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Semi-Autonomous Parking system for Automatic Transmission vehicles

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Abstract. This paper proposes an automated perpendicular parking strategy for a car which is to be designed. The design considers general cases of perpendicular parking for a rectangular body within a rectangular space. The system works in phases named: The Scanning phase, the parking environment is detected by ultrasonic sensors mounted on the extreme ends of body and a parking position and maneuvering path is produced if the space is enough. Then in the positioning phase, the model positions itself and get aligned with the parking space avoiding potential collisions. Finally, in maneuvering phase, the model moves to the parking position in the parking space in a specified path, which requires clutch, brake control, backward and forward maneuvers depending on the dimensions of the parking space. Based on the characteristics, a collision-free path is planned about the surroundings. The strategy is to be integrated into an automated parking system, and implemented in the car, showing capable of safe parallel parking in tight situations and as automated parking device to help vehicle drivers.

Keywords: Semi-Autonomous Parking, Automated Manual Transmission, Automatic Transmission, Ultrasonic Parking sensors, Parking Algorithm.

1. Introduction

Autonomous parking is an autonomous maneuvering system which can perform angled, parallel, or perpendicular parking of any automobile. Aim of this system is to enhance the safety and comfortability of driving in such constrained space where attention, skill and experience required in controlling the vehicle is high.

Parking of a car requires space width greater than car body's actual width because driver need to open the doors to come out of the vehicle after parking it. Also, space concern is increased due to increasing number of vehicles used. Even for small space, wrong judgement of driver may result in damage to car body. Hence, attempts are made to make 'Parking' an autonomous task.

The motion can be made smooth and clean using sensors to avoid any collision by processor-controlled motion of vehicle within the available space. The 'Parking maneuver' is achieved by simultaneous and coordinated control of steering and speed, keeping constant check on actual situation of surrounding.



2. Methodology

The method by which the system works as follows:

1. Attach proximity sensors at extreme locations of vehicle to cover complete body ensuring no body-part is outside the envelope of sensors.
2. Collect distance data to determine appropriate parking location by the processor.
3. Control whole maneuvering process (propulsion and braking) till desired position is obtained.
4. Continuous check on proximity to ensure zero possibility of collision.

The longitudinal speed control system for the containing speed within specified safe value is developed. The expected speed tracking can be done by the speed data gained from vehicle itself. The speed data can be obtained by the control system to analyze the condition and throttle and brake control.

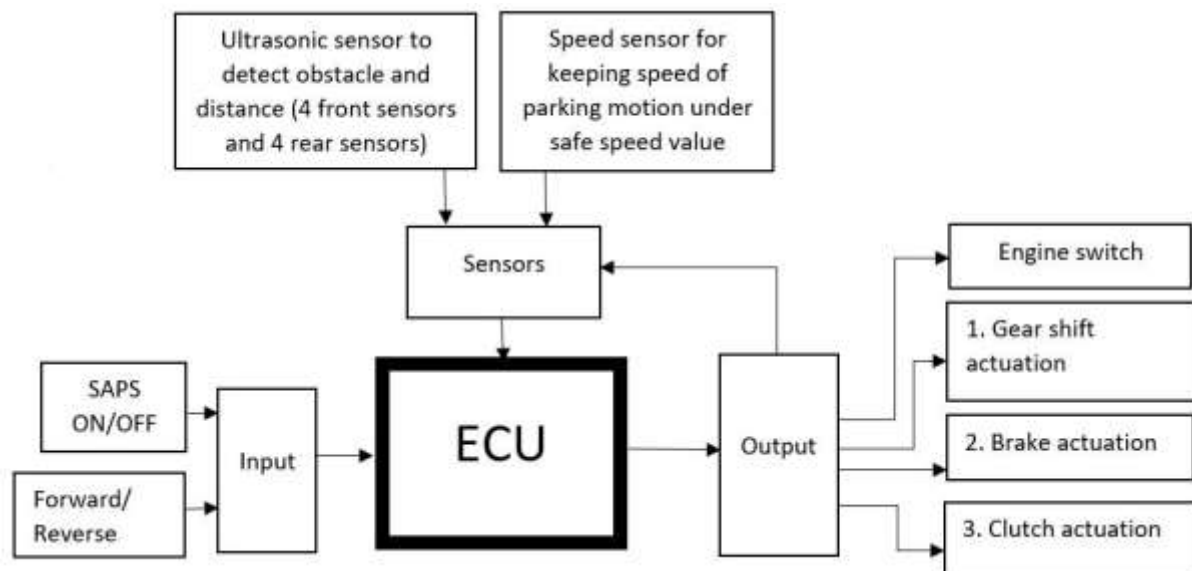


Figure 1. Block diagram of the ECU system.

3. Location of Sensors

The system features ultrasonic sensors to measure the distances to nearby objects. This is to help reduction in system cost by use of already available resources.

Working of Rear sensors and Front sensors can be activated when respective gear is selected, and other side can be deactivated. This is to be done for avoiding unnecessary warnings when there is no motion towards reverse direction when Drive gear is in action, and vice versa.

