AUTOMATED PARKING SYSTEM

Project Report

EKLAVYA MENTORSHIP PROGRAMME

At

SOCIETY OF ROBOTICS AND AUTOMATION,
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Abstract

Vehicle automation, autonomy and connectivity is a subject of mechatronics integrating many engineering disciplines including electrical, mechanical, control, and computer engineering (and technology). It is fundamentally changing the concept of automobile transportation and manufacturing. Therefore, developing new, technologically progressive curricula and hands-on lab as well as student project materials is desired to prepare for the future workforce needs of autonomous cars in the automotive industry. This "Automatic Vehicle Parking System" is a research and concept-proving project that will be prepared and extended to develop teaching materials for courses and students project on the subject of vehicle automation, autonomy and connectivity. In this project, an RC (remote-controlled) toy car is modified by integrating ultrasound sensors and Arduino with a high current shield to control the vehicle movements and the parking processes. Parking strategies and the corresponding algorithms are explored and programed through Arduino. During testing, the car is able to move to detect the imitated "roadside" environment, judge a space suitable for parking or not, and then drive to park automatically. A 3D printer is utilized to build the parts needed for modification. Student working processes of design, hardware modification, as well as the algorithm and coding procedures are observed and evaluated for systematic course material development

INTRODUCTION

The introduction of vehicle automation, autonomy and connectivity is fundamentally changing the concept of automobile transportation. Although many automated, autonomous and connected vehicle technologies are still in development in lab, some of these technologies are already available and demonstrated by the prototypes such as Google and Toyota self-driving cars. Therefore, developing new, technologically progressive curricula and hands-on lab as well as student project materials is desired to prepare for the future workforce needs of autonomous cars in the automotive industry. According to the U.S. Department of Transportation, automated and autonomous vehicles refer to the vehicles with safety-critical control functions that do not need direct driver inputs, including steering and braking1. They can also be connected to communicate with infrastructures or other vehicles wirelessly. In the United States, there are over 5 million crashes each year, killing over 30 thousand people and causing more than 2 million injuries2, 3. It has been reported that 94% of all traffic accidents involve human errors, which would be favorably influenced by collision warning systems that rely on vehicle automation and connection4. Toward this end, the understanding of vehicle automation, autonomy, and connectivity will have a broad impact on improving driver safety and reducing the number of casualties in road accidents even further. We look forward to building curricula with courses and projects providing the students hands-on experience of mechatronics on automotive sensors and control modules building, as well as system integration

Project Description

The project is focused on achieving a single task (automatic parking) by integration of sensors and actuators controlled by microcontroller and strategy planning/coding, therefore the vehicle platform is not built from the parts but from modifying a RC toy car instead for saving the time. There are generally three kinds of parking patterns: parallel, front/back-in perpendicular, and with an angle (usually 45 degrees), and this project is just focused on the parallel parking. The modified toy car is expected to do the following tasks in a complete automatic parking process:

1. Drive along an imitated road-side environment and detect the distance from the car to the road-side obstacles such as parked cars or just curb on the right hand side.
2. Once the length of a parking space larger than the length of the car plus a buffering distance is detected, the car will stop automatically.
3. Perform a smooth and efficient parking behavior according to the relative positions of the car and the parking space.

PARKING STRATEGY DESCRIPTION

1. Detecting a proper size parking space After the switch is turned on, the car starts moving in a constant speed along the "road" with a fixed distance from the other "parked cars". Once the car passes an empty space, the two side sensors will judge if the "depth" of the space larger than the car width for parking. If the parking space is not wide enough, the car will continue moving; while even if the space width is large enough, the car will still keep on moving to measure the space length. The ultrasonic sensors collect real-time distance measurements and record the moments of sudden distance changes. The information will be sent to the Arduino micro controller to calculate the length of the empty parking space. If the parking space is longer than the length of car by a distance lb, for instance, 10 cm in our example, the car will automatically stop, usually overshoot by a distance from the front end of the space. Otherwise, the car keeps running until finding the next available parking spot. Once the car finds a suitable parking space and stops, it either starts the parking process or waits until the "driver" pushing a switch to start the parking process. Figure 3. The moments the car pass the parking space edges where the sensors detect significant distance differences.

