Software Requirements Specification (SRS)

Active Park Assist

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1 Introduction

This project will create an Active Park Assist (APA) system to be installed in vehicles to improve the driver’s parking experience. This introduction will define the purpose, scope, and give background information for the project.

1.1 Purpose

This document will describe the system, lay out its requirements, build models for system behavior, and describe a prototype interface for the system. This document is for development team members to reference during development and the customer to confirm requirements are met.

1.2 Scope

The name of this project is the Active Park Assist System (APA). The APA is a feature that enables the car to select and park in a parking space at the request of the driver. This system will be embedded into the vehicle’s current computer systems and will interface with several of the vehicle’s subsystems. The APA will be able to see available parking spots when the driver turns the system on and will display the available spots to the driver. Upon selection, the system will then begin to park in the available space. The vehicle will avoid all obstacles and park within the bounds of the selected space.

1.3 Definitions, acronyms, and abbreviations

1. Abbreviations and Definitions:
   a. Human-machine interface (HMI): The HMI is a control panel that the driver can use to adjust settings in the car and initiate the auto-pilot features
   b. Active Park Assist (APA): The Active Park Assist system we will build.
   c. Available parking spots: A parking spot width is >1.2x where x is the width of the vehicle.
   d. Limited parking speed: < 5 mph.
   e. A reasonable parking time: <15 seconds

2. Terms:
   User input and pre-parking phase:
a. The system will allow parallel, perpendicular and diagonal parking mode. The parking mode can be chosen by the user through HMI before parking process.
b. The system will use the front and rear cameras to identify the available parking spots.
c. Then the system will use ultrasonic sensors to measure if the parking spot is large enough to fit in.
d. After parking spot is identified, the system will wait for user verification through HMI.

**System maneuver phase:**

a. Once the spot is verified, the APA system takes over the driving of the vehicle. During the system maneuvering, Any user interference will abort the system and notify the user on the HMI.
b. If the user aborts the parking, the system should be able to resume or restart the parking maneuver.
c. The system will shift the automatic transmission into the appropriate range (reverse or drive) and will accelerate, brake, and steer the vehicle into the parking spot at limited speed.
d. During the maneuver, radar/camera system will continue to monitor vehicle position to ensure that vehicle does not bump into any of the other parked vehicle.
e. The system should be able to identify obstacles that have moved into the path of the vehicle after a parking maneuver has started, and activate the brake.
f. At the end of the maneuver, the APA feature will put the automatic transmission into the Park position.
g. When parking finished, the system is inactive and indicate to the user that the parking process has completed through HMI. Finally, return control of the vehicle to the user.

1.4 Organization

The rest of this document will describe, model, and prototype the APA project. Section 2 will describe the systems characteristics, functions, and constraints. Section 3 will define requirements for building the system. Section 4 will model various use cases and system diagrams. Section 5 will provide a prototype description and some samples scenarios.

2 Overall Description

This section will provide a general introduction to the system, which will include detail of the system such as the perspective and functions, and the user characteristics. Constraints, Assumptions and Dependencies will also be listed below.

2.1 Product Perspective

The Active Park Assist (APA) system is designed to provide drivers the option to let the vehicles parking by themselves automatically with the minimum interaction. Parking a vehicle can be a challenging task for any driver in any given circumstance. This system is intend to provide better experience for drivers, as well as increased safety for both the passenger and the surroundings include pedestrians and other objects nearby.
The APA system is formed by 6 subsystems which include Park Control Subsystem, Powertrain Management Subsystem, HMI Subsystem, Brake Control Subsystem, Steering Control Subsystem and Vehicle Position Subsystem.

The user interface of this system is provided through the onboard Human Machine Interface (HMI) system. The HMI is a control panel that the driver can use to adjust settings in the car and initiate the auto-pilot features (like APA). The HMI will provide two options: the type of parking (parallel or perpendicular) and available parking spots. There is one more way that the user may use to interact with the system by taking control of the vehicle directly.

