A Solution to the Parallel Parking Problem

Sinan Öncü and Mürvet Kırcı

Faculty of Electrical & Electronic Eng.
Technical University of Istanbul, İstanbul, Turkey

Abstract. Nowadays parts of a car have been designed form in which make us easy driving. One of the driving problems is parallel parking. This study gives a solution with an algorithm to the parallel parking problem. Simulation of the solution including all cases in the parallel parking has been made based on this algorithm. Implementation of the simulation has been made as a robot car. The approach has been integrated into an automated parking system, and implemented a modified car. It shows the potential to be integrated into automobiles.

1 Introduction

This work is related with a mobile robot car (MCR) solving parallel parking problem. Parallel parking is a method of parking a vehicle in parallel to the other car. It is proposed to develop a parking helper system which is possible apply to the real car. Autonomous parking is necessary sensing environmental conditions, calculating the dynamic paths. In this work implementation of parallel parking algorithm on mobile robot car will be presented. The parallel parking involves many problems such as recognition of driving circumstances, maneveuring and vehicle control. In the literature there are some works related with this subject. Yasunobu and Murai have purposed a controller based on hierarchical fuzzy control.[1] Jenkin and Yuhas have reported a simplified neural network controller.[2] These algorithms are based on the kinematics data to formulate intelligent controllers.Lo et.al have presented an automated parallel parking strategy for a vehicle like robot[3]

In our system works in three step; scanning, calculating and parking. In scanning step the requiring parking area is scanned by infra red sensors. Then in second step the car is moved to a suitable parking area where the parking maneveurs can begin. The required maneveurs for the parking step are calculated dynamically. In the last step MCR follows the path to the suitable location. Parallel parking algorithm and implementation on the MCR is discussed in section 2. In the section 3.application of the algoritm is explained. The application consists of two steps. First,a visual computer program running in PC environment is developed in order to simulate the approach above. In the second part, hardware implementation of the parallel parking algorithm on a MCR and modules that are used will be explained.

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2 Parallel Parking Algoritm

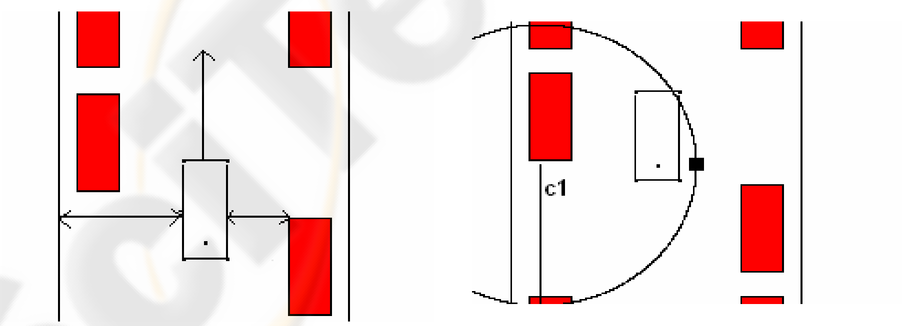
A mechanical system consists of different compenents. In this case where the deformations of the body are significant compared to the motion of the body as a whole body is called a rigid body The idealization allows us to reduce the equations needed to describe a rigid body.[4] In this work the system has been assumed as a nonholonomic system.[5-7] In this method datas from the sensors and closed loops for dynamic circumstances are used. In this section it is given an algorithm to solve parallel parking problemof MCR.There are three step in this method.

a) Scanning Step

In scanning step it is determined potential places using closed loop controls so that it does not hit around objects and borders. MCR is parallel y axis in initial case. Every action loop for parking is correspond to a displacement 1cm direction in +y axis. As the angle of the steering was zero degree, x axis and the angle of the position of the MCR do not change. The action of the MCR is forward. It seeks a convenient parking place acting in low velocity. Sensors mounted to the left and right side of MCR give necessary knowledge for seeking. The sensor in font of the MCR also gives some knowledge about a possible accident undesired will be done. After every action loop correspond to a scanning 1cm has been finished the variables of the parking area are updated. Distance between MCR and other parked vehicles are also noted in memory. When the variable of the parking area has exceeded a fixed value specified with dimensions of MCR, this fixed value is pointed as a potential target. The center of the circle C1 is settled on a line perpendicular to this point on the coordinate plane.The center of the circle C1 is calculated by following formulas:

$$\begin{aligned} C1x &= fx + \Delta x - R \\ C1y &= fy \end{aligned} \tag{1}$$

Where Δx displacement. If parking area has suitable dimensions it will be passed to the calculating step



