Autonomous Vehicle Reverse Parking System

S. Julius Fusic[a], J. Madhubalan[a], K. Gautham[a], Dr. L. R.Karl Marx[a]
[a]Department of Mechatronics Engineering,
Thiagarajar College of Engineering,
Madurai – 625015, India

***Abstract*:- Parking is considered to be one of the hardest thing for the driver's while driving the car which leads to high stress maneuver. This paper proposes the concept of autonomous reverse parking system where vehicle is going to park in its respective slot. The first step is to identify whether the slot is vacant or occupied. For this the Image processing techniques are used to identify it. Here the vacancy is determined in both ways, first with the help of slot markings and other with the presence of vehicle in the slot. After the detection of the vacant slot, with the help of MATLAB programming path for the vehicle to follow is being generated. This mainly deals with the steering angle of the wheel and the dimensions of the vehicle. So that vehicle park's safely in its slot. In order to ensure that the vehicle is following in the path generated by the MATLAB commands Kalman filter tracking techniques are used. By this we can able to park the vehicle autonomously in the parking slot. Also the hardware was developed to interface with raspberry pi to implement in four wheeled robot.**

Keywords: Autonomous parking; parking slot detection; entropy minimization; invariant image; path planning, path tracking.

In every major cities parking is limited due to traffic congestion, pollution, and driver frustration. In order to identify the vacant slot and to park the vehicle in the empty slot is considered to be the ridiculous work for the driver. Thus innovative parking systems should be adopted in order to overcome the needs in the parking environment. With the effective functioning of the electronic technologies, wireless communication, control techniques can provide service oriented parking systems and improve the driver experience. So far many new innovations have been adopted in different types of car parking systems but still all of them requires some degree of human interventions. For example the driver need to take control of the brake pedal in case of Toyato prius and BMW 7, in this the system, control of steering wheel is automated.. Generally parking is of two types. They are reverse parking and parallel parking. The proposed concept deals with the reverse parking system where the vehicle is going to park with respective of the parking slot. In order to park the vehicle autonomously three important steps are to be analyzed they are target position designation, path planning and path following or tracking.

1. METHODOLOGY

1.1 Detection of Vacant Slot:

The first step in this proposed concept is to identify whether the slot is vacant or occupied. For this two different kind of methods are utilized one by detecting the slot markings and other by detecting the presence of vehicle in the parking slot. The Standard Hough Transform (SHT) [1] was implemented with the help of the Hough function. This Hough function is mainly based on the parametric representation of lines.

$$\rho = x*\cos(\theta) + y*\sin(\theta)$$

where ρ is distance from the origin and the vector perpendicular to the line and θ is the angle of projections measured in the clockwise direction from the x-axis. Here the θ varies from -900<= θ =+900.The parameter space matrix is being implemented by the SHT functions whose rows and columns are filled by the ρ and θ values. The SHT elements are being represented in the accumulator cells. Initial value of this cells are assumed to be zero. Then for value of ρ, value is calculated and the values are correspondingly incremented in the accumulator cells.

1.2 Line Detection Algorithm.

The second method of detecting the slot markings from the image obtained from the parking environment is Line detection algorithm [1]. The collection of the four kernels (refer with: Fig.1) shows the kernel for each point obtained in the image. With the help of this kernel applied over the obtained image the slot markings such as horizontal lines, vertical lines, +45 degree lines and -45 degree lines are being detected.

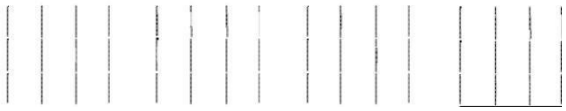


Fig.1. horizontal, vertical and oblique (+45 and - 45 degree) kernels for line detection.

By applying this above mentioned technique the following observations are being made as mentioned above slot marking are determined using Hough transform [1] (refer with: Fig.2 (a) and Fig.2(b)) and line detection algorithm (refer with: Fig. 3).

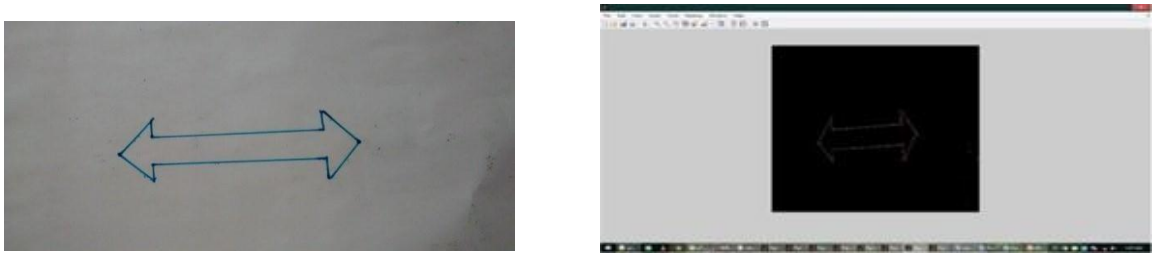


Fig.2: (a) Input image for hough transform (b) Hough transform result image for given input sign.