This system requires additional hardware that has to be installed on the vehicle to function. Cameras installed at the front and back of the vehicle will be used to identify the parking spots available nearby. This system also requires ultrasonic sensors to measure the distance. This system also requires radar to monitor the position of vehicle.

There will be some software required to process the data that is critical for this system. It requires a software to handle the input from the user. Then it needs to process the data gained from onboard sensors to identify the environment nearby. It also requires a software to calculate the trajectory and the handle should be done to the vehicle.

This system will have an interface to connection between the subsystems included. The Park Control Subsystem is responsible for the entire APA system. When this system is activated by the user, it will first accept user’s input through the HMI subsystem. Then it will call the Vehicle Position Subsystem to process the data gained from sensors to identify vehicle positions and nearby parking spots, and provide the information to the HMI. During the parking procedure, Park Control Subsystem will calculate the vehicle trajectory based on information from the Vehicle Position Subsystem, and then control the vehicle’s accelerate, brake, and steer through the Powertrain Management, Brake Control and Steering Control subsystems. It will also provide information to the HMI subsystem that should be displayed to the user, including the camera information and other message related.

This system will be designed to be integrated into other onboard systems, and thus, sharing the primary and secondary memory with other systems.

There are two modes available. In the normal mode, this system needs user’s input to initialize the parking procedure, however once it is activated it does not require regular interaction with the user until it is aborted. It also does not require specific action to be taken during unattended operation. Information will be given if the system is aborted. This system may operate in backup mode if single point failure of any sensor input is detected. In that case this system will notify the user that there is a problem.

### 2.2 Product Functions

The major function of this software system is to provide the vehicle the ability to automatically park itself into a available parking spot. First the user will be able to activate the system through the HMI system. Then the user will be given the option to choose from parking parallel or perpendicularly. After the type of parking is chosen, the system will try to detect the available parking spots nearby. The system will use vehicle-mounted cameras to identify the parking spots, and the ultrasonic sensors will be used to measure the distance between the vehicle and parking spots. Then the user will be able to choose the desired spot through available spots identified. After that the parking procedure is initialized, and the system will take over the control of the vehicle. The system will use the sensors to determine the position of vehicle, and will accelerate, brake, and steer to direct the vehicle into the parking spot. The system will also continue
to detect the obstacles through the sensors and take action if necessary. Once the vehicle is in the parking spot, the system will switch the automatic transmission in Park position and exit automatically. The entire parking procedure will take no more than 15 seconds to finish. During the parking procedure, the user is able to abort this system and retake the control of vehicle at any time. The HMI will give information when the system aborts and normal control resumes.

2.3 User Characteristics

The user is expected to be a licensed driver. This system does not require general expertise, but the user should be able to interact with the onboard HMI. The user should also able to finish the parking procedure without the use of assistance system.

2.4 Constraints

The APA is a complex system and there are some shortcomings in its subsystems which may affect the overall performance.

- The auto-pilot function currently is not common on automobile vehicles, and the reliability is not proven yet. There may be legal issues to install this system widespread.
- The video cameras are vulnerable to the weather and outside's brightness. And the ultrasonic sensors have blind spots. These factors may reduce the real-time performance of the Vehicle Position System.
- Also due to the limitation of the performance of onboard computer system, if the information gained from the sensors are complex(such as there are irregular objects nearby) or conflict(if the camera or ultrasonic sensor is interfered and providing incorrect data), the system may operate with a reduced performance.
- This system may be attacked by third-party, and this is severe security risk since this system can directly control the vehicle.
- If some of the sensors become unreliable, or completely unable to function, this system may run in a downgraded mode, since it requires more time to try to recover the missing information from the data from other sensors. And if the missing part of information is too large to recover, or there is a issue in critical subsystems, such as the HMI, this system will not be able to function at all.

