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, 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 negative consequences from occurring while using this feature, however this is what the system is limited to, as it won't un-park 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.
- **Collision:** Any outside variable coming into contact with the vehicle.
- **HMI:** The Human-Machine Interface in the car that allows the driver to interact with the APA system

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

The following sections will thoroughly describe the Active Parking Assist 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 Active Park Assist system main goal is to eliminate the stress the driver endures when parking their vehicle. The system 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. This allows the vehicle to automatically park itself in either a parallel or perpendicular parking space. This 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:

- Park Control Subsystem
- Powertrain Management Subsystem
- HMI Subsystem
- Brake Control Subsystem
- Steering Control Subsystem
- Vehicle Position Subsystem
- Drivers Cell phone

2.2 Product Functions

The Active Parking Assist system is utilized to help the driver park their vehicle autonomously. Upon 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 look for 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 systems 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 control both the acceleration and braking systems simultaneously as this could cause damage to the vehicle. This means that if the system ever attempts to control the brakes or accelerator, it must relinquish control of 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, 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.

3 Specific Requirements Needs to be reorganized and separated into more specific requirements

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.
    a. 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.
    b. The system can only activate when the car is at a complete stop.
2. This system should support being enabled entirely through a companion app, all necessary HMI features should be replicated in the app.
    a. There must be a security measure in place to confirm the user of the companion app is the driver of the car
3. The HMI system or FordPass app should display all valid parking spots and allow the driver to select the one they desire
    a. Upon selection, the system should activate the car's turn signal in the direction of the selected space until the maneuver is completed.

4. If the car is not already there, the system should position for one of 3 standard procedures
    a. 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
    b. Perpendicular Parking, forward - the system will position the car behind the available parking space with enough room between to drive into
    c. Perpendicular Parking, reverse - the system will position the car ahead of the available parking space with enough room between to reverse into
5. Once in position the system will set the car in the appropriate transmission range, and begin adjusting the steering system, pointing it toward the parking space.
    a. 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.
    b. 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.
    c. In either case, parking should take no longer than one minute in ideal conditions
    d. Camera feed should display in the HMI or FordPass app through the entirety of the parking maneuver
6. The driver may override speed control of the car with the brake pedal, canceling the system and slowing the car to a stop.
7. 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.
    a. The driver will be notified through the HMI or app that the maneuver has been completed
8. While the system has control over the vehicle's movement, there will be exceptional cases to monitor for in order to avoid collisions
    a. 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
    b. 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.
9. The system should be able to recognize faults in the sensors and controllers and determine if it is safe to continue

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 1 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.