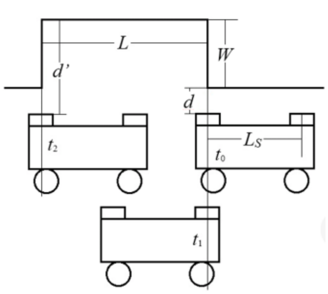


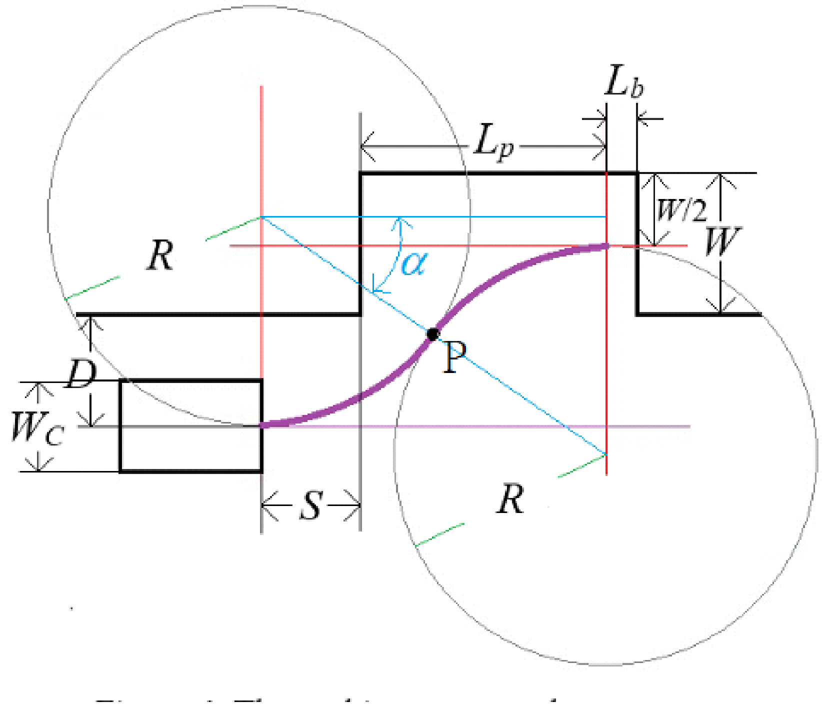
Figure 3 demonstrates the picture of the setup and strategy of this space finding process.

Two ultrasonic detectors are mounted on the right hand side of the car by a distance LS, one is located around the front wheel and the other is near the rear wheel. Since no speedometer is installed in this toy car, the distance between the front and rear sensors must be utilized to decide the parking space length. The ultrasonic sensors can collect real-time distance measurements from the car to the road-side objects. Once the sensors detect significant distance changes, the corresponding time is recorded and sent to the Arduino microcontroller to calculate the empty parking spot length L, which is given by

$$L = \frac{t_2 - t_0}{t_1 - t_0} L_S,$$

where LS is the distance between the front sensor and the rear sensor, t0 is the time that the front sensor detects the first significant distance change, t1 is the time that the rear sensor detects its first significant distance change, and t2 is the time that the front sensor detects its second significant distance change. Meanwhile, the average speed of the car v can be obtained by

$$v = \frac{L}{t_2 - t_0} = \frac{L_S}{t_1 - t_0}.$$



.Figure 4. The parking curve and parameters.

2. Driving in the parking spot

One of the simple parking paths is along the curve composed of arcs from two circles with radius of the minimum circle the car can turn10. Ultrasound sensor data feedbacks are used for more accurate controlling in this parking process. The parking curve and parameters are demonstrated in Figure 4. The purple curve is the trajectory of the rear center of the car, and Lb is the rear buffering space. The angle α can be expressed as

