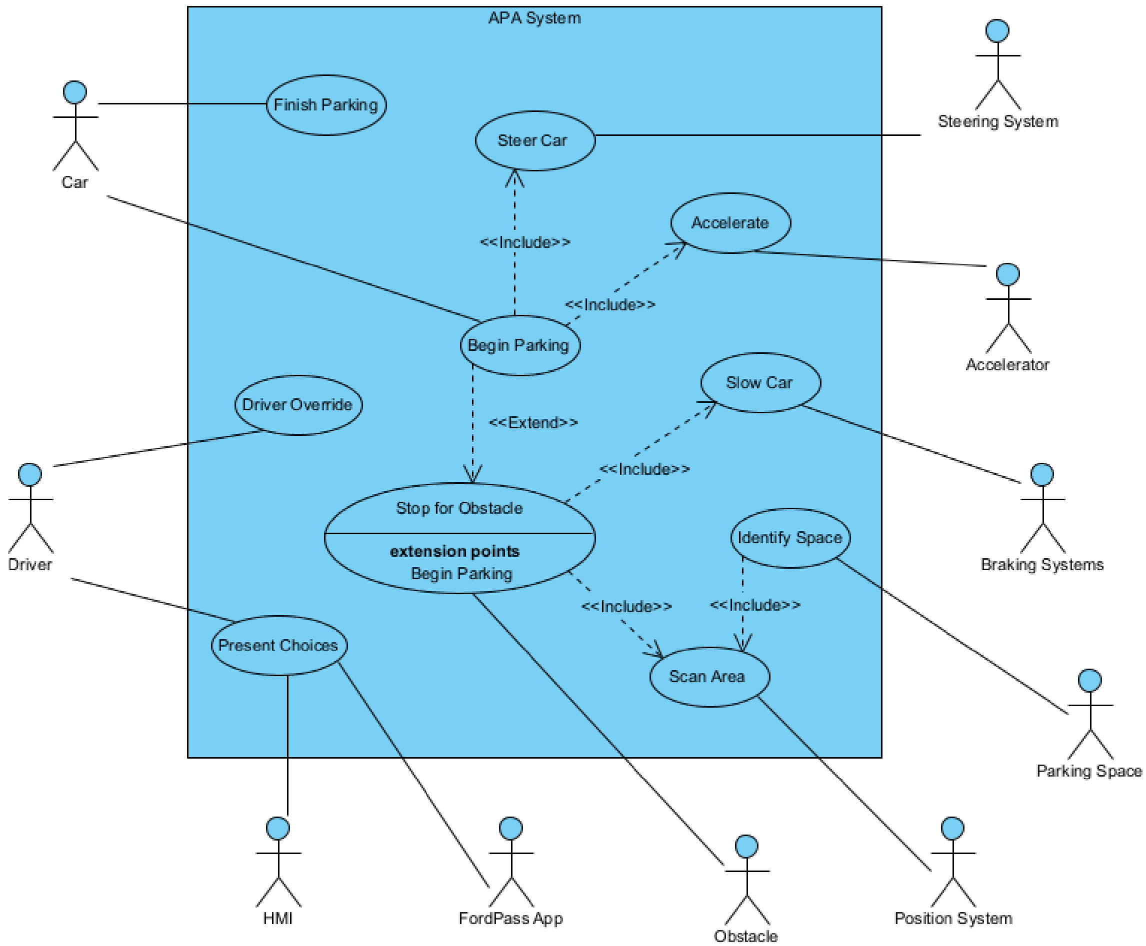

Figure 2 Use Case Diagram for the APA System

Use Case:	Begin Parking
Actors:	Car
Description:	The car will begin to start moving itself without the help of the driver. It will avoid collisions and any obstacles while driving itself and move towards the identified parking space that has been selected to park in.
Type:	Primary
Includes:	Steer Car, Drive
Extends:	Stop for Obstacle
Cross-refs:	Requirements: 2.1, 2.3,
Use Cases:	Steer Car, Drive, Stop for Obstacle

Use Case:	Steer Car
Actors:	Steering System
Description:	Will allow the car to turn itself to properly avoid any collisions or obstacles as well as successfully move the car towards the desired parking location.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 1.1, 1.2, 2.4, 3.1
Use Cases:	N/A