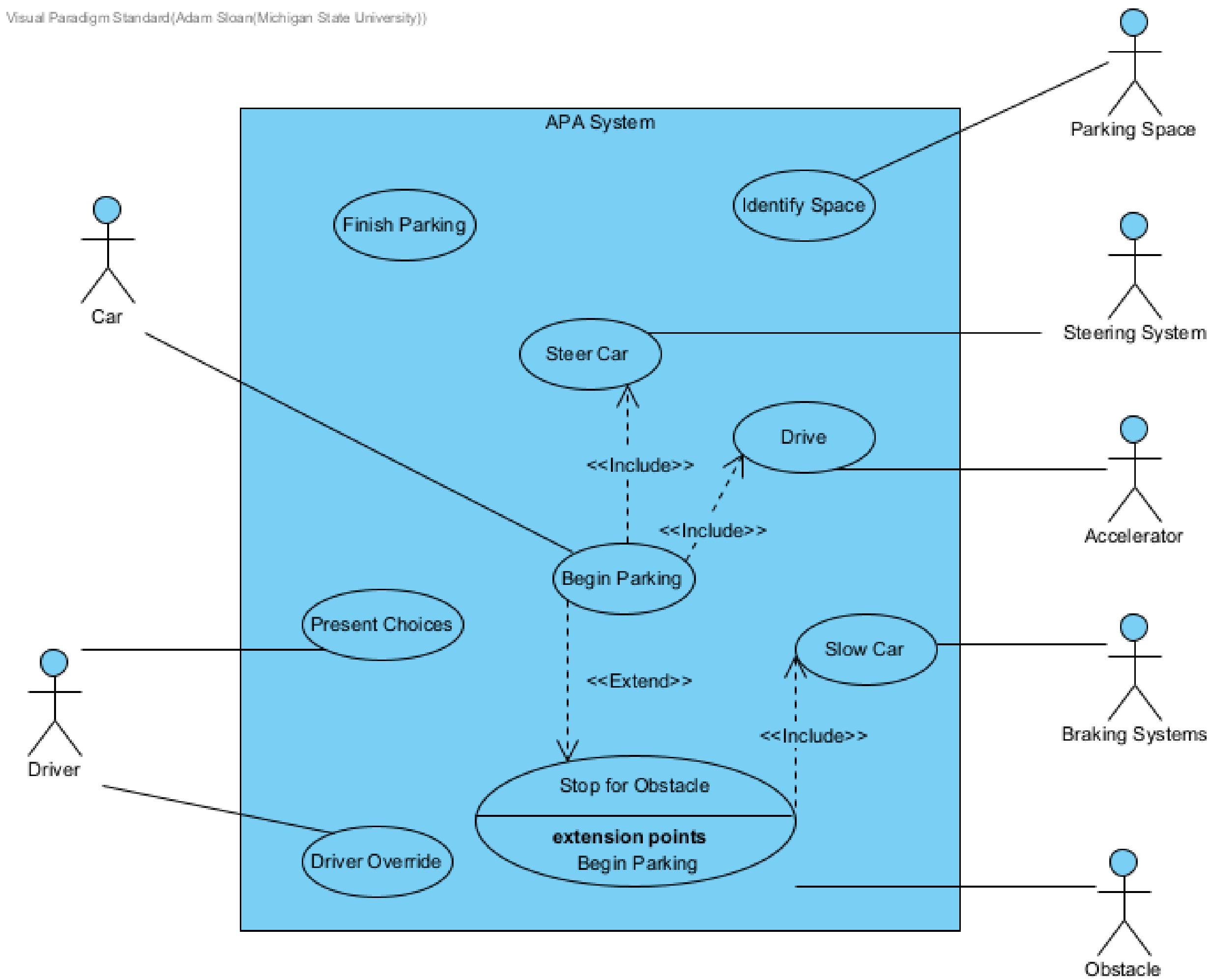

Figure 1 Use Case Diagram for the APA System

4.2 Domain Model

Figure 2 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.