Ultrasonic sensors are to be positioned as shown in figure:

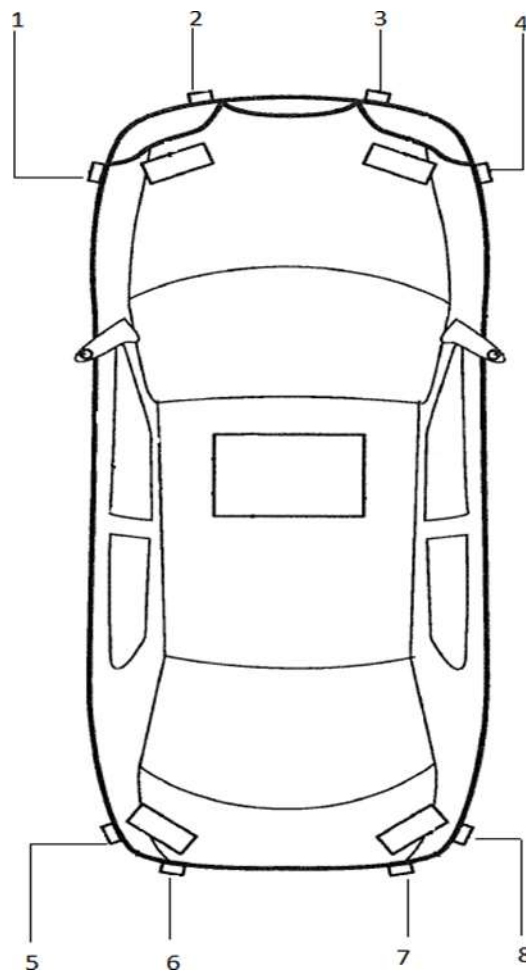


Figure 2. Location of sensors.

4. Development of Algorithm of Automated Parking

The Algorithm was developed to trace the following working method:

Distance data collected from ultrasonic sensors attached to the body of car is to be used to determine relative location of car with respect to obstacles and target parking location.

b. Then a path is to be determined to reach the target location. After this, parking process is to be initiated and moving the car to get the desired target location.

The operational flowchart for the system designed is as follows:

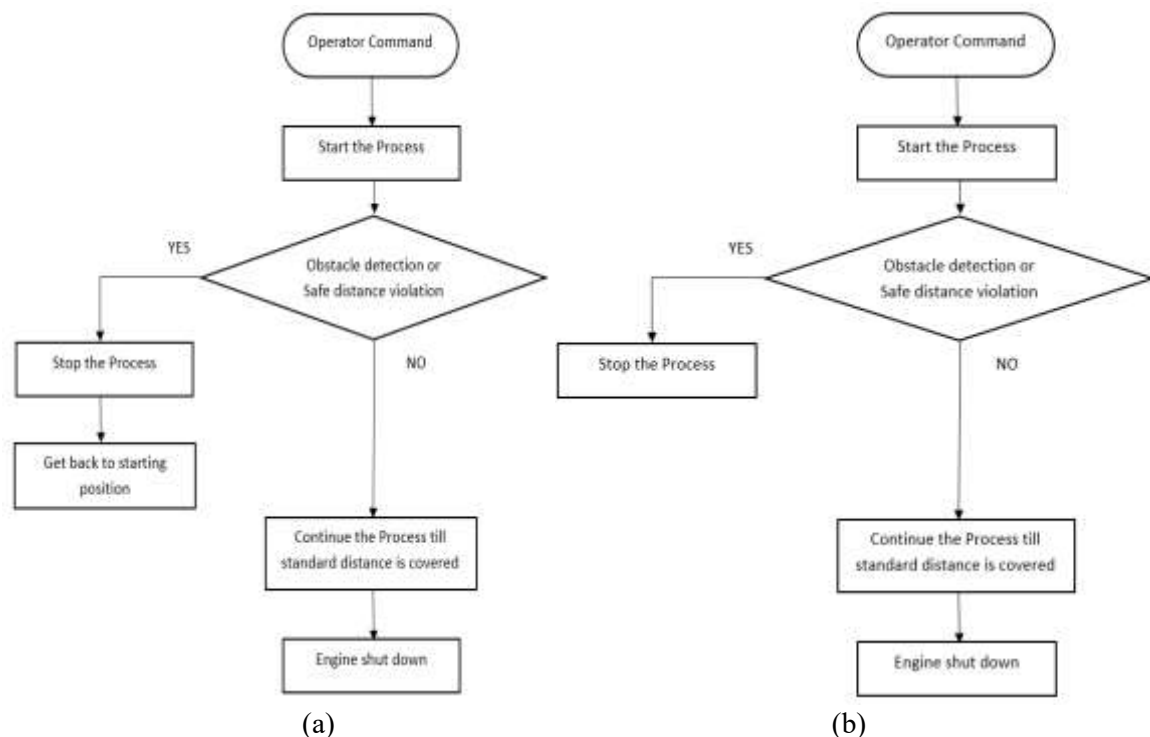


Figure 3. System flowchart for (a) PARK command and (b) CALL-OUT command.

The Algorithm developed is as follows:

- Step 1: START
- Step 2: Read command from Operator (PARK or CALL_OUT)
- Step 3: Initialize system with $DISTANCE = 0$, $VELOCITY = 0$, $STANDERD_DISTANCE = 4$ meters
- Step 4: Start Engine
- Step 6: Shift gear according to received command (Forward motion – Gear D, Reverse motion – Gear R)
- Step 7: Clutch engagement and Motion initiation
- Step 8: Read $VELOCITY$ and check $VELOCITY \leq 10$ kmph. If $VELOCITY > 10$ kmph, control clutch actuation and maintain value of $VELOCITY$
- Step 8: Read $DISTANCE$ while in motion and move until $DISTANCE = STANDERD_DISTANCE$ in given direction
- Step 9: Read distance data from all 8 ultrasonic sensors during motion and check for $SAFE_DISTANCE \geq 0.2$ meters
or When $SAFE_DISTANCE < 0.2$ meters
If task is PARK
- Step 9.1: Stop motion in ongoing direction. Give warning notification to operator and get back to the initial location by moving distance $DISTANCE$.
If task is CALL_OUT
- Step 9.2: Stop motion in ongoing direction and give warning notification to operator.
- Step 10: If $DISTANCE = STANDERD_DISTANCE$, Stop the motion and Notify the operator about the completed task.
- Step 11: Shut down the Engine
- Step 12: STOP

5. Simulation Scenario

For simulation of this Autonomous system, environmental assumptions are set for standard working scenario of system. The assumptions are:

1. Working area is horizontal which is free from any irregularity.
2. Parking space is surrounded as shown.

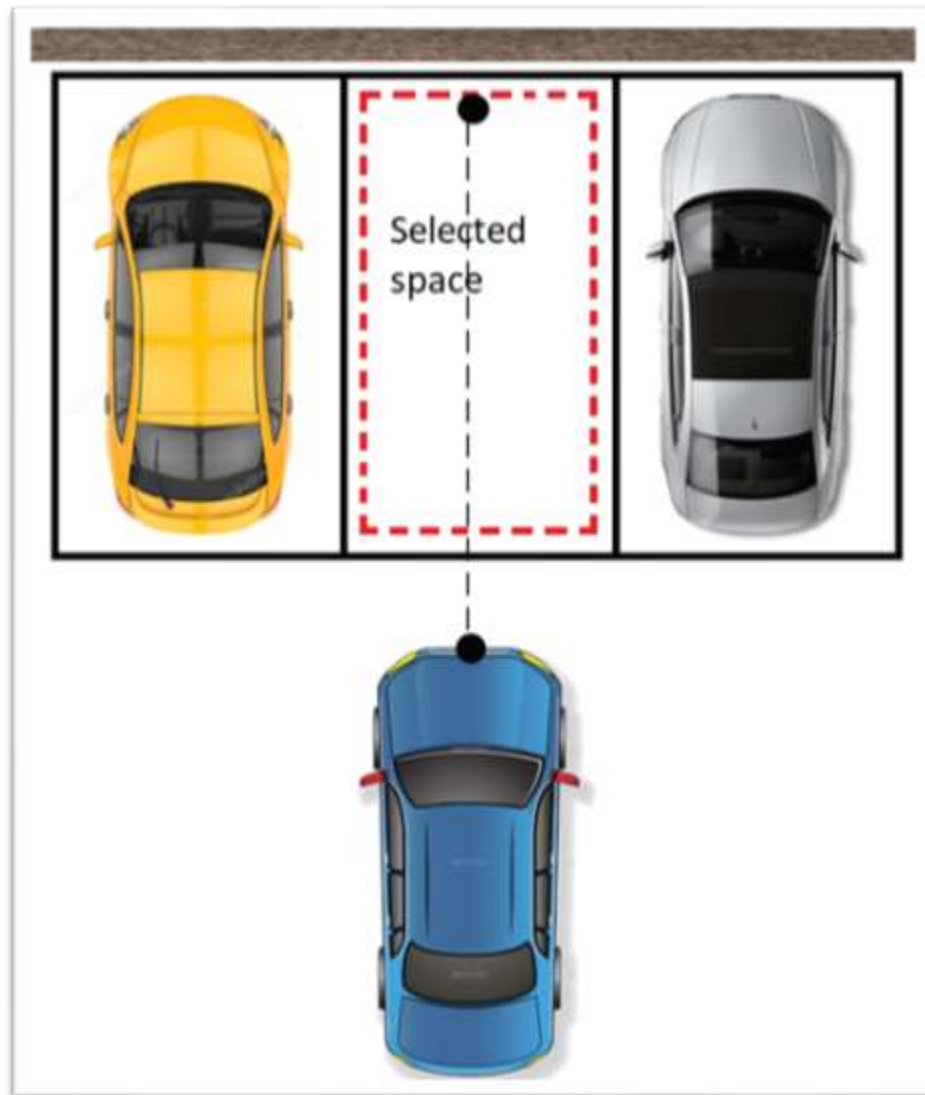


Figure 4. Target parking space.

Initial state for parking function to initiate is:

1. Engine is off.
2. Brakes are free.
3. Gear position is Neutral.
4. Steering wheel is CENTRE position.

Distance constraints are as follows:

1. Safe distance on Left and Right side is 20 cm.
2. Safe distance for Front and Rear area is 15 cm.
3. Standard distance to be covered in Parking function is 4 meters (Assuming that Ego Car body length is 3.5 meters)

