VISION BASED APPROACH FOR PERFORMING REVERSE PARALLEL PARKING

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***Abstract*—Parallel parking is considered to be a difficult task owing to the sheer amount of expertise it demands. Performing the same activity without any human intervention is even harder owing to the continuous monitoring of various parameters. The studies until now use an ultrasonic or an infrared sensor to perform the activity of space detection and then continue the process of maneuvering. The use of camera in aiding in parallel parking is very limited. With the increased usage of cameras in the recent automobiles, it is possible to use this image data for other uses. So, we propose the use of a camera to perform the activity of parallel parking and use it as a standalone system to perform all aspects of parallel parking without the use of any other sensor and to study the effects of the same. A prototype has been manufactured and the proposed strategy has been implemented on it.**

I. INTRODUCTION

Performing parallel parking is not an easy task and requires constant observation from the driver about surroundings and should have the vehicle under complete control. The driver identifies the parking space and does the whole maneuvering on his own. It is usually a three-phase task to perform. 1) The driver identifies the parking slot. 2) Takes the vehicle to a starting point. 3) Maneuver the vehicle into the available parking slot. This whole process is a tiresome and complicated process to perform.

The objective of this research paper is to develop a parking assistance system that can aid the driver in parallel park his vehicle autonomously. For this purpose, we have built a car like mobile robot which can work autonomously and perform the unmanned parking process.

A lot of research and innovation has taken place over the years which used different strategies to perform parallel parking. Some used ultrasonic sensors along with infrared sensors and some used camera in aid with ultrasonic sensors. However, these strategies are often complex and costly owing to the hardware and maintenance involved. So, we have used only a camera to achieve all the requirements to perform the task. Hence providing a low cost and easy maintenance solution.

The strategy involved in our parking system is three-fold. Firstly, the camera used will scan the entire area and identifies the parking slot. Secondly, a start position will be decided and the vehicle will move to that point. Finally, the parking process will be initiated. The whole process is shown in Figure 1.

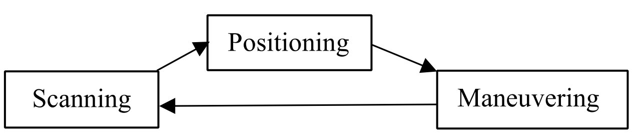

Figure 1. Strategy of Parallel Parking System

II. SYSTEM METHODOLOGY

Once the parking assistance protocol is enabled, the computer enables the camera to scan the entire area for a suitable parking space. If the space available is sufficient then the computer estimates a starting point for the vehicle. Then the vehicle will be moved to that starting position at a constant speed. Once the vehicle reached its starting position, the steering will be turned and moved backward until it reaches the start point. Then reverse the steering and move backward until it reaches the endpoint. The whole process is depicted in Figure 2.