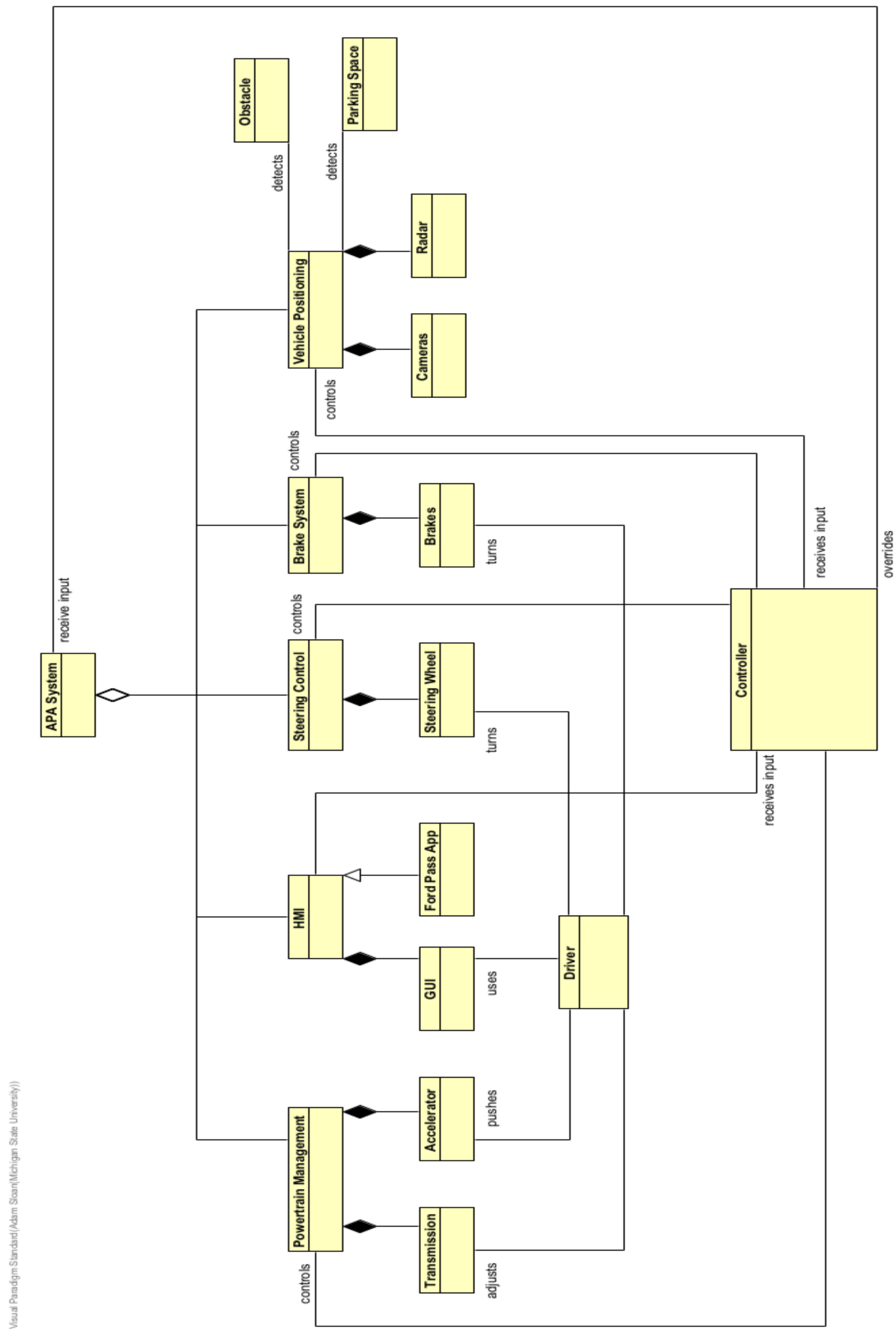

Figure 2 Domain Model for the APA system

4.2 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.

Figure 3 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.

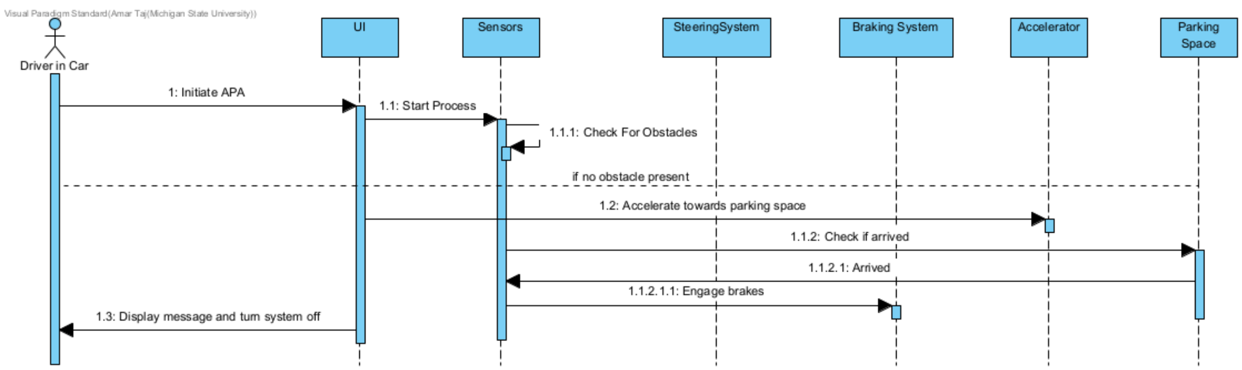

Figure 3 Sequence Diagram detailing a normal parking scenario

Very similar to figure 3 above, figure 4 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.