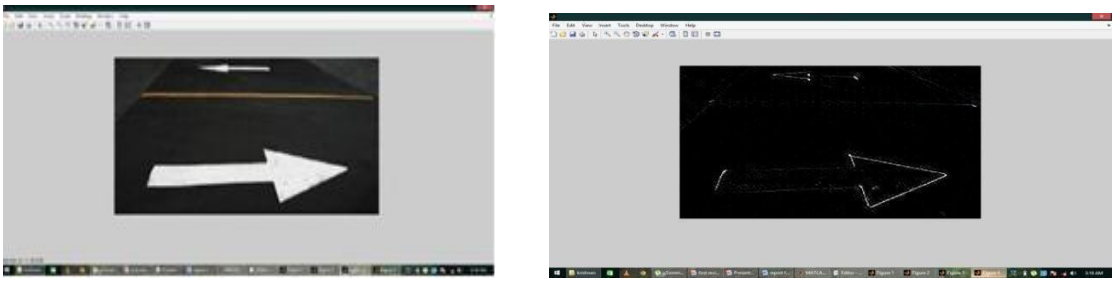


Fig 3: (a) Input image for Line detection (b) Line detection result image for given input sign ($+45^0$ and -45^0 lines are detected)

1.3 Entropy minimization for shadow removal

In this concept the main idea is to remove the shadow of the image under different illumination so that the vehicle present in the parking slot can be detected. For this method first we have to convert the obtained RGB values into 2-D band ratio chromaticity space. After that logarithm are applied over it in order to make all values in the straight line of the 2-D plot under different illuminations. Therefore the gray scale image with inherent reflectance properties are being obtained. The log chromaticity of each pixel as {log(R/G),log (B/G)}, appears as a dot in a 2-D plot. Consider the RGB color R formed at a pixel,

$$Ck = Rk / Rp \qquad (2)$$

Where p is one of the channel and k=1,2 indexes over the remaining responses. Here we use p=1(when divide by red) and so calculate c1=G/R and c2=B/R. By applying this technique the vehicle in the parking slot is being detected was shown (refer with: Fig.5).

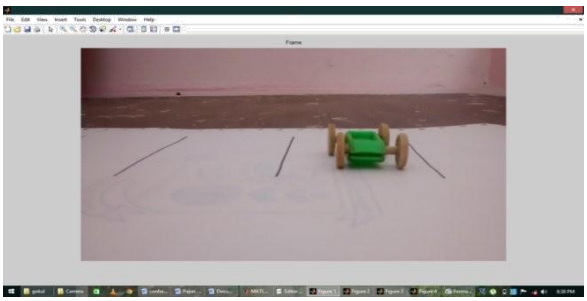


Fig 4: Image of parked vehicle in parking slot

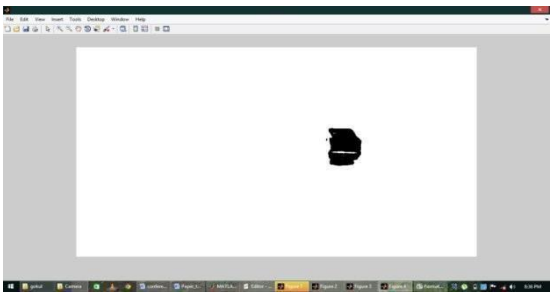


Fig 5: Parking slot identification through entropy minimisation

2. PATH PLANNING OF VEHICLE:

After detecting the presence of empty slot in the car parking environment the vehicle should plan accordingly to park in the detected vacant space. For this appropriate MATLAB commands and functions should be used. In this algorithm the initial position of the vehicle present in the the parking slot and the vehicle which is to be parked are defined first [3]. Once we defined the initial positions then each vehicle's dimensions we can able to alter the position of the vehicle along the X and Y coordinates defined for our working environment. The initial position of the vehicle are shown (refer with: Fig.6) Next step is to define the path to be traced by the vehicle in order to park it in the respective slot. For this maximum steering angle is to be set so that rear wheel is being set according to the steering angle defined in the MATLAB programming [3]. Here the steering angle should be converted into Radians which is given in terms of the degree. Therefore by defining the end point with respective to the X and Y co- ordinates vehicle is going to park safely in the slot allocated for it.

In order to ensure that the vehicle is parked in its respective slot tracking techniques are used. Here tracking algorithm utilizes the kalman filter approach to follow the vehicle while moving. Here the assumption is that process and measurement noises are to be Gaussian [4]. The Kalman filter technique utilizes the linear time invariant model for analysis. There are two process are performed one is the prediction which estimates the position of the target obstacle and the other is the correction state which detects the measurement and update the filter state [4]. By applying this technique, obtained results for tracking are shown (refer with: Fig.8).

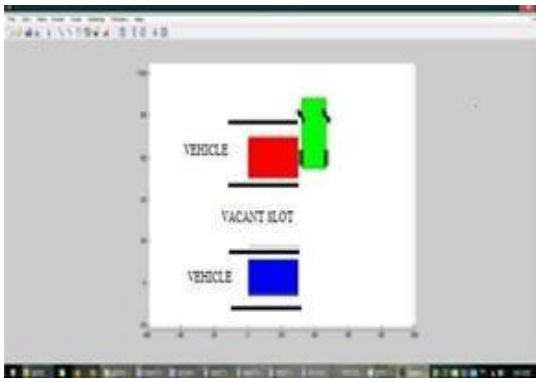


Fig 6: Matlab simulated results of initial position of parking.