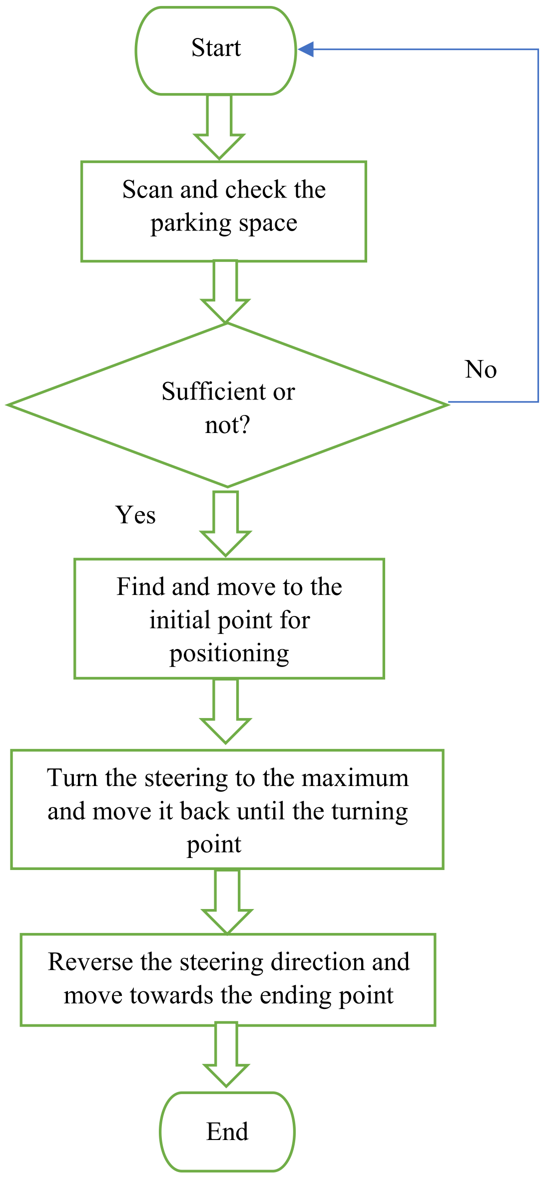

Figure 2. System Methodology

III. SYSTEM IMPLEMENTATION

The system configuration for a car like mobile robot is shown in Figure 3. The car like mobile robot is equipped with DC motors to propel, a servo motor to control the steering, a motor driver, camera module, Raspberry Pi, Arduino Uno Microcontroller, and Power Unit.

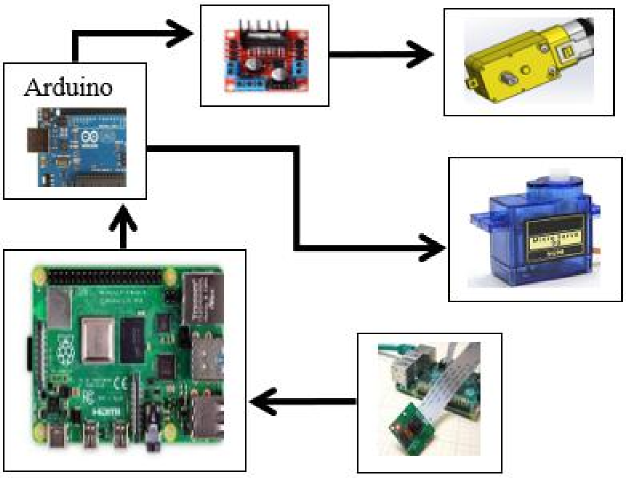

Figure 3. Block Diagram

Figure 4. Prototype

The use of a separate steering mechanism in CLMR has been scarcely used. Most of the papers involve the use of an all-wheel-drive to perform steering by varying the speeds of the different wheels. We have designed a steering mechanism similar to the Ackerman Steering for the prototype. A servo motor controlled by the Arduino connects the motor and the steering linkage. This servo motor will give input for the necessary steering action. The steering mechanism is shown in Figure 5.

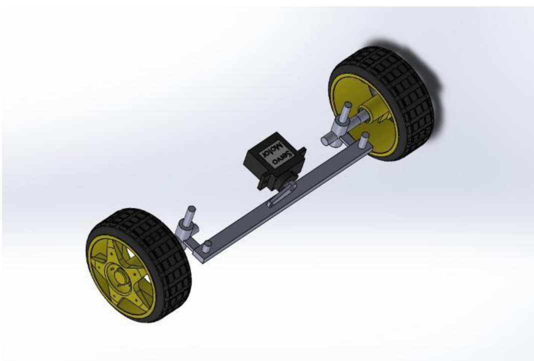

Figure 5. Steering Mechanism

The camera captures the BGR image which is sent to the Raspberry Pi where the image is converted into Grayscale. Region of Interest is segregated from the image containing noise. After the selection of ROI, threshold and Canny Edge detection functions are applied. The lanes of parking spots are detected and the Raspberry Pi triggers the microcontroller which initiates the parking procedure. The controller provides the control signal to the motor driver for the intelligent motion of the robot via the DC motor. The steering mechanism is operated by a servo motor which is controlled by the controller. The whole process is depicted in Figure 6.