Use Case:	Drive
Actors:	Accelerator
Description:	Will change the speed of the car as it is moving itself towards the desired parking location. This will ensure it can park in a reasonable time while also stopping it from collision with anything.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 1.1, 1.2, 2.4, 3.1, 3.5
Use Cases:	N/A

Use Case:	Stop for Obstacle
Actors:	Obstacle
Description:	If an obstacle is in the way of the car while it is trying to park in the desired parking location then the car will automatically stop to avoid any kind of collision with this obstacle.
Type:	Primary
Includes:	Slow Car, Scan Area
Extends:	N/A
Cross-refs:	Requirements: 1.1, 1.4, 3.4
Use Cases:	Slow Car

Use Case:	Slow Car
Actors:	Braking Systems
Description:	This will allow for the car to slow down in certain situations. These situations can range from slowly backing near a car to try and get the parking perfect to significantly slowing down the car as it senses an obstacle approaching or in the way of the vehicle.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 1.1, 1.2, 2.4, 3.1, 3.4, 3.5
Use Cases:	N/A

Use Case:	Identify Space
Actors:	Parking Space
Description:	The vehicle will identify a parking space that it will be parking itself in. The space must be a legal, valid location as well as large enough to fit the vehicle that is being parked.
Type:	Primary
Includes:	Scan Area
Extends:	N/A
Cross-refs:	Requirements: 2.1, 2.2, 2.3, 3.6
Use Cases:	N/A

Use Case:	Finish Parking
Actors:	Car
Description:	This marks the end of the car controlling itself to get into a parking location. At this point the car has been fully parked and now control is fully given back to the driver.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 1.1, 1.2, 2.4, 3.1, 3.5
Use Cases:	N/A

Use Case:	Driver Override
Actors:	Driver
Description:	This allows for the driver to stop the vehicle from moving itself or doing anything that it’s trying to do. This is an important safety feature as it gives the driver the power to stop anything bad that may happen as a result of the parking system malfunctioning.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 1.5, 3.3
Use Cases:	N/A

Use Case:	Present Choices
Actors:	Driver, HMI, FordPass App
Description:	This will give the driver the option to choose which parking location they would like to park in if there are more than one spots available.
Type:	Secondary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 2.1, 2.2, 2.3, 3.6
Use Cases:	N/A

Use Case:	Scan Area
Actors:	Position System
Description:	This will monitor the surrounding area using available sensors and cameras to determine what's in the surrounding area to find parking spaces and obstacles
Type:	Secondary
Includes:	N/A
Extends:	N/A
Cross-refs:	Requirements: 2.1, 2.2, 2.3, 3.6
Use Cases:	N/A

4.2 Domain Model

Figure 3 shows a domain model to illustrate the separate components of the system and how they interact. The diagram uses UML class diagram notation, where the boxes represent components that interact with the system and the lines represent associations, where an arrow shows inheritance, a hollow diamond shows aggregation and a filled diamond shows composition.