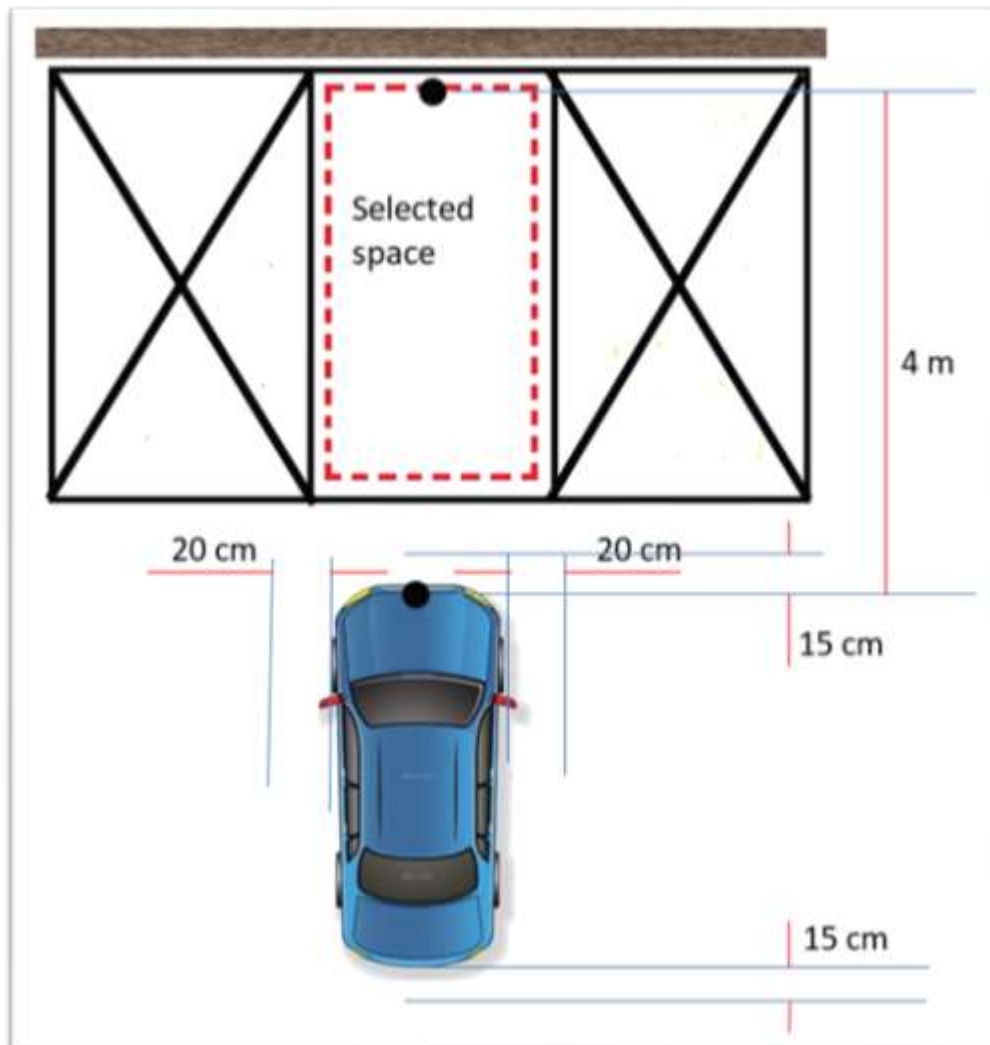


Figure 5. Positions and distances.

Vehicle model is to be prepared as follows:

Ego car: Rectangular body

Length = 3.5 meters

Width = 1.7 meters

y = Global Y position of the car point

v = Speed of the car

d = Distance measured from initial position of motion

T = Throttle position (Positive for Acceleration)

Manipulative variable

G = Gear position (D or R)

6. Simulation Process

The simulation is done on MATLAB SIMULINK to examine the prepared control method. The overview of the system is shown in following figure:

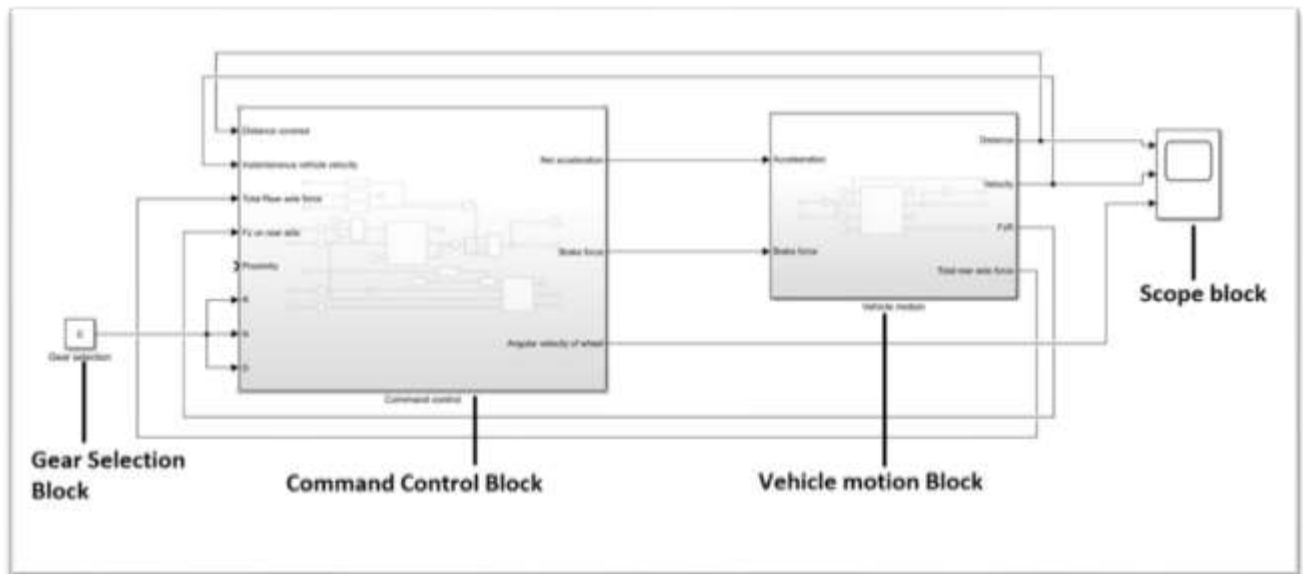


Figure 6. Overview of Simulation system.

The simulation process comprises Vehicle motion block and Command control block. The Vehicle motion block takes Acceleration and brake force as input and gives Distance traveled, Instantaneous velocity and Rear axle forces as output. This works as a last block of simulation Process. The Command control block have inputs from User as Front Parking, Reverse parking, or Callout; Nearby object distance data from Proximity sensors; and feedback data from Vehicle motion block which is used in controlling the motion giving Net acceleration, Net brake force as output.