(a) (b)

Fig. 1. (a) The car is seeking a park place. (b) The center of the circle C1 is being calculated.

b) Calculating Step

When the convenient parking area has been found the MCR passes to this step. The aim of the MCR is to arrive a good position for beginning car parking maneverous. This Position is the point specified as a target in the scanning step. Firstly, it is defined a circle which is described points MCR be able to arrive on coordinate plane. Coordinates of the center of this circle are calculated as follows:

$$C2x = fx + R$$
$$C2y = fy \tag{2}$$

To find a point is an intersection of these circles MCR acts forward. Distance between two circles is 2R at this tangent point. Therefore tangent point is

$$\sqrt{(C1x.C2x)^2 + (C1y.C2y)^2} = 2R \tag{3}$$

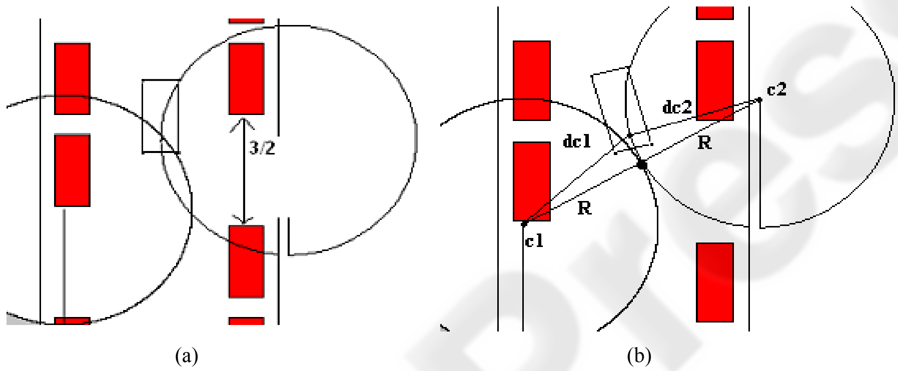


Fig.2. (a) The MCR has found the convenient park place. (b) Parking Maneveurs are being calculated.

Then MCR arrives to the tangent point acting backward with a specified steering angle. At tangent point following equations are satisfied

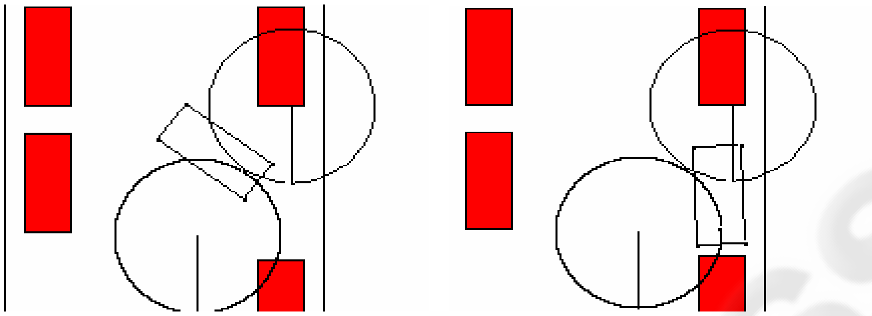
$$dc1 + dc2 = 2R$$
$$dc1 = \sqrt{(fx - C1x)^2 + (fy - C1y)^2}$$
$$dc2 = \sqrt{(fx - C2x)^2 + (fy - C2y)^2} \tag{4}$$

When MCR has reached to the tangent point C1,C2 and F(fx,fy) are situated on the same line. Then MCR realizes steering maneverous inverse direction with same angle value. So it follows arc which is occurred by C1 and passes between the circles

Finally the MCR is backed up with the determined steering angle until its orientation angle is again parallel to the y-axis. The sideways displacement obtained can be observed in the figure 2 (a) and (b).

c) Parking Step

In the parking maneuveurs the same approach is used that was explained calculating step with sideways displacement resulting in the final location where the MCR is desired to be lacated after the parking is completed. Different from the calculating step greater steering angle values are used during parking maneveurs to increase maneveuring capability of the car. The parking maneveurs for the given scenerio are shown in the following figure 3.