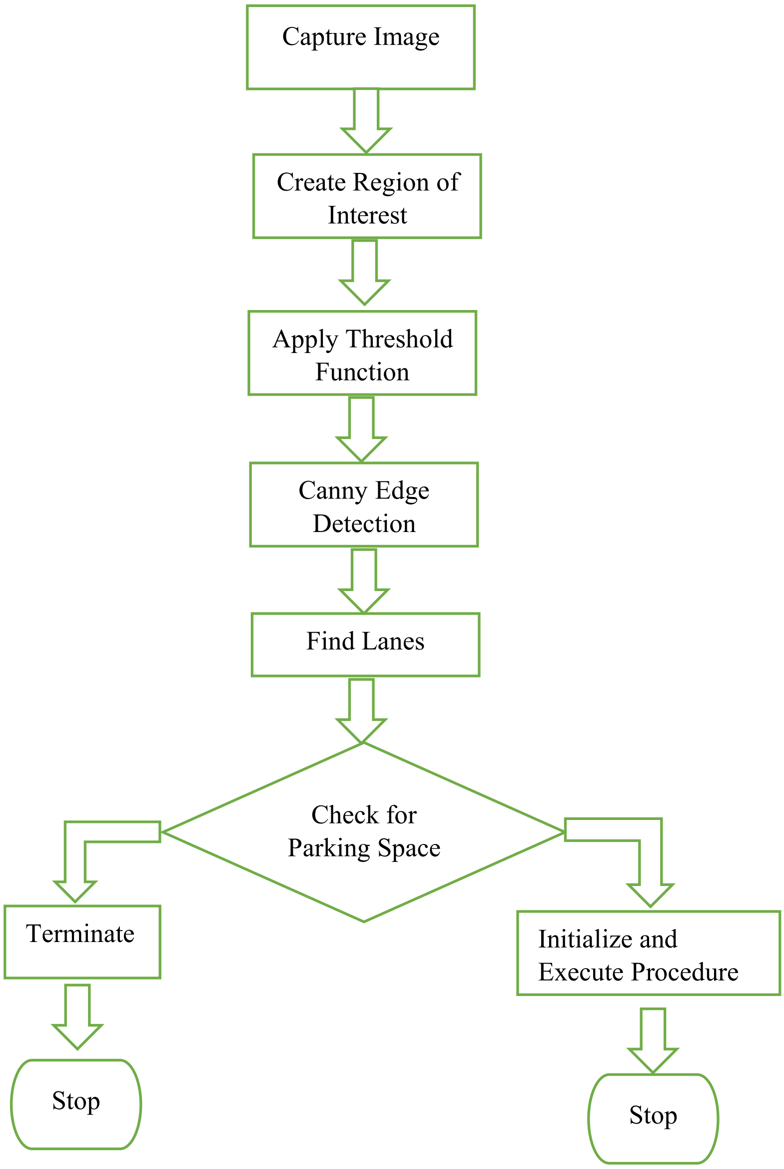

Figure 6. Parking Procedure

IV. PATH PLANNING APPROACH

The path planning approach used is based on a geometric approach. This makes more sense because we are using a constant speed throughout. The path involves two-quarter circles and when the sequence is initiated, the first quarter circle is followed. When this sequence ends, the steering is reversed and the instantaneous center about which the car like mobile rotates now shifts to the other side of the car like mobile robot, thus changing the direction of the rotation. As a result, this now aligns the car like mobile robot in the direction of the parking slot. Now, forward motion is carried out because, after the end of the second quarter circle, this endpoint is beyond the parking slot. So, it is necessary to move the car like mobile robot forward into the space. In Figure 6, the maneuver is clearly depicted.1 denotes the first quarter circle, 2 denotes the change in direction of the steering and turning back, and 3 denotes the forward motion initiated to park in the bay.

