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Design and Manufacturing Prototype of Semi-Automated Parking System

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Abstract - Parking a car parallel to another car when there isn't enough room is known as parallel parking. In the past, the driver needed to make a lot of modifications, which took more time and accuracy. This can be avoided by installing a new technology in the car that will allow it to be parked more accurately and in the lowest amount of time and distance, preventing collisions. Cars are becoming more and more popular in today's globe as people seek improved living conditions. As a result, parking is becoming a bigger issue every day. In order to solve this issue, new technologies are developed. One well-known method is Smart Parking. We demonstrate the Smart Parking System prototype in this project. The Smart Parking method assists in reducing the quantity of cars parked in less space.

1. INTRODUCTION

Parking becomes a major issue as the number of vehicles in a metropolitan area increases because there will be less space available. To prevent this annoyance, cars should be parked in parallel parking, which is a line. The car's issue will be lessened if the cars are parked parallel to one another. The incapacity of the inexperienced driver to park the car quickly is another issue. This motorist has the potential to collide with either the front or back side of the vehicle. Without a mechanism, parallel parking requires twice the length of the space; the vehicle's forward and backward take up the double space. An additional issue with the car is its fuel, which will be wasted when parking because it takes longer. Therefore, there are significant issues like inexperienced drivers parking their cars, a lack of space, fuel usage, and time consumption. According to a number of studies that compare crash experiences with unintentional experiences, parallel parking has crash rates that are between 19 and 71% lower than angle parking. A separate system is utilized to park the car parallel to each other without risk or effort in order to avoid any of these issues. Since everyone wants to own a car and the amount of space needed to park is decreasing, parking has become a major issue in the modern world and the age of downsizing. The driver tries to find a parking spot for his car since proper visualization of the necessary parking space is not prioritized. The challenge for the driver is to safely park the car in the allotted spot without coming into contact with another parked car.

2. Procedure to Built a System

Component Selection and Procurement :

- **Bearings:** 6000z bearing number: 7, ID: 10 mm, OD: 26 mm
  6003z bearing number: 2, ID: 17 mm, OD: 35 mm
- **Motor:** DC Motor, 12 Volt, 30 RPM
- **ABS Plastic:** Styrene butadiene acrylonitrile
- **Acrylic Sheet:** Made from synthetic polymers, acrylic sheets are transparent or colored thermoplastic sheets that are also referred to as plexiglass or acrylic glass. Their optical purity and shatter resistance make them a popular substitute for glass.
- **Lead Screw:** A mechanical linear actuator that transforms rotational action into linear motion is called a lead screw.
- **L298N motor driver module:** is a high-power motor driver module designed to drive stepper and DC motors.
- **Rack and Pinion:** Rotating motion can be converted into linear motion and vice versa using a rack and pinion gear arrangement.
- **Structural Frame**

3. Literature Survey

Priyadarshini R, et al.[1] completed the task of using the fifth wheel to park cars in parallel. His research indicates that parallel parking is the practice of parking a car parallel to another car while maintaining a safe distance. By adding a fifth wheel to the back of the car, they created a system. To lower the wheel and raise the car from the back, the pneumatic system is utilized as a jack. The fifth wheel is powered by the prime mover, and a motor is also utilized for forward and backward rotation. The car is first positioned at an angle from the front by the driver. The wheel descends and the car rises from the back as soon as the driver presses the button. The vehicle parks between the cars, and the prime mover rotates the wheel in the desired direction (forward or reversed). A digital display is used in this system to show the fifth wheel's condition.

Mr. Paresh G. Chaudhary et al.[2] created a parallel parking system with a Stepney wheel as an auxiliary drive wheel. The rear of the car is where this auxiliary wheel is located. This mechanism is made up of a chain, sprocket mechanism, triangle hub with one vertex fixed, rack and pinion, and DC motor. The auxiliary drive wheel's movement is controlled by the triangular hub mechanism, which consists of a rack and pinion. The mechanism developed in this work transfers motion from the rack and pinion to the triangle hub, which raises the vehicle because it has a single point and is pivoted. A DC motor or a chain and sprocket mechanism, depending on the situation, will deliver motion to the auxiliary drive wheel after the vehicle has been lifted (forward and reversed). The fifth wheel does not touch the ground when driving, and the back two wheels do not touch the ground when parking.