2.5 Assumptions and Dependencies

The following assertions and dependencies that this system required to function normally will be made:

- The vehicle is automatic transmission.
- The handling (steer/break/etc.) of the vehicle is in good condition.
- The sensors that this system relied on is in good condition.
- The vehicle is expected to be parallel, perpendicular, or diagonal to the paring spot and is fully stopped before the system is activated.
- The request to activate this system is initialized by the user via the HMI. Any other type of requests will be ignored.
- The parking spaces should be clearly marked in line.
- If there are any obstacles in the path of the vehicle, the sensors will be able to detect them and necessary actions will be made.
During the parking procedure, any attempts from the user to control the vehicle will be considered that user want to abort this system.

2.6 Apportioning of Requirements
Currently all of the requirements are determined, and no requirements are expected to be delayed until future version of the system.

3 Specific Requirements

Hardware Requirements:
1. Human-machine interface (HMI): The HMI is a control panel that the driver can use to adjust settings in the car and initiate the auto-pilot features
   1.1. The HMI will accept user input and allow user to choose or verify selections.
   1.2. The HMI will display selection through the screen
   1.3. The HMI will able to display vehicle position while APA is active.
2. Cameras: The camera will allow system to identify parking spots and provide user rear vision.
   2.1. The cameras will be able to provide high resolution for system to identify parking posts.
   2.2. The cameras will provide surrounding vision to support parallel, perpendicular and diagonal parking.
3. Ultrasonic sensors: distance measurement hardware.
   3.1. The ultrasonic sensors will have an accuracy at least 0.01m in distance measurement.
   3.2. The ultrasonic sensors will provide surrounding measurement to support parallel, perpendicular and diagonal parking.

External Interface Requirements: The system will be integrated into the vehicles existing computer control system. The existing system has several subsystems that the APA system will interface with.
1. HMI Subsystem: Interfaces with the user to provide information and accept input.
2. Powertrain Management Subsystem: Accepts inputs from the APA system, selects the transmissions gear and controls the vehicle’s acceleration.
3. Brake Control Subsystem: Accepts inputs from the APA system, controls the vehicle’s brakes.
4. Steering Control Subsystem: Accepts inputs from the APA system, controls the vehicle’s steering and trajectory.
5. Vehicle Position Subsystem: processes information from the vehicle’s sensors and cameras to identify vehicle position and identify parking spaces.

Functional Requirements:
1. User input and pre-parking phase: Accept user input and identify parking spot.
   1.1. The vehicle must be in park for the system to be initiated.
   1.2. The system will allow parallel, perpendicular and diagonal parking mode. The parking mode can be chosen by the user through HMI before parking process.
   1.3. The system will use the front and rear cameras to identify the available parking spots.
1.4. Then the system will use ultrasonic sensors to measure if the parking spot is large enough to fit in.
   1.4.1. In parallel and diagonal parking, the width of the vehicle should be >1.2x where x is the width of the vehicle.
   1.4.2. In perpendicular parking, the width of the vehicle should be >1.2x where x is the Length of the vehicle.

1.5. After parking spot identified, System will display all available parking spots.

1.6. Wait for user selection and verification through HMI

2. System maneuvering phase: System take over the control of the vehicle and start park the car into the spot.
   2.1. Once the spot is verified by the user, the system takes over the driving of the vehicle. During the system maneuvering, any user interference will abort the system.
   2.2. The system will shift the automatic transmission into the appropriate range (reverse or drive).
   2.3. steer the vehicle to the appropriate angle.
   2.4. Accelerate or brake the vehicle to park into the spot.
   2.5. System will continue to monitor vehicle position to ensure that vehicle does not bump into any of the other parked vehicles.
      2.5.1. The distance between other vehicles should be kept at least 0.2m.
      2.5.2. The system should steer, accelerate or brake the vehicle to keep the distance between other vehicles and obstacles.
      2.5.3. If the vehicle is about to bump (distance <0.2m) the brake should be activated, and system should abort.
   2.6. When vehicle is parked into the spot:
      2.6.1. Put the automatic transmission into the Park position.
      2.6.2. Return control of the vehicle to the user
      2.6.3. indicate to the user that the parking process has completed through HMI.
      2.6.4. Exit The system.