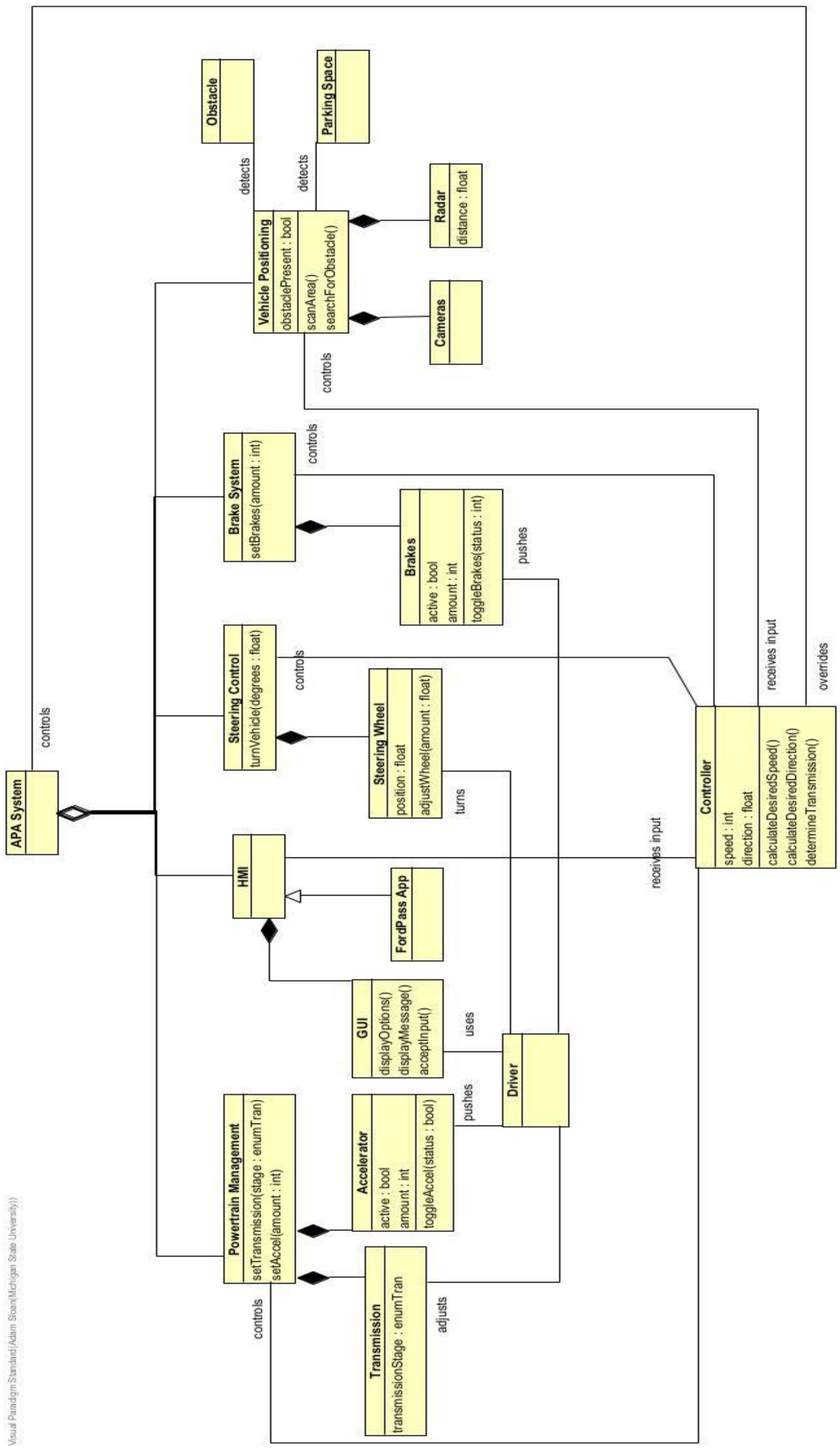

Figure 3 Domain Model for the APA system

Class	APA System
Description	This class encompasses all the methods and classes contained within the system.
Relationships	Association: Controller Aggregation: Powertrain Management, HMI, Steering Control, Brake System, Vehicle Positioning
Attributes	
Operations	

Class	Powertrain Management
Description	This class governs the control of the powertrain components of the vehicle, such as the transmission and the accelerator.
Relationships	Association: Controller, APA System Composition: Transmission, Accelerator
Attributes	
Operations	setTransmission(stage : enumTran) sets the transmission to a determined setting (Park, Reverse, Neutral, Drive) setAccel(amount : int) sets the amount to accelerate represented as an integer

Class	HMI
Description	The HMI class refers to the human-machine interface of the system, which contains the FordPass app and the GUI within the vehicle's entertainment system.
Relationships	Association: Controller, APA System Composition: GUI Inheritance: FordPass App
Attributes	
Operations	

Class	Brake System
Description	The brake system class governs the brake system of the vehicle.
Relationships	Association: Controller, APA System Composition: Brakes
Attributes	
Operations	setBrakes(amount : int) sets the amount to brake represented as an integer

Class	Steering Control
Description	The steering control class governs the control of the steering system of the vehicle.
Relationships	Association: Controller, APA System Composition: Steering Wheel
Attributes	
Operations	turnVehicle(degrees : float) turns the steering wheel to face the car by a number of degrees represented as a float

Class	Controller
Description	Receives input from the APA system and uses that information to determine the speed and direction the vehicle needs to travel in order to successfully park the vehicle.
Relationships	Association: Powertrain Management, HMI, Steering Control, Brake System, Vehicle Positioning, APA system
Attributes	Speed: int, amount: float
Operations	calculateDesiredSpeed(), calculateDesiredDirection(), determineTransmission()

Class	Vehicle positioning
Description	The vehicle positioning class governs the components of the system that determine the vehicle’s position, such as the Radar sensors and the cameras. It is responsible for detecting obstacles and parking spaces.
Relationships	Association: Controller, APA system, Obstacle, Parking space Composition: Cameras, Radar
Attributes	obstaclePresent: bool
Operations	scanArea(), searchForObstacle()