Mandir Harer et al. [3] Create and construct a 90-degree steering system that includes a chain, sprocket, internal gear, bevel gear, and rack and pinion. Through the use of a unique kind of mechanism, they are altering the steering system such that the front axle wheel turns in a left half direction while the other wheels move in a right half manner. The car or vehicle spins 360 degrees as a result of this upgraded steering mechanism. This method is inexpensive and easy to use. The steering radius in this mechanism. When the car is making a U-turn or a 90-degree turn, it has many benefits.

K. Lohith et al. [4] Instead of a two-wheel steering system, design a four-wheel steering system. A two-wheel steering system, which has a high turning radius, is utilized in standard automobiles. There are issues with this system when turning or parking a car. A four-wheel steering mechanism is used to alleviate this issue. When making calculations, they take the Maruti Suzuki 800's specifications into account. For design, they used Catia software, and ADAMS was used for motion simulation. The constant radius test, or CRS, was used to determine the turning radius.

Suraj Bawankude et al. [5] created a system that will fasten to the vehicle's underside. A 12V battery, a pedestrian bearing, a lead screw, and geared motors make up this system. The four auxiliary wheels are attached to the vehicle in this system at a 90-degree angle to the vehicle's longitudinal axis. The hydraulic or pneumatic actuators at the vehicle's bottom are coupled to this auxiliary wheel mechanism. The entire car is prepared to travel transversely when the actuator forces the four-wheel mechanism downward, lifting the vehicle upward. A remote controller is used to control the car's movement, and the auxiliary wheel's speed during movement is 30 rpm. The purpose of the lead screw is to stabilize the auxiliary wheels. Additionally, this device serves as an integrated jack. Because the DC geared motor that is attached to the auxiliary wheels provides the power, this mechanism uses less fuel and requires less work.

Muhammad Faiz Bin Wahab et al. [6] Create a small mobile vehicle's automatic parallel parking system model. It includes a relay, an Arduino MEGA 2560 microcontroller, a DC geared motor, a servo motor, and an ultrasonic sensor. This paper also suggests a conceptual explanation of how this mechanism operates. The sensors in the model are positioned such that the total number of parking spaces may be determined. When the ultrasonic sensor detects that there is enough room for the car to park, the next step is initiated. This phase, known as the placement phase, occurs when the car senses the space, reverses, and enters the parking slot without colliding. Finally, the car adjusts the distance between the front and back of the vehicle to move into the proper parking position in the parking slot. According to this research, a parking spot that is 1.33 times the length of the car is needed. The tiny car parks effectively without colliding with any obstacles or front or rear cars.

S-J Huang et al. [7] Using self-organizing fuzzy logic, a parallel car park model was created. It has a self-organized fuzzy controller with several ultrasonic sensors to sense the vehicle's coordinates, trial-and-error-designed parameters that provide the desired outcomes, and fuzzy rules that require expert setting. To make the system better, the attributes and the finicky rules were changed along the procedure. Using coordinates, the system's many ultrasonic sensors create a two-dimensional environmental map. A two-dimensional environmental map served as the basis for the effective planning of the entire route. Additionally, the vehicle's surroundings are built. The front wheel steering angle and the vehicle's X-Y components are calculated. The path is tracked by the fuzzy logic controller. It controls the steering angle on the front side

based on the controller's track. Finally, it travels to the parking spot, which will be the vehicle's target position, after estimating the vehicle's present position, location, and orientation. In the event that the parking location varies, repeat the trajectory path and make the necessary adjustments to the car. The system stops after proper parking.

Dr. Gene Yeau -Jian Liao et al. [8] has talked about the automated parking scheme. Additionally, he talks about creating the toy or prototype and putting the system on it. In order to save time, the vehicle platform is modified from an RC toy car rather than being constructed from components because the project's main goal is to accomplish a single task (automated parking) by integrating sensors and actuators controlled by a microcontroller and strategy planning/coding. This project focuses mostly on parallel parking, but there are three broad types of parking patterns: parallel, front/back-in perpendicular, and with an angle (often 45 degrees). The following functions are anticipated to be performed by the customized toy car throughout a full automated parking process:

1. Navigate a constrained roadside area and measure the separation between your vehicle and any roadside obstructions, including parked cars or just the curb on the right.

2. The automobile will automatically stop when it detects that the length of a parking spot is greater than the length of the vehicle plus a buffering distance.

3. Parking should be done smoothly and effectively based on the relative locations of the vehicle and the parking spot. A microcontroller, a fuzzy controller system, ultrasonic sensors, a dc motor, a servo motor, and other components are required for this specific project. This will totally automate the vehicle and eliminate human error-related accidents by around 94%. The author also talked about Toyota's and Google's automotive automation technologies.