3. System Abort: Any system error or user manually abort will enter the system abort phase.
   3.1. The system should stop the vehicle and return the transmission to park.
   3.2. Notify the user System abort information on the HMI.
      3.2.1. Information includes: Abort message, Abort Type (e.g. manual or system error), Abort time.
   3.3. Return vehicle control to user.
   3.4. The system should be able to resume or restart the parking.

Quality Requirements:
   1. Security:
      1.1. The system must have verifying that the driver has initiated the request
      1.2. System must verify the request was not a result of a fault in the HMI system or a malicious 3rd party attack.
      1.3. If any security issue is detected, APA feature will not be allowed to be started and indicate user through HMI.
   2. Safety:
2.1. The system should be able to identify obstacles that have moved into the path of the vehicle after a parking maneuver has started.
   2.1.1. If the system detects an obstacle moving into the path of the maneuver, the maneuver should be aborted.
   2.1.2. The driver will be notified that the maneuver has been aborted through the HMI.

2.2. Once a parking event is initiated, it shall be completed in a reasonable time (15 seconds). If time expired, the system should abort the parking process.
   2.2.1. Timer is initiated when user verified parking spot and system start to control the vehicle.
   2.2.2. Timer stops when vehicle is parked into the spots.
   2.2.3. If system is aborted timer is paused.
   2.2.4. Timer continue if user resume from abort.

2.3. A single point failure of any sensor input shall be detectable and notify the user on the HMI.
   2.3.1. The system will verify that it has not been initiated incorrectly.
   2.3.2. The system will not be initiated if any of the vehicles sensors required for the maneuver are not working correctly.
       The required sensors are the front and rear cameras, ultrasonic sensors, and radar systems.

4 Modeling Requirements

Use Case:

Figure 1 below is the use case diagram for the Active Park Assist system and describes different scenarios between the user/driver and system.

Figure 1. Use case diagram describing the interactions of the APA system.

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 chengb.cse.msu.edu)
The operator uses the APA system in order to park their vehicle with minimal interaction. The operator activates the system through a Human Machine Interface. Once activated, the user will select the spot type and the system will identify the available spots by monitoring the vehicles location. Then through the HMI, the user can select which spot they would like to park in and the system will park the vehicle in the spot and notify the driver through the HMI once parking is complete. Any driver interference will abort the APA system and notify the user. The descriptions of each use case is in Table 1 below.

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Spot Type</td>
<td>The user uses the Human Machine Interface to select what type of parking space they would like to park in.</td>
</tr>
<tr>
<td>Select Spot</td>
<td>Using the HMI, the driver selects which spot to park the car in.</td>
</tr>
<tr>
<td>Park Vehicle</td>
<td>The APA system steers the vehicle into the parking spot and then notifies the user through the HMI.</td>
</tr>
<tr>
<td>Identify Spots</td>
<td>Using the sensors and cameras on the vehicle, the system locates available spots to park in.</td>
</tr>
<tr>
<td>Abort APA System</td>
<td>The user interferes with the system by manually using the steering wheel, brakes, or gas and the system aborts.</td>
</tr>
<tr>
<td>Monitor Vehicle</td>
<td>The APA uses the sensors and cameras to park the car without hitting adjacent vehicles or any object the move into the path of the vehicle.</td>
</tr>
</tbody>
</table>

Table 1. Description of Use Cases

Class Diagram:

Through the Active Park Assist System class, the parkVehicle command is called and the Vehicle Controls class issues commands to the vehicle controls including the velocity of the vehicle which controls the speed, direction, and braking of the vehicle, and steering of the vehicle which controls the direction that the vehicle will turn. The Active Park Assist System gathers data from the Vehicle Sensor class which uses the...
Radar to detect the available parking spots and objects that may come into range of the vehicle, and the Camera which detects the parking spot that the user would like to park. The system is controlled by the Human Machine Interface class. The user interacts with the system through the HMI by selecting the type of spot, and selecting a specific parking spot after the HMI displays the available spots to park in. Once the vehicle is finished parking, the HMI will display a message notifying the driver that the parking process is complete.