Class	Obstacle
Description	An obstacle that the vehicle has to avoid.
Relationships	Association: Vehicle Positioning
Attributes	
Operations	

Class	Parking Space
Description	The parking space that’s the goal point of the vehicle.
Relationships	Association: Vehicle Positioning
Attributes	
Operations	

Class	Transmission
Description	The transmission of the vehicle.
Relationships	Association: Powertrain Management, Driver
Attributes	transmissionStage : enumTran, the current transmission stage of the vehicle (Park, Reverse, Neutral, Drive)
Operations	

Class	Accelerator
Description	The accelerator system of the vehicle.
Relationships	Association: Powertrain Management, Driver
Attributes	active : bool, true if the accelerator is in use amount : int, number representing how much to accelerate
Operations	toggleAccel(status : bool) toggles the accelerator to on or off

Class	GUI
Description	The user-interface of the system within the vehicle's entertainment system.
Relationships	Association: Driver, HMI
Attributes	
Operations	displayOptions(), displayMessage(), acceptInput()

Class	FordPass App
Description	The mobile application used by the driver of the vehicle where the system can be initiated from.
Relationships	Association: HMI
Attributes	
Operations	

Class	Steering wheel
Description	The steering wheel of the vehicle.
Relationships	Association: Brake system, Driver
Attributes	active: bool, amount: int
Operations	toggleBrakes(status: int)

Class	Brakes
Description	The brakes of the vehicle.
Relationships	Association: Brake System, Driver
Attributes	active : bool, true if the brakes are in use amount : number representing how much to brake
Operations	toggleBrakes(status : int) toggle the brakes on or off

Class	Cameras
Description	The peripheral cameras of the vehicle, responsible for determining the positioning of the vehicle and detecting obstacles
Relationships	Association: Vehicle Positioning
Attributes	
Operations	

Class	Radar
Description	Radar sensors installed on the vehicle's exterior that help determine position and detection of the obstacles
Relationships	Association: Vehicle Positioning
Attributes	distance: float
Operations	

Class	Driver
Description	The driver of the vehicle
Relationships	Association: Transmission, Accelerator, GUI, Sterling wheel, Brakes
Attributes	
Operations	

4.3 Sequence Diagrams

This section shows a number of sequence diagrams, detailing the order of events for specific scenarios for the system. Shown with actors and objects related to the system at the very top, the timeline of events moves along the vertical axis, and communication between actors or components represented by arrows connecting their respective timelines.

4.3.1 Normal Parking Sequence

Figure 4 below shows a sequence diagram representing a normal parking scenario, which could be parallel or perpendicular parking. This shows the driver initiating the system through the user interface of the HMI, which begins the search of a parking space through sensors, then control of the vehicle through the accelerator, brakes and steering system until it reaches the parking space.

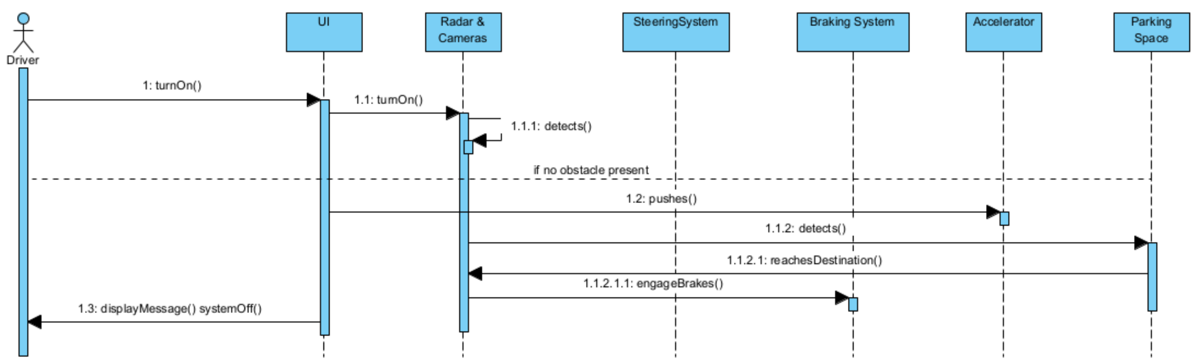

Figure 4 Sequence Diagram detailing a normal parking scenario

4.3.2 Parking Sequence with Obstacle

Very similar to figure 4 above, figure 5 shows a sequence diagram for attempting to park the vehicle when an obstacle is detected in its path. In this case the braking system is used to bring the car to a stop and using the steering system to adjust the cars path around the obstacle as necessary until parking is complete.