$$\alpha = \sin^{-1}\left(\frac{2R - D - W/2}{2R}\right),$$

$$D = d + \frac{W_C}{2}.$$

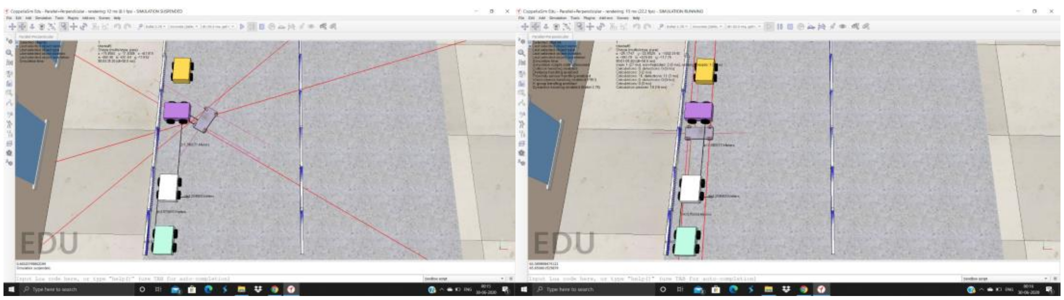
Taking the car out of parking lot is same as before but in reversed order

EXPERIMENTAL RESULTS

The car detects the parking space checks if the condition is satisfied then it performs the parking function.The car parks itself without colliding with other cars or the wall with the help of sensors in the front and back as well as the sides

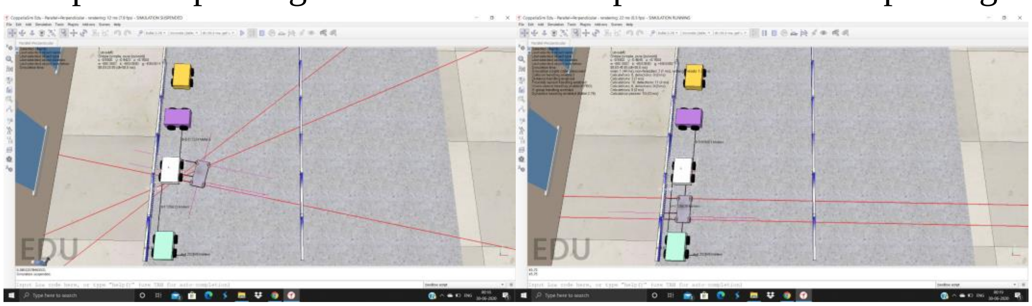
PERPENDICULAR PARKING

The perpendicular parking takes only one 90° arc

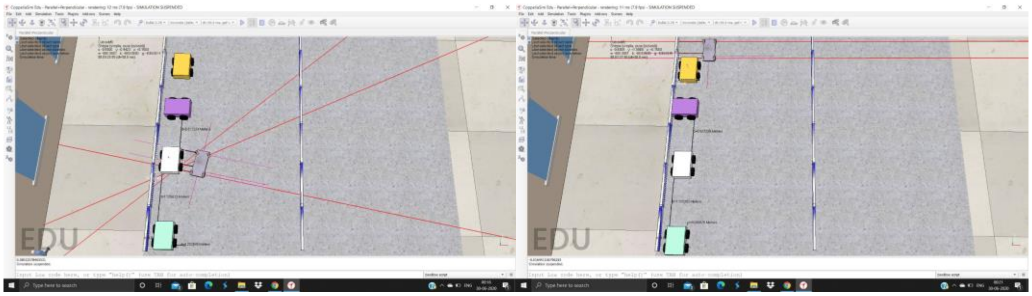


PARALLEL PARKING

The parallel parking takes two arcs as explained above for parking



Exit from parking lot



Parallel Parking: https://youtu.be/n02HSPTUTH8

Perpendicular Parking: https://youtu.be/cG3JKu5vsXQ

CONCLUSION

The major object of this project is to evaluate the work load and time frame of implementation a similar or equivalent project on the topic of autonomous vehicles in student senior project and final project of instrumentation/mechatronics courses. Automatic parking is an autonomous car-maneuvering system that moves a vehicle from a traffic lane into a parking spot to perform parallel, perpendicular, or angle parking. The automatic parking system aims to enhance the comfort and safety of driving in constrained environments where much attention and experience is required to steer the car. The parking maneuver is achieved by means of coordinated control of the steering angle and speed which takes into account the actual situation in the environment to ensure collision-free motion within the available space.The source code can be found in
GITHUB LINK-https://github.com/kart1802/Automated-Parking-System.git

ACKNOWLEDGMENTS

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REFERENCE

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https://www.researchgate.net/publication/319853826_AUTOMATIC_PARKING_OF_SELF-DRIVING_CAR_BASED_ON_LIDAR