**Data Dictionary:**

<table>
<thead>
<tr>
<th>Active Park Assist</th>
<th>System controlling the parking process of the vehicle. This class gathers data about the vehicle position and its surroundings and issues commands to the vehicle controls to park the vehicle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attributes</td>
<td></td>
</tr>
<tr>
<td>vehicleWidth : double</td>
<td>The width of the vehicle</td>
</tr>
<tr>
<td>VehicleLength : double</td>
<td>The length of the vehicle</td>
</tr>
<tr>
<td>Operations</td>
<td></td>
</tr>
<tr>
<td>parkVehicle()</td>
<td>Sends data and commands to the Vehicle Controls class which then maneuvers the car into the parking spot</td>
</tr>
<tr>
<td>abortParkingProcess()</td>
<td>Aborts the APA system when an object is detected, or the user manually aborts the process</td>
</tr>
<tr>
<td>parkingComplete()</td>
<td>Checks if the vehicle parking process is complete and sends a message through the HMI if the process is complete.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Velocity Control</th>
<th>Accepts data from the Active Park Assist System to control the velocity and direction of the vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td></td>
</tr>
<tr>
<td>SetVelocity()</td>
<td>Sets the velocity of the vehicle. Values above 0 denote forward movement and values below 0 denote a reverse movement.</td>
</tr>
<tr>
<td>SetBrakes()</td>
<td>Initiates the brakes of the vehicle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steering</th>
<th>Accepts data from the Active Park Assist System to control the velocity and direction of the vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td></td>
</tr>
<tr>
<td>setSteering()</td>
<td>Sets the value for the steering to maneuver the vehicle into the parking spot.</td>
</tr>
</tbody>
</table>

| Human Machine Interface | The HMI is the system that the user interacts with. The HMI displays messages to the user as well as allows the user to select an available parking spot. |

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 chengb.cse.msu.edu)
<table>
<thead>
<tr>
<th>Operations</th>
<th>displayMessage()</th>
<th>Displays a message to the user when the parking process is complete or when the process is aborted by the user, or by a detected object.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>activateAPASystem()</td>
<td>Activates the Active Park Assist System and detects the available spots.</td>
</tr>
<tr>
<td></td>
<td>selectSpotType()</td>
<td>Allows the user to select what type of parking spot the vehicle should be parked into (perpendicular or parallel)</td>
</tr>
<tr>
<td></td>
<td>selectSpot()</td>
<td>Allows the user to select which spot they would like to park in.</td>
</tr>
</tbody>
</table>

**Camera**

| Operations                  | detectTargetParkingSpot() | Collects and sends data to the Active Park Assist System about the spot that the user selected. |

**Radar**

| Operations                  | detectObject()            | Collects and sends data to the Active Park Assist System about the spots that are big enough to park in and detects objects that are in the way of the vehicle. |
|                            | findAvailableSpots()      | Detects if an object is in the way of the vehicle. If so, the process is aborted. |

**Sequence Diagram:**

![Sequence Diagram for APA operation](image)

**Figure 4. Sequence diagram for APA operation**

**State Diagram:**

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 chengb.cse.msu.edu)
5 Prototype

The prototype will be run from a link via the website and will be built using angular. It will show the center display which will be the front facing camera allowing the user to select which parking space they would like to park in. The user will then be able to select and verify the parking space that they want. We will also have an overhead view of the car and parking lot to show the stages of parking the car as you go through the parking process.

An example scenario would start with a car in a parking lot and two possible parking spots (left and right). The user will pick one of the two parking spots on the screen. The display will then highlight that parking spot and ask the user for verification.
via a popup. Once the user verifies the spot, the car will then move into the spot and you will see it in the spot from the overhead view.

6 References


7 Point of Contact

For further information regarding this document and project, please contact Prof. J. Daly at Michigan State University (dalyjame 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.