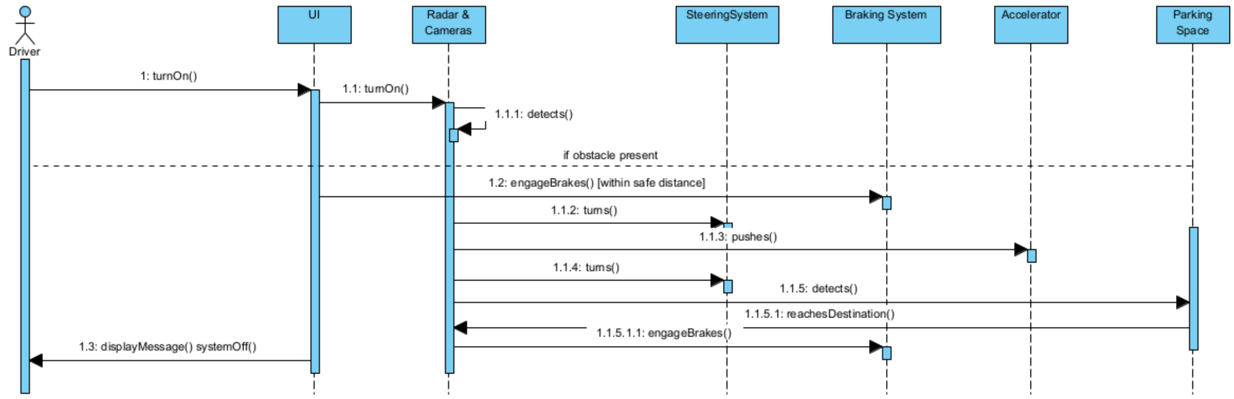

Figure 5 Sequence Diagram detailing parking scenario where an obstacle is detected

4.3.3 Overridden Parking Sequence

Lastly, figure 6 shows a scenario in which the APA system is activated, but is cut short by driver override. This is achieved through the driver manually activating the brakes, stopping the vehicle and aborting the APA system.

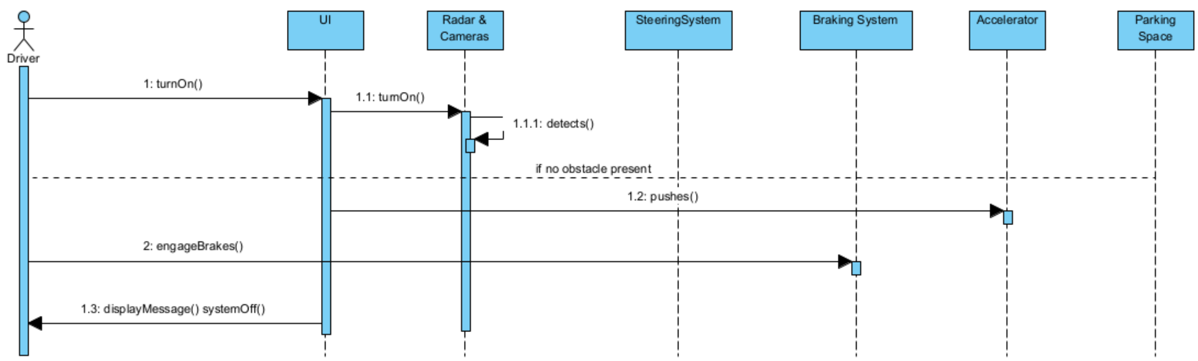

Figure 6 Sequence Diagram showing an override scenario

4.4 State Diagrams

This section shows state diagrams detailing the APA system. These diagrams show certain common events the system will go through, the states involved and how transitions between those states are taken. All of the diagrams are made in UML state diagram notation, where each state begins at block dot, transitions are indicated by arrows labeled with the requirement to take that transition - or no label for transition that should always be taken - and states are shown as a bubble.

4.4.1 System Start State Diagram

Figure 7 shows the state machine for the APA system on startup. Immediately after activation, the system will use the available sensors to scan the immediate area for valid parking spaces. If no spaces are found the system will abort, otherwise it will display a selection for the driver using the HMI or FordPass app. From this selection the driver can manually abort the system, or select a space, beginning a parking maneuver.