4. Methodology

1. Problem Definition
2. Conceptual Design
3. Mechanical Design
4. Material Selection
5. Prototype Development
6. Testing

1. **Problem Definition:** Car parking systems are complex and time-consuming, and drivers must be extra careful to prevent colliding with other vehicles when parking in reverse. Thus, the idea of a smart parking system was created in order to prevent this.

2. **Conceptual Design:**

   - Vertical Tower Frame
   - Lifting Gate
   - Car Platforms
   - Guiding System
   - Remote Motor Driver

   Design Goals: Space-efficient vertical parking. High mechanical reliability. Modular and scalable structure. Safe and user-friendly operation.

3. **Mechanical Design:** From the designer's perspective, the mechanical design phase is crucial since the project's overall success rests on the accurate design analysis of the issue. This stage involves the elimination of numerous preliminary options. The physical characteristics of materials, loads, stresses, deformation, and failure should all be sufficiently understood by designers. He should determine the internal and external pressures affecting the machine parts using theories and wear analysis.

4. **Material Selection :** The primary goal is to choose the right materials for the various components of a machine. in the process of building machines. A design engineer must understand how the characteristics of materials are affected by the manufacturing process and heat treatment. The following elements influence the material selection for engineering purposes:
   1. The materials' accessibility.
   2. Materials' suitability for the operational state of the machine.
   3. The price of the materials.
   4. The material's chemical and physical characteristics.
   5. Material mechanical properties.

5. Prototype Development

- Frame Fabrication: Mild steel square tubes were used to build the main frame. Cross-bracing was welded into the frame to guarantee stability. firmly fixed to a sturdy base plate.
- Lifting Mechanism Assembly: Lead screw sprockets and a round ABS plastic disc were installed. For torque multiplication, an electric motor is connected to a gearbox. Pulleys for platform lifting are attached to lead screws. To park the car in a parking space, an electric motor connects the rack and pinion to the platform.
- Parking Slot Fabrication: Acrylic sheet was used to create lightweight vehicle platforms.
- Remote Operate: Limit switches were installed for parking levels, forward and backward positions, top and bottom positions, and circular rotating motion positions.

6. Testing

Testing of Prototype:

1. Material-Based Component Testing:
   - Metal Frame: The mild steel metal frame was tested for vibration and stability under a full dummy load, which replicates a vehicle. No discernible displacement or distortion during lift movement. After several operations, the integrity of the bolted joints and welds was examined.
   - Circular Platform: The circular moving platform made of ABS plastic has been tested for load carrying capacity and smooth rotation. confirmed resilience to wear and torsional strength under load. With less motor torque, light weight guaranteed effective motion.
   - Parking Slots using Acrylic Sheets: tested for flexibility and resistance to cracking. Clear visibility for platform alignment was confirmed.
     Proven capacity to grasp and maneuver toy automobile models
2. System Testing:
   - Lift Mechanism Test:
     Smooth vertical movement of platform over multiple levels. Tested for jerk-free operation using controlled motor speed.
   - Load Test:
     Applied incremental weights (e.g., sandbags, dummy load). No failure or cracks in plastic or acrylic components.
   - Sensor Test:
     Limit switches triggered precisely at top, bottom, and parking levels. Emergency stop successfully halted lift operation mid-motion.
   - Rotation Test (for circular platform):
     Checked full 360° rotation without jamming. Verified positional accuracy using visual markers.
3. Repeated Operation (Cycle Test):
   The prototype ran continuously for more than 20 cycles. No motor overheating or moving component wear. There is not much wear on the plastic surface.
4. Safety Testing:
   Lift motion instantly stopped when the emergency stop was activated. In the event of a power outage, a manual override is tested and the platform is secured with a mechanical stop.