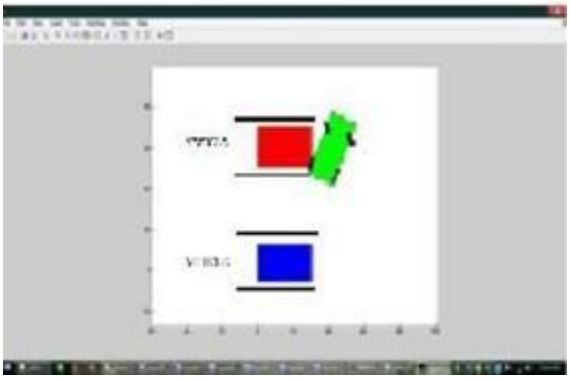
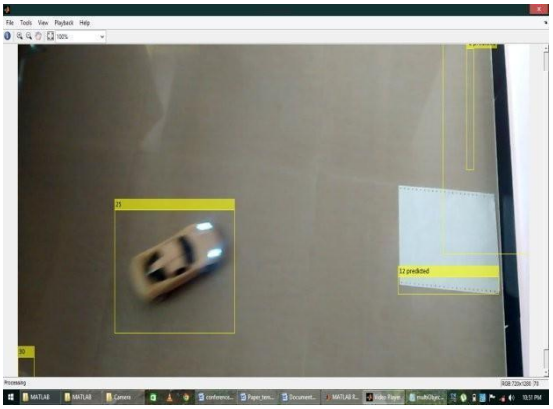
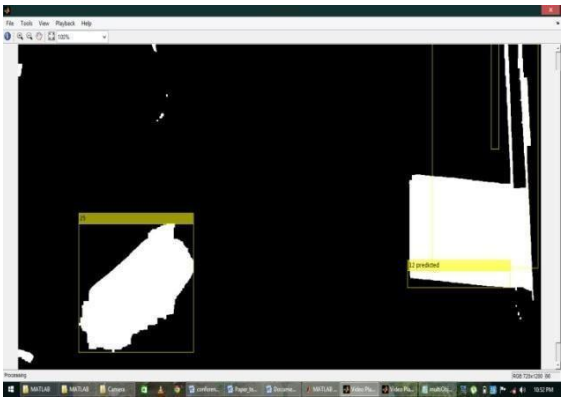


Fig 7: Matlab simulated results of steering control of position in slot.



(a)

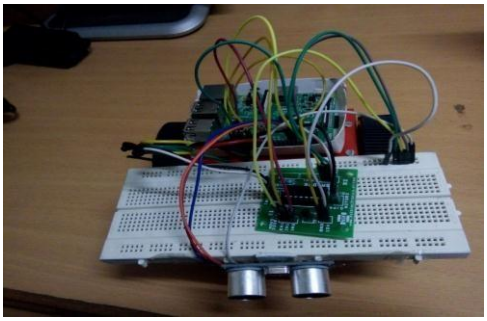


(b)

Fig: 8 (a) Car tracking in parking slot zone (b) Identification of car position using Kalman filter.

3. HARDWARE MODEL

In the hardware model as shown in fig 9 (a) the ultrasonic sensor is interfaced with the Raspberry pi controller and in practical this setup is fitted in the car backside to ensure the obstacle or parked car identification and also detect the distance between the car and the parked vehicle. The figure 9 (b) shows the 5MP pi camera to identify the parking slot and symbols and the empty slot.



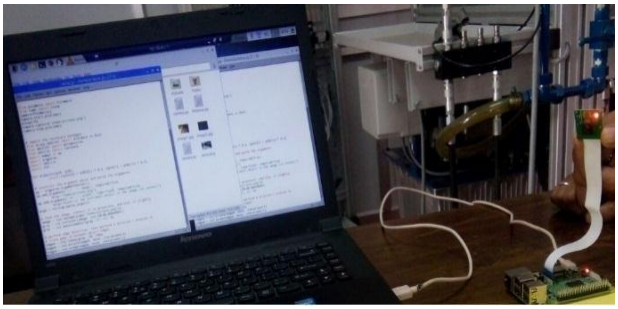


Fig: 9 (a) Ultrasonic sensor interfaced system (b) Pi camera interfaced with raspberry pi

4. CONCLUSION

In this work the vacant slot is found by slot markings or based on the presence of the vehicle in its slot and if there is no vehicle is present then with the help of path generating commands vehicle will generate the path to reach the respective slot in the parking environment. In order to ensure that the vehicle is going in the desired location kalman filter tracking algorithm is used to track the vehicle until it reaches the desired location. These results are experimented and verified with the help of MATLAB. In Prototype model the Raspberry pi is connected with the 5MP pi camera and ultrasonic sensor to detect the distance of the parked car or barrier and the camera indicate the dimension of the slot using line detection method and symbols are identified by the Hough transform in python code.

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