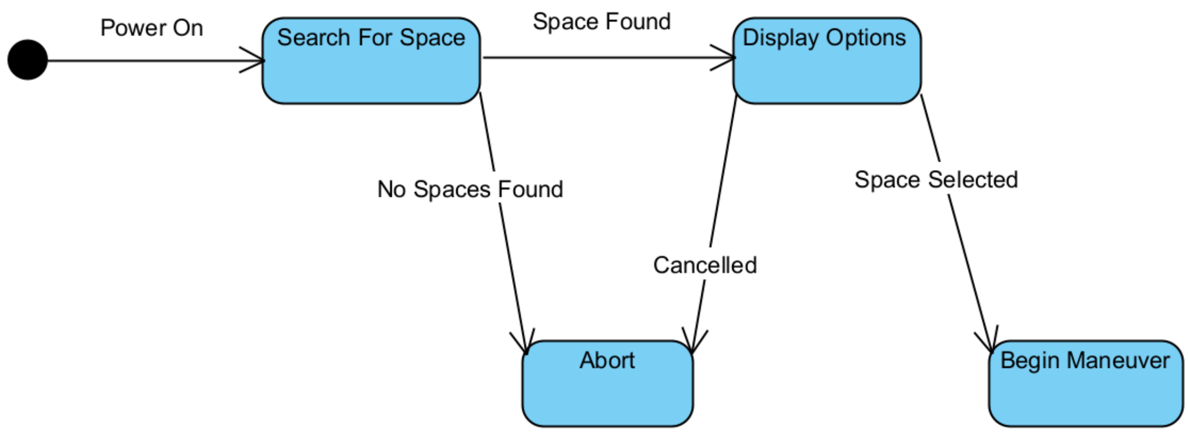

Figure 7 Diagram showing states to find and display available parking spaces

4.4.2 Parking Maneuver State Diagram

Figure 8 shows a state machine for maneuvering the vehicle into the desired parking space, beginning when a parking space is selected. Immediately the system will adjust the steering system to direct the vehicle toward the space, it will also adjust the transmission system to drive or reverse as necessary, and then it will begin driving, maintaining a speed of 5 mph until the vehicle is fully parked. At any moment before the vehicle is parked, the driver may override the system and take control of the vehicle by using the steering wheel or fully applying the brakes.

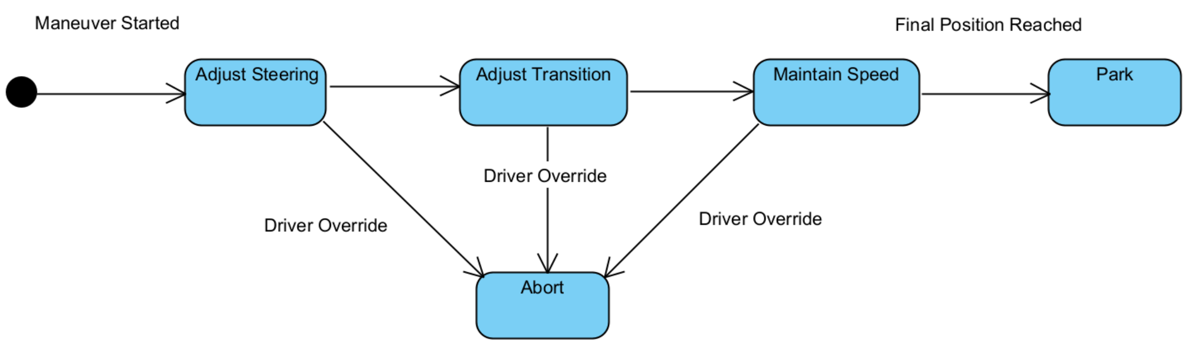

Figure 8 Diagram showing system states of a parking maneuver

4.4.3 Maintain Speed State Diagram

Below, figure 9 shows how the system maintains speed during a parking maneuver. The APA system starts by monitoring the available sensors to determine if any obstacles are in its path, if there is an obstacle the brakes will be applied, if not the system will monitor speed and accelerate if currently moving below 5 mph, or brake if moving above 5 mph. After accelerating or braking, the system will return to monitoring the sensors, starting the process over again.