Each of them is explained as follows:

1. Command Control block:

This block is going to control all actions of vehicle according to surrounding conditions and given command. The block is developed so far as given below:

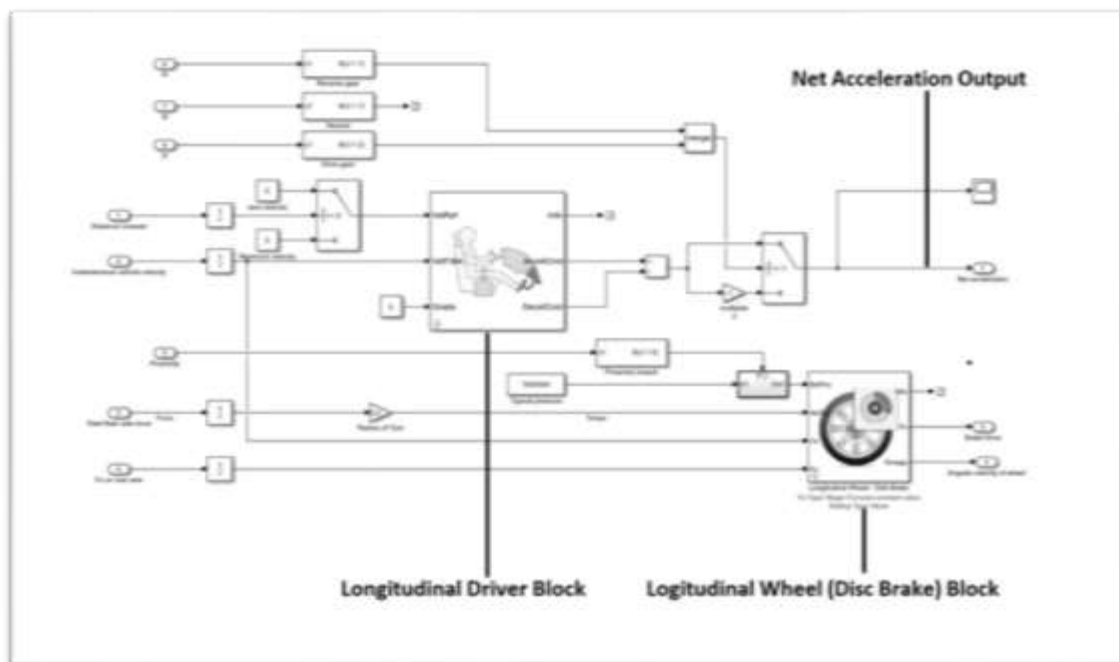


Figure 7. Command Control Block interior.

2. Vehicle motion block:

This block receives the control signal from Command control block such Acceleration and Brake force and performs motion of vehicle. This block will simulate the vehicle motion and gives output as Distance covered, Velocity of motion and Rear axle force. These outputs are further used by Command control block for keeping vehicle motion parameters in check, whereas the Distance and Velocity shows the behavior of test subject. The block interior is as shown below:

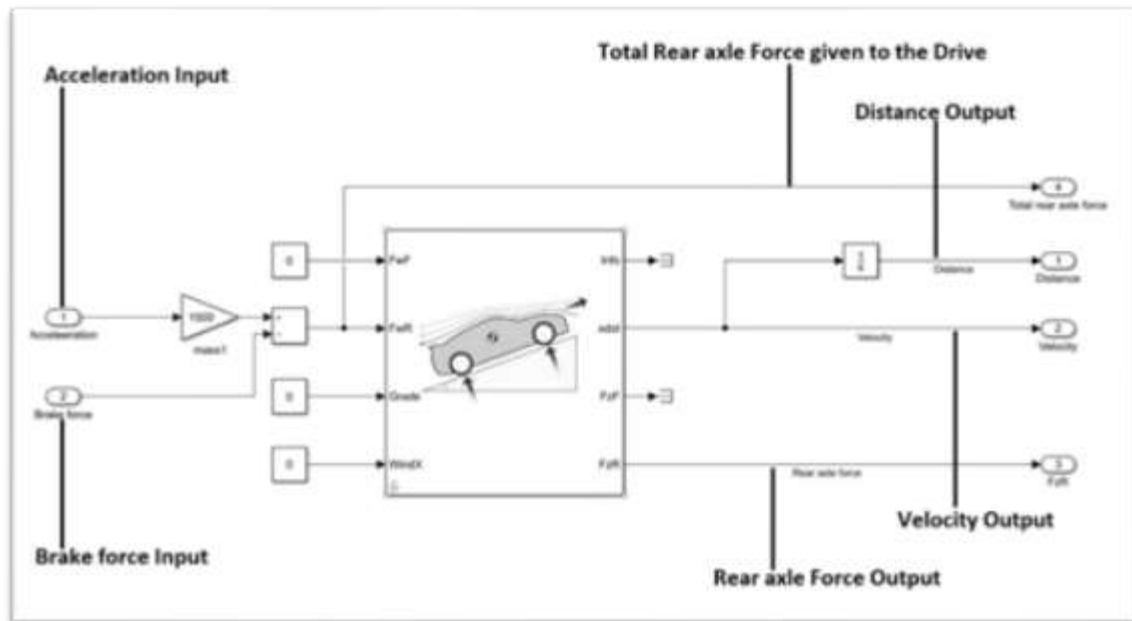


Figure 8. Vehicle motion Block interior.

7. Simulation Results

The Simulation process was conducted on three different cases:

1. Forward Parking:

a. In this case, the car engages DRIVE gear and commences the motion towards parking space. The initial distance is set as Zero. As the motion progress, the distance counters starts and measures to 4 meters. After that, the motion ceases and Car stops. This case is shown in following graph:

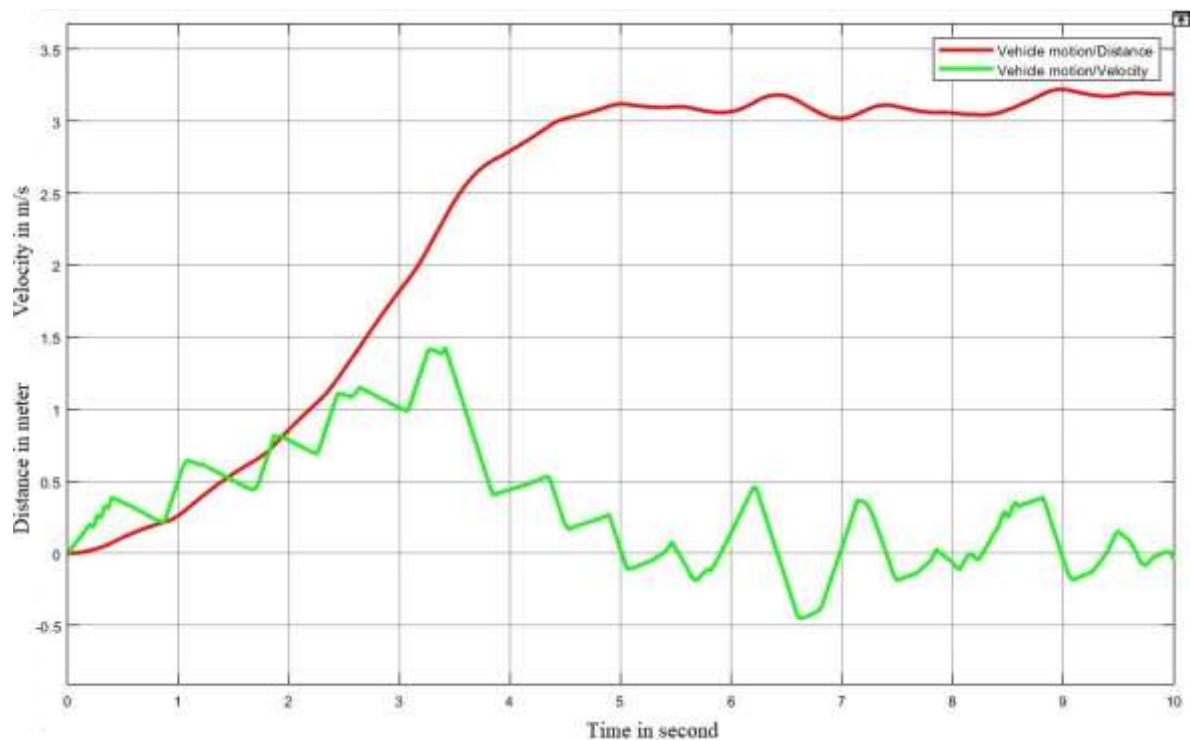


Figure 9. Forward Parking motion parameters behaviour

The Red line indicates the distance covered by vehicle during the process. The Green line shows the velocity of motion. As the car reaches the maximum distance (Here it is 4 meters), the velocity reaches gradually to zero.

- b. In case there is any obstacle in the motion path (here, at 2m ahead), the car will stop before that by controlling throttle and brake functions and will get back.

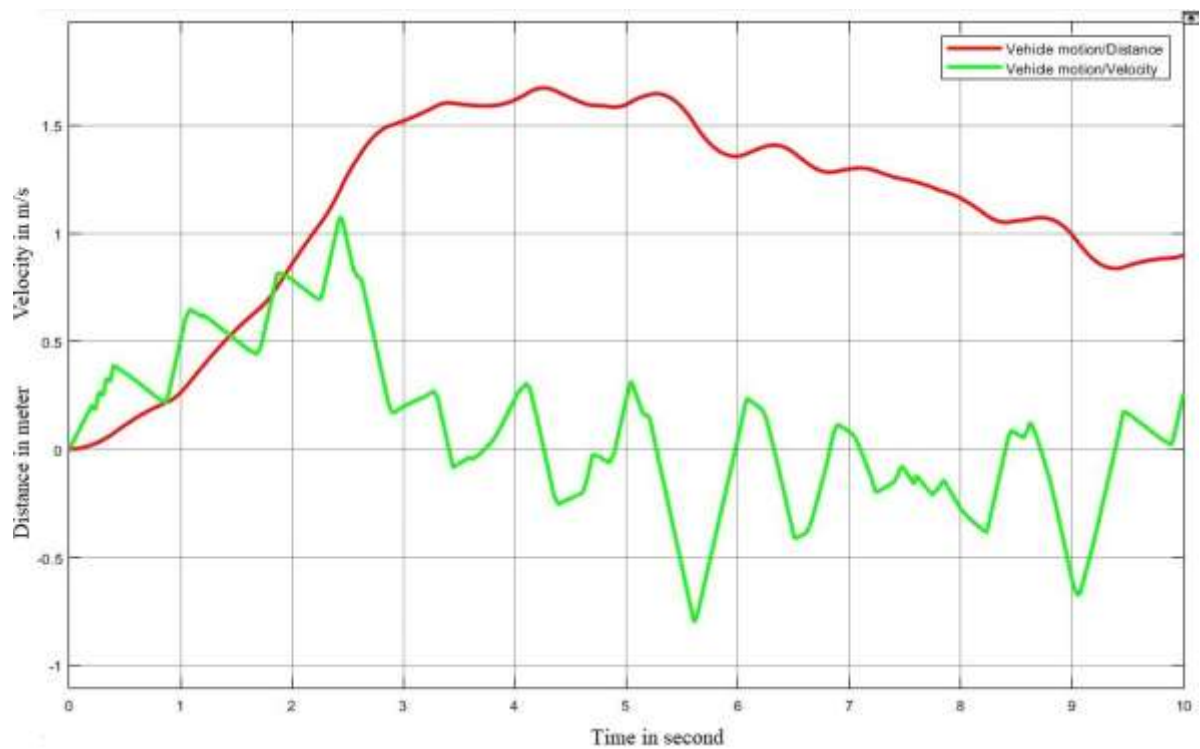


Figure 10. Forward Parking Obstacle detection behaviour

c. During Retrieval, the motion behaviour of car is as shown below:

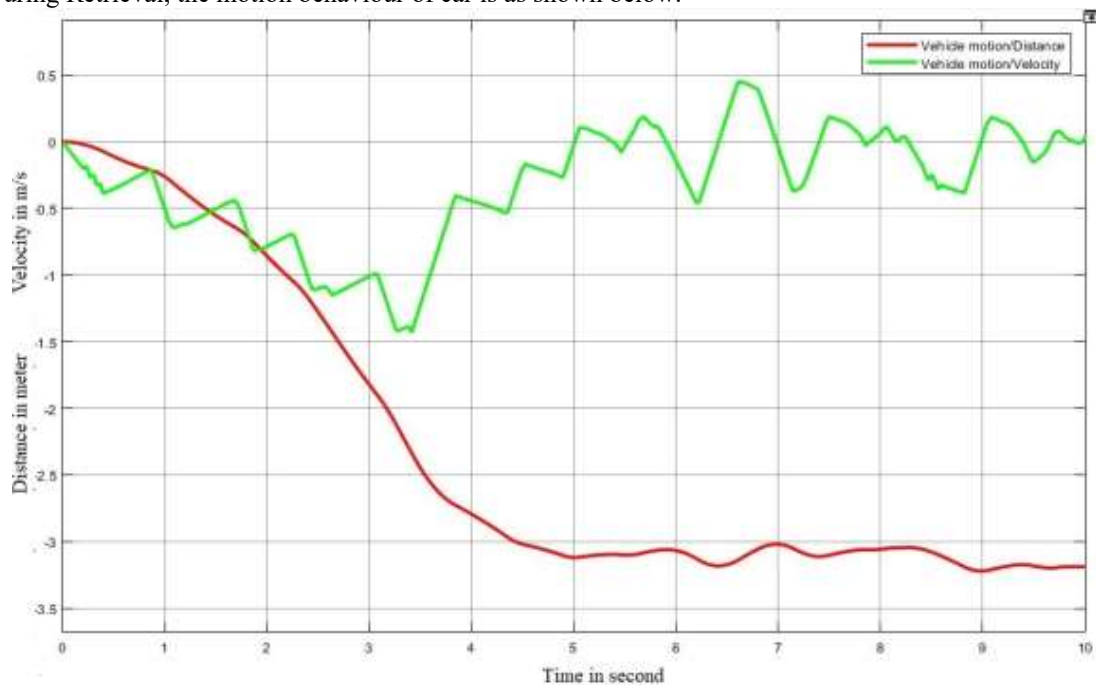


Figure 11. Forward Parked Retrieval motion parameters behaviour

2. Reverse Parking:

a. During this case, the process starts with shifting gear REVERSE. Then, the initial distance is set as Zero by the counter. As the motion progress, the distance counters starts and

measures to 4 meters. After that, the motion ceases and Car stops. This case is shown in following graph:

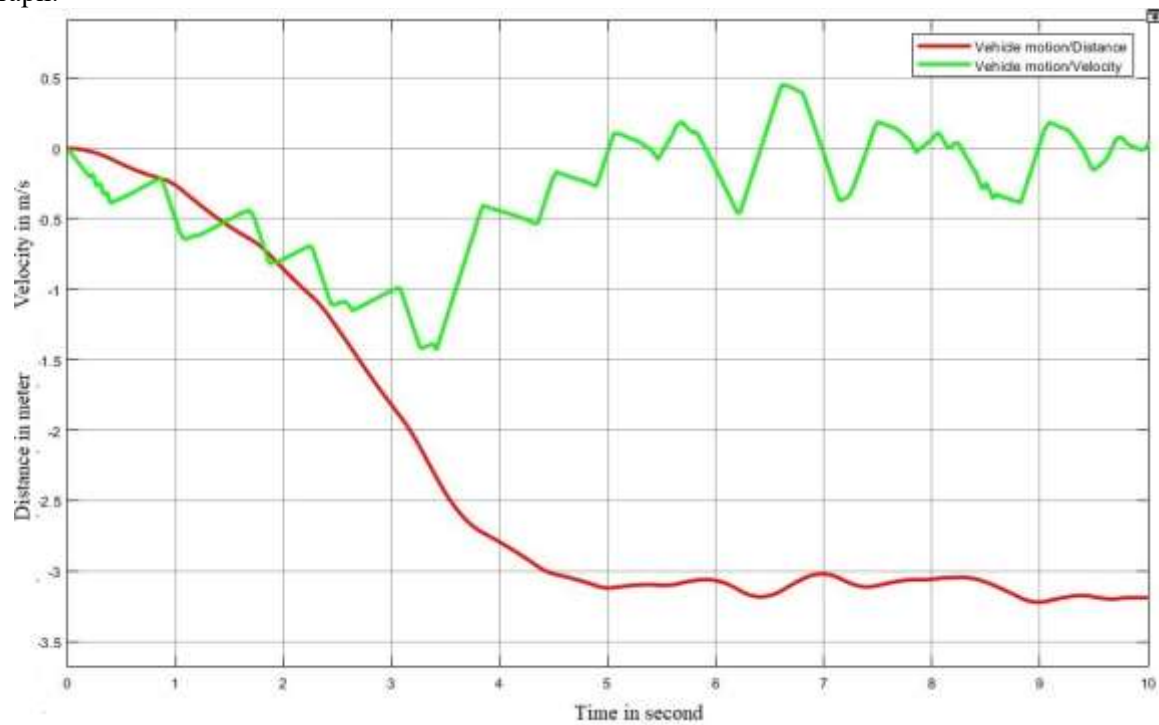


Figure 12. Reverse Parking motion parameters behaviour

b. In case there is any obstacle in the motion path (here, at 1 meter behind), the car will stop before that by controlling throttle and brake functions and will get back to initial position.