5. Manufacturing Data

The purchase of components, mechanical fabrication, electronic integration, and assembly are all part of the manufacturing phase of the Smart Parking System Design and Manufacturing process. The manufacturing data is summarized in the table and details below:

Sr. No.	Components	Cost (INR)
1	Frame	2500
2	DC Motor	900
3	ABS Plastic	700
4	Acrylic Sheet	900
5	Lead Screw	750
6	Rack &Pinion	250
7	Bearings	100
8	Hardner Bar	650
9	Adaptor	250
10	M6 Bolt	100
11	Motor Drive	600
12	Other Expenses	500
13	Total Cost	8200

Table No. 1 Cost Estimation of the Model

Material Components List

Sr. No.	Components	Specification / Model	Quantity
1	Frame	Mild Steel (MS)	1
2	DC Motor	12V, 30RPM	3
3	ABS Plastic	ABS (Acrlonitrile Butadiene Styrene) Plastic	1, 3/3 Foot
4	Acrylic Sheet	Synthetic Polymer	1, 3/3 Foot
5	Lead Screw	Lift Load capacity	1
6	Rack &Pinion	Sliding Platform	1
7	Bearings	Smooth rotation	4
8	Hardner Bar	Load Stability	2
9	Adaptor	12 Amp	1
10	M6 Bolt	Fit	10
11	Motor Drive	L298N, 2Amp	1

Table No. 2 Material Component List

6. Layout

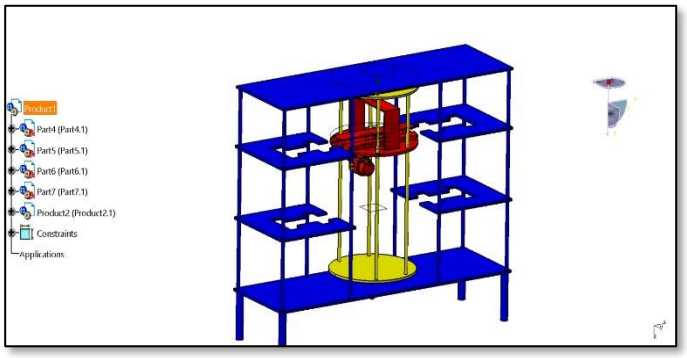
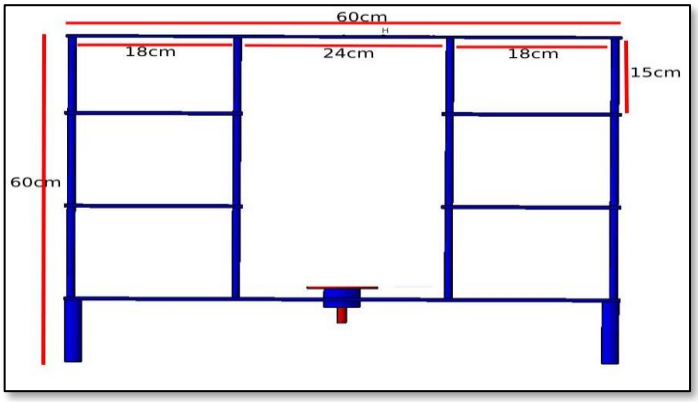


Fig No. 1 CAD Design

5. Design Calculation



Frame Calculation :
Size of Frame : 60 × 60 × 20cm
Surface Area = 2(lb+lh+hb) = 2(60×20+60×60+60×20)
= 6000cm²

Calculation for DC Motor :
Rpm = 60; Voltage =12 v; Current = 0.3 amp;
Power = V x I = 12 × 0.3
P = 3.6 watt
Torque required for motor is

$$\frac{2\pi NT}{60}$$

$$3.6 = \frac{2\times 3.142\times 30\times T}{60}$$

T = 1.145Nm

7. Future Scope

- Full-Scale Implementation: Enlarge the prototype to fit actual automobiles with steel platforms, hydraulic/electric actuators, and high-capacity motors.
- Automation: For automated motion control, slot assignment, and vehicle recognition, incorporate PLC or Arduino-based control.
- IoT Integration: Include remote booking capabilities, a smartphone app, and real-time slot availability.
- Energy Efficiency: To cut down on power usage, install solar panels or regenerative braking devices.
- Enhanced Safety: For complete security, use CCTV, RFID, and infrared sensors.
- Modular Design: Use prefabricated modules to expand either vertically or horizontally in accordance with site needs.

8. Conclusion

The created smart parking prototype effectively illustrates a small, effective, and mechanically stable vertical car parking solution. A metal frame, an ABS rotating platform, and acrylic slots provide a nice mix of durability, portability, and visual appeal.

Important accomplishments:

1. Smooth platform movement in both vertical and rotational directions.
2. No material breakdown and dependable load handling.
3. Working limit switches and emergency stop provide precise control.
4. Safety features are examined and confirmed.
5. The system achieved its functional goals, and with more robust materials and complete automation, it might be scaled up for real-world use.

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