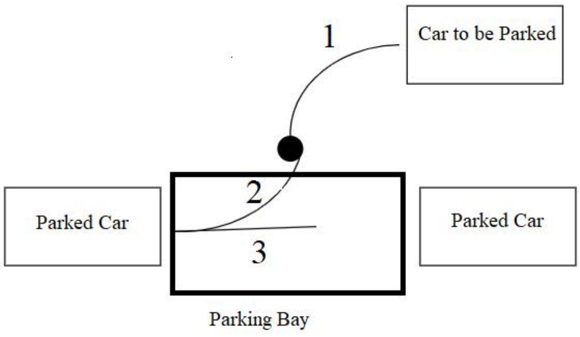

Figure 7. Path Planning Manoeuvre

V. EXPERIMENTATION

Dimensions of the Prototype:

Total Length	25 cm
Wheel to Wheel Total Width(a)	22.5 cm
Wheel Base(b)	19.5 cm
Front Wheel Track(c)	20 cm

We know that the fundamental equation of correct steering is given by

$$\cot \emptyset - \cot \theta = \frac{c}{b}$$

And the maximum turning circle radius is of the outer front wheel, whose value is given by

$$R = \frac{b}{sin\emptyset} + \frac{a-c}{2}$$

Where, a denotes the wheel track, b denotes the wheelbase, c denotes the distance between the pivots of the front axle, θ denotes the angle turned by the inner front wheel and ∅ denotes the angle turned by the outer front wheel.

The maximum steering angle used is 30^o. Thus, substituting these values in the above equations, we get $\emptyset = 23.07^o$ and R= 53.5 cm.

However, in reality, the value of θ was measured to be 30^o, and the value of ∅ was measured to be 21^o. This implies that the maximum turning circle radius is R = 58.4 cm in the car like mobile robot. Thus, this variation in the actual turning circle radius and that coupled with various other factors induce an error in the overall maneuver. This error was taken into account while performing the maneuvering task. During the path planning, as the path involves the use of quarter circle geometries, the error induced in the path will be the same as the error in the radius, because the length of the path is directly proportional to the turning circle radius. This error comes to be 8.1% which is acceptable.

The implementation of the proposed strategy can be seen in Figure 8.

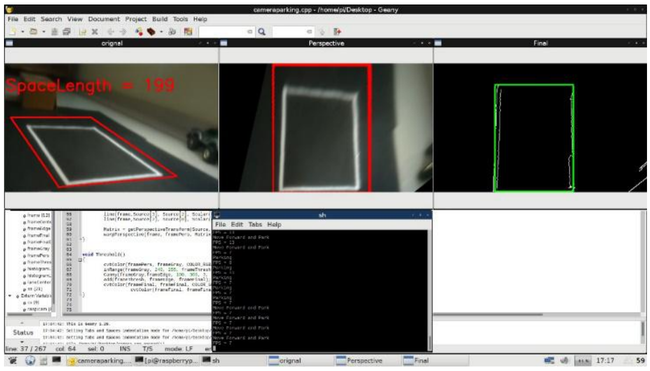

Figure 8. Implementation

Based on the conditions, the whole maneuver can be classified into three cases, each of which is discussed below.

Case 1: No Parking Slot is available.

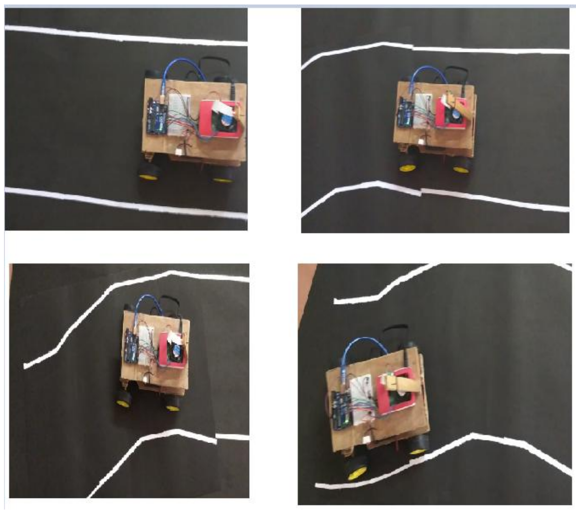

Figure 9. No Parking Slot is available

Whenever there is no parking space available, the car like mobile robot continues to follow the path and search for a parking space. Whenever there is no further path available or there is no slot available, the car like mobile robot terminates the procedure.