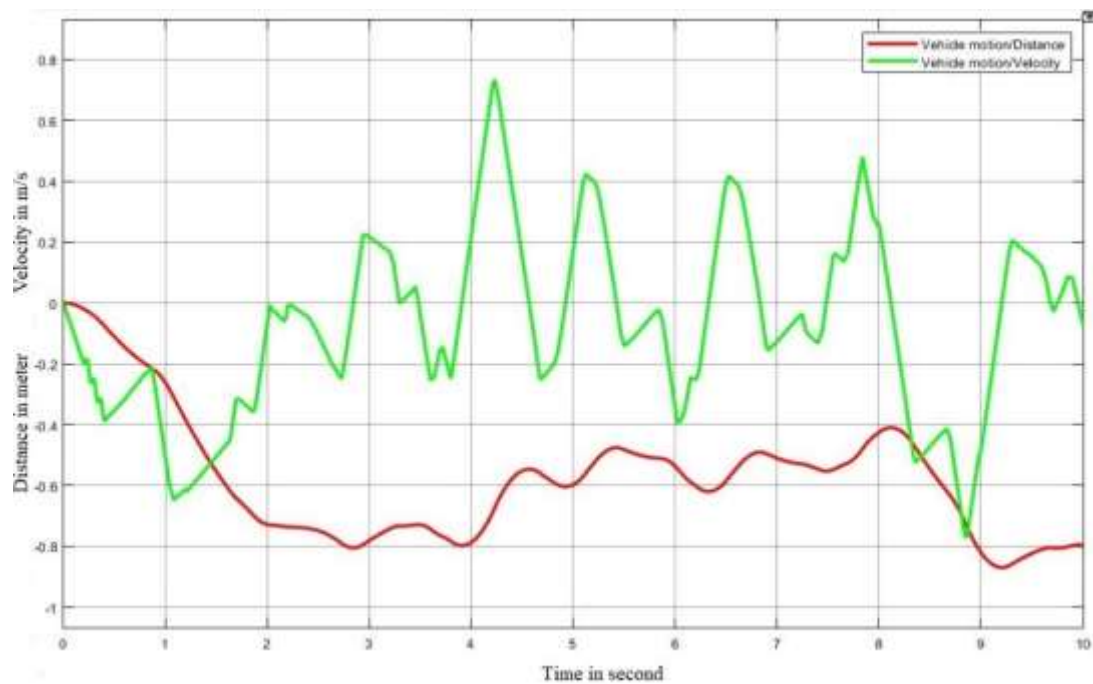


Figure 13. Reverse Parking obstacle detection behaviour

c. During Retrieval, motion characteristics are as shown below:

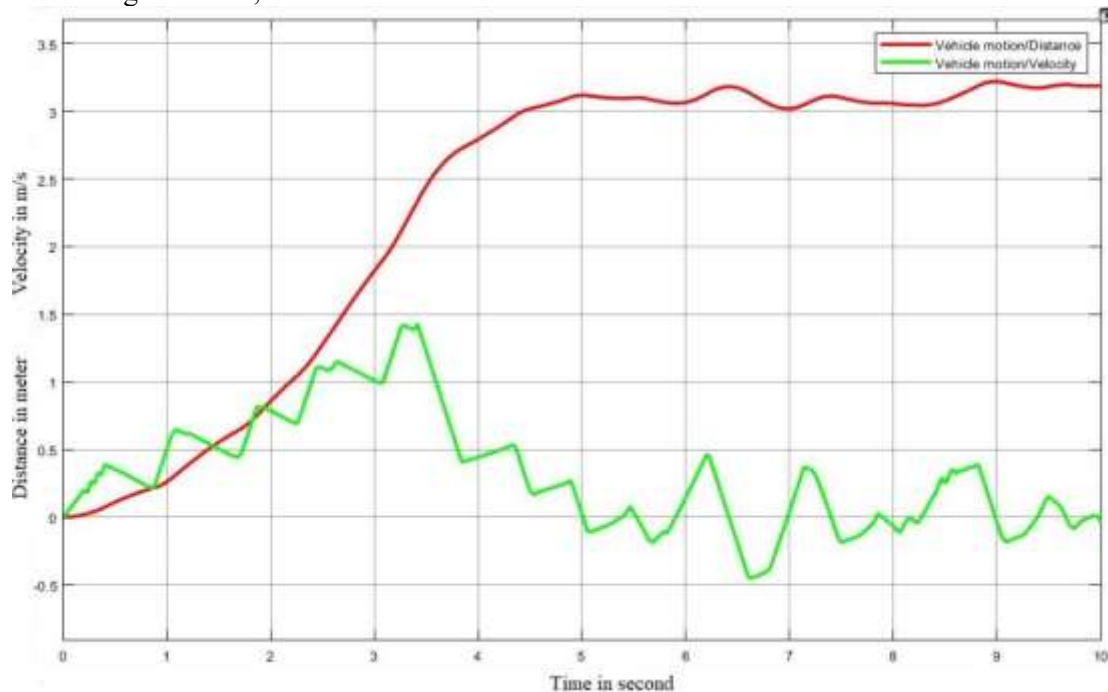


Figure 14. Reverse Parked Retrieval motion parameters behavior

8. Conclusions

The system architecture for Semi-Autonomous Parking System is thoroughly studied with the help of Literature Review and its possible new development have been proposed in this report.

The concepts rely on cheap sensors that are already used in conventional cars, along with a processor and communication device for user command. The designed algorithm and procedure for motion control is simulated on MATLAB SIMULINK. The proposed system starts by manual switch command for Forward or Reverse Parking. The proximity sensors around the body activates and gives distance data to the ECU of Parking Controller. The vehicle moves obeying given command with specified motion velocity and Distance covered. Any obstacle detected will be treated according to the task. During this, any possible collision between Car and surrounding objects is avoided by continuous check on distance from the nearest objects. If any obstacle is detected at any point of process within decided action sequence and distance parameter, the car will stop the motion in the direction and will:

- STOP and get back to initial position when working on Parking function and
- STOP and stay in the same location when CALL-OUT function is running.

As the PARK function or CALL-OUT function is completed, the vehicle will stop and will notify the user about completion. After that, system will switch off and the system will transfer control to the user. The method is capable of parking the car in straight line in Forward and Backward parking position by input commands given by the user. The Distance movement control is within 75% accuracy.

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