(a) (b)

Fig.3. (a) The MCR is doing parking maneveurs. (b) The MCR is arriving to the final location.

3 Application

Application of the parallel parking algorithm on a MCR consists of two steps. First, a visual computer program running in PC environment is developed in order to simulate the approach above. The program allows the user to generate random scenarios for parallel parking. In the first section of this chapter the simulation program is explained In the second part , hardware implementation of the parallel parking algorithm on a MCR and modules that are used will be explained.

3.1 Simulation

In the simulation program, physical model of a MCR is generated first. The coordinates of the reference point F(fx,fy) is the main control point. The corner points of the vehicle are generated with referencing to the reference point.The kinematic model is implemented on this model. After each cycle of the main program loop, coordinate parameters of the reference point are calculated depending on the previous values and steering angle. On this car model four sensors were modelled which obtain the enviromental data from the simulation screen by checking color changes Which is an abstraction of the real world operation of sensors.

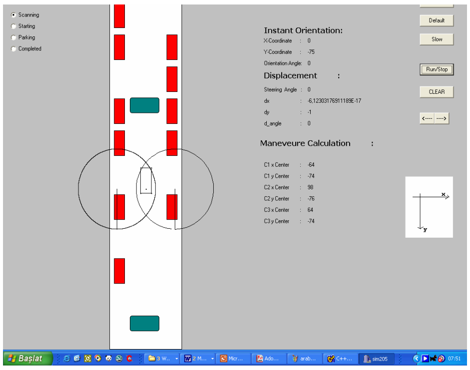


Fig.4. A screen shot from the from the simulator.

A random scenario generator program has been developed in order to simulate the environment. For decision making tasks a program simulation te controller is generated which obtaines the enviromental data, makes decision and sends the control signals to the motion module Simulator. In the figure.4. a screen shot from the simulator running in PC enviroment is seen.

3.2 Hardware

Realizing the parallel parking algorithm on a MCR requires obtaining enviromental data, making decision and driving the car to perform the task.The requirements are satisfied using three modules of hardware:

1.) The sensor module
2.) The Microcontroller module
3.) The motion module

For the parallel parking of the MCR SharpGP2D120 distance measuring infra-red sensors were used to obtain enviromental data.These IR sensors operate between 4~30cm distances which is sufficient for our 20x50cm robot. The experiments showed that sensor data resolution is sufficient in the interval 4-20cm which covers the critical ditances for the parallel parking problemof a MCR wit dimensions 20x50cm. In this project Microchip PIC16F877 micro controllers were chosen because of their large memory size, built in ADC, low price and incircuit programming capability. The motion module consists of two stepper motors and their driver chips, the ULN2003A. Stepper motors are used for both steering and driving of the robot because accurate control on the motion of the robot is needed for the controller software to predict the displacements of the robot body.

A MCR has been developed with 20x50 cm dimensions. This a four wheeled rear-driven car with front-steering wheels. It is equipped with 2 stepper motors. One of the stepper motors is used for driving and the other is used for controlling the steering system. 4 IR sensors are placed on the robot.

4 Conclusions

The parallel parking algorithm introduced in capter 2 has been realized on the car-like robot (MCR) using closed loop control and path following methods. The approach was verified with experimental studies. The method can be used in different sized cars by modifying relevant parameters (car length, width etc.) in the controller software.

The approach solves the parallel parking problem for a general case. The approach can be implemented on more complex scenarios which include various parking spaces with the use of hybrid sensor systems for better modeling of the environment.

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