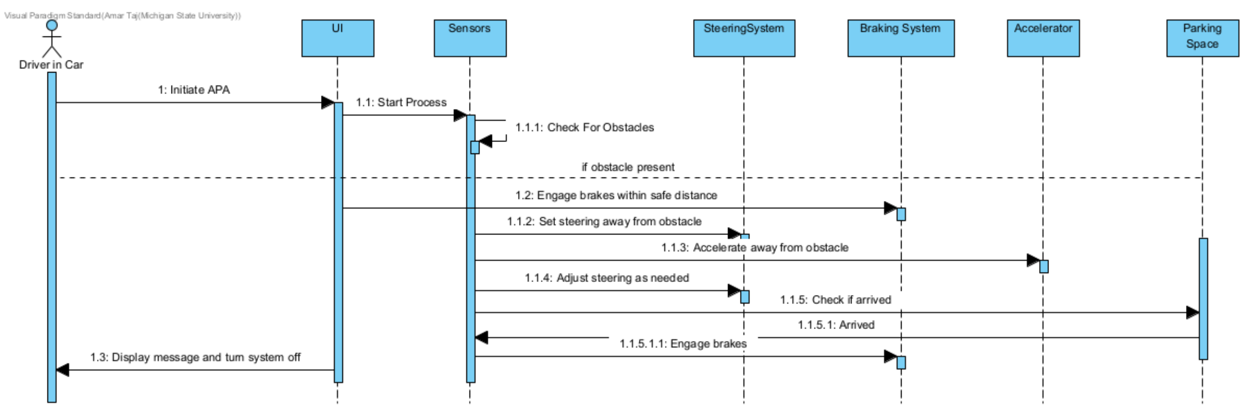

Figure 4 Sequence Diagram detailing parking scenario where an obstacle is detected

Lastly, figure 5 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 car and aborting the APA system.

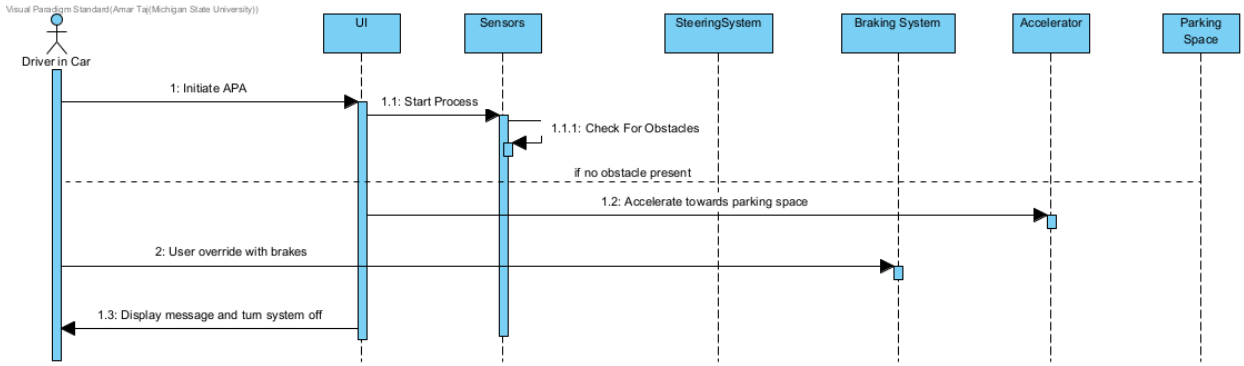

Figure 5 Sequence Diagram showing an override scenario

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 video demonstrating the scenario described above in an application designed in Unity.

5.2 Sample Scenarios

The Prototype currently shows a forward perpendicular parking scenario with no obstacles, the driver approaches the parking space, indicated by traffic cones, upon which the APA system takes control and guides the vehicle into the 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).

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.