Case 2: Open Parking Slot

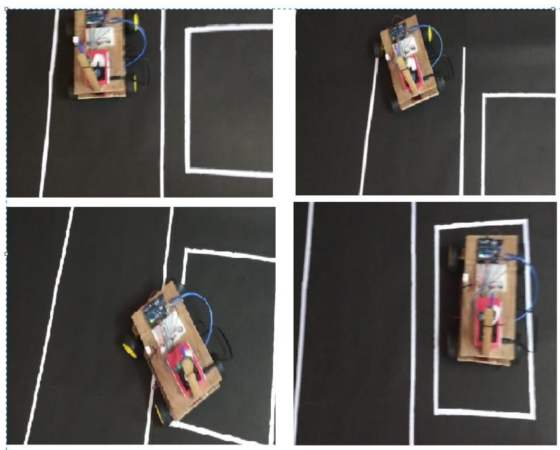

Figure 10. Open Parking Slot

In Figure 10, the parking slot that is detected doesn't have any obstacles in the front and the rear of the slot. Thus, the process of parking is relatively easier. First, when the slot is detected, it traverses to the point beyond the parking slot. Now the steering is reversed completely and rearward motion begins. In the third part, we can see the point of the turning of the steering in the opposite direction. Finally, a car like mobile robot is parked inside the slot.

Case 3: Parking Slot is available between two cars

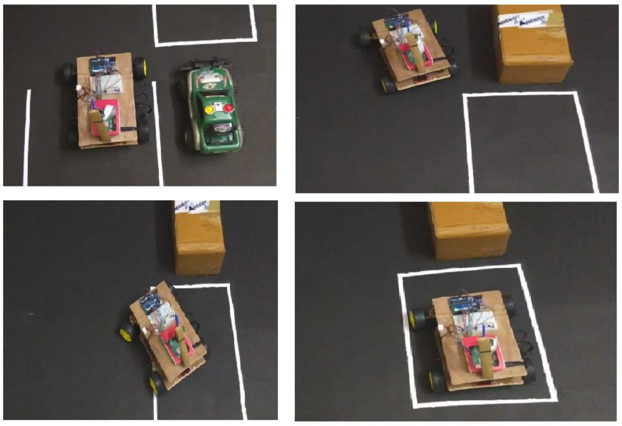

Figure 11. Slot available between two cars

In Figure 11, the parking maneuver when there is a slot available between two obstacles is shown. The maneuver is explained above. One thing that has to be noted is, that in the previous case because there are no obstructions, the freedom for the car like mobile robot to turn is more, and thus it follows a more liberal path whereas in this case, it is far more critical.

VI. RESULTS AND CONCLUSION

The error induced due to the steering mechanism is 8.1%. This is within the acceptable limits. The proposed strategy performs well irrespective of the case of the parking it needs to perform. The use of camera as a standalone system is studied and it was found that although the room of error is high and there are a lot of areas where it could be improved, it can still be used as an auxiliary system to assist the driver in parking, rather than using the system alone to park. To achieve complete autonomous parking, it would involve sensor fusion techniques by using ultrasonic or infrared sensors in tandem with the camera, which in turn demands more computing power, and thus increasing the cost. Future scope involves the use of more efficient path planning techniques and the use of Machine Learning techniques such as R-CNN and YOLO to make it a more seamless process.

VII. REFERENCES

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