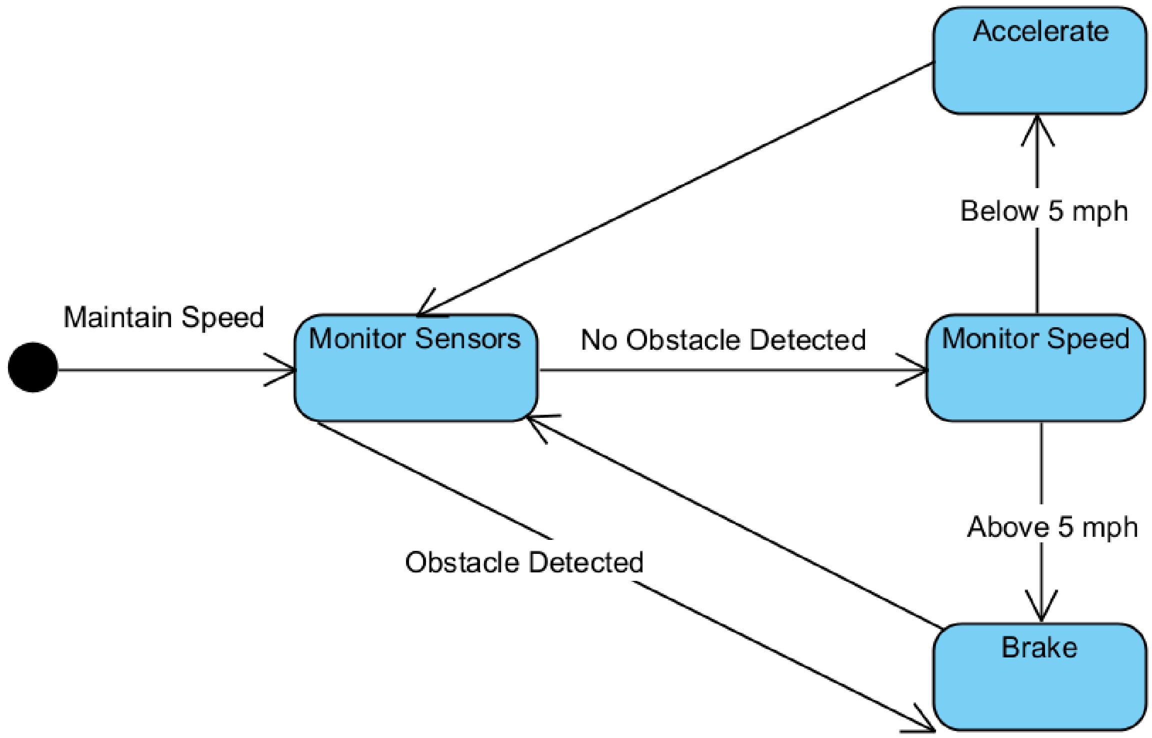

Figure 9 Diagram showing how the system controls speed, determining when to brake and when to accelerate

5 Prototype

The prototype below shows a situation where the APA system automatically parks a vehicle into a perpendicular parking space, pulling it off the road and stopping the vehicle in between a set of cones, used to emulate other parked cars.

5.1 How to Run Prototype

As a functioning web based prototype is being developed, here is a download link for the prototype. After clicking the link and downloading the zip file, extract it and from the extracted folder run ‘My project.exe’ which will launch the sample scenario.

5.2 Sample Scenarios

The Prototype currently shows a forward perpendicular parking scenario with no obstacles. The vehicle will begin driving forward towards a parking space indicated by a red block, the starting layout is shown in figure 10, with the parking space seen in front of the car to the right.

Figure 10 initial state of the prototype, the vehicle will begin by driving forward along the road

The vehicle will move forward until it is near the indicated parking space, at which point it will begin the parking maneuver, the transition is shown in figure 11.

Figure 11 the vehicle detects a valid parking space and begins the parking maneuver

The vehicle will turn right and continue moving forward until it is positioned above the red parking space, and park, resulting in figure 12, showcasing a possible perpendicular parking scenario.

Figure 12 the vehicle parked on the indicated parking space

6 References

[1] "FordPass Mobility App With Connected Services." ford.com. FordPass® | Mobility App With Connected Services | Ford Owner Support

[2] E. Davidson. "Active Park Assist." [Online] https://www.cse.msu.edu/~cse435/Projects/F2022/ProjectDescriptions/2022-APA-Ford-Davidson.pdf (Accessed Nov. 1, 2022).

[3] https://cse.msu.edu/~durustan/

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.