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Smart Car Parking System and Wireless E-Vehicle Charging Station

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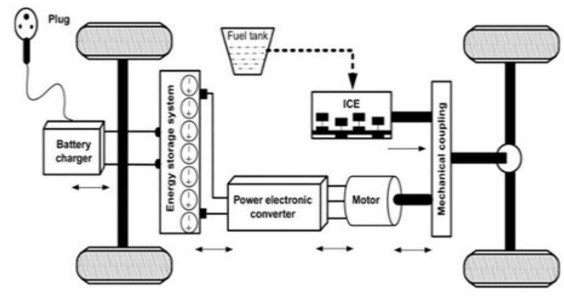
***Abstract*—In today's rapidly developing urban world, parking space management and electric vehicle (EV) charging have become major challenges due to the increasing number of vehicles. The Smart Car Parking System with Wireless E-Vehicle Charging Station is an innovative approach designed to automate vehicle parking and integrate an efficient, contactless charging mechanism for electric vehicles. This system aims to reduce human intervention, save time, and provide a reliable solution for managing modern parking infrastructures. The proposed system utilizes Arduino Uno as the central controller that monitors and manages all hardware components. The Infrared (IR) sensors detect the presence of vehicles in each parking slot and send real-time data to the Arduino. Based on this data, the I2C 16x2 LCD displays show the number of available and occupied parking spaces, allowing users to easily identify where to park. The servo motor is used to control the parking gate automatically — opening it when a vacant slot is available and closing it when all slots are full, ensuring a smooth and organized parking process. This paper demonstrates how embedded systems and automation can enhance the functionality of public and private parking spaces. The integration of wireless charging minimizes cable clutter and provides convenience to EV owners. Furthermore, the system promotes energy efficiency, reduces manual labor, and optimizes space utilization. Such a model can be scaled for large parking lots, shopping malls, or smart cities. In conclusion, the Smart Car Parking System and Wireless E-Vehicle Charging Station represents a step toward intelligent urban mobility. It not only improves the parking experience but also contributes to the sustainable adoption of electric vehicles.**

***Index Terms*—Battery; Micro Controller; Solar Wireless Electric Vehicle Charging System; Transformer; Microprocessor; Electric Vehicle.**

I. INTRODUCTION

The rapid growth of urbanization and the increasing number of vehicles have led to significant challenges in managing parking spaces efficiently. In most cities, drivers waste valuable time searching for available parking spots, which causes congestion, fuel wastage, and unnecessary stress. At the same time, the rise of electric vehicles (EVs) has created a new demand for charging facilities that are easy to use, fast, and safe. To address both these issues, the Smart Car Parking System and Wireless E-Vehicle Charging Station project aims to automate parking management and integrate a contactless wireless charging feature within a single system. This project combines embedded systems, sensor technology, and wireless power transfer principles to create a modern and efficient solution. The system detects the presence of vehicles using IR sensors, displays parking slot availability on an LCD screen, and operates a servo-based gate for vehicle entry and exit. In addition, when an electric vehicle is parked in a specific slot, a wireless charging unit automatically activates, providing convenient, cable-free charging.

II. ELECTRIC VEHICLE



An electric vehicle (EV) is a vehicle that uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels, fuel cells or an electric generator to convert fuel to electricity [4]. EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft. EVs firstly came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types [5]

An electric vehicle charging station, also called EV charging station, electric recharging point, charging point, charge point, electronic charging station (ECS), and electric vehicle supply equipment (EVSE), is a machine that supplies electric energy for the recharging of plug-in electric vehicles—including electric cars, neighbourhood electric vehicles and plug-in hybrids. Some electric vehicles have converters on board that plug into a standard electrical outlet or a high-capacity appliance outlet. Others use a charging station that provides electrical conversion, monitoring, or safety functionality.

III. AIMS & OBJECTIVES

The main objectives of the project are:

- To design and implement a smart parking system that automatically detects vacant and occupied slots.
- To control vehicle entry and exit using a servo motor-driven gate.
- To display real-time parking information using I2C 16×2 LCDs.
- To develop a wireless charging mechanism that activates only when a car is present.
- To minimize human effort and improve space utilization in parking areas.
- To enhance user convenience, safety, and energy efficiency.

IV. LITERATURE REVIEW

Over the past few years, numerous smart parking and EV charging solutions have been developed using various technologies. However, most existing systems focus individually on either smart parking or EV charging — not on integrating both functions together. Below are some of the notable existing works and their limitations:

1. Ultrasonic-Based Smart Parking System:
Several projects use ultrasonic sensors to detect the presence of vehicles in parking slots. The sensor measures distance between the car and the slot surface, sending the data to a microcontroller like Arduino or Raspberry Pi. The availability is then displayed on an LCD or mobile app.

2. RFID-Based Parking Management System:
In this system, every vehicle is provided with an RFID tag, and an RFID reader installed at the gate scans it for authentication. The slot information is updated automatically and shown on a display. Limitations: • Requires RFID tags and readers for every user, increasing cost. • Focuses on vehicle identification and access control rather than parking automation. • No wireless charging integration.

3. IoT-Based Smart Parking System:
This project connects parking sensors with a cloud platform using Wi-Fi or GSM. Users can check slot availability through a mobile application or website. The system updates slot status in real time and helps in booking.

4. Energy Management and Optimization:
Literature has addressed the development of intelligent energy management and optimization algorithms for electric vehicle charging systems. These algorithms aim to optimize charging schedules, balance energy demand and supply, and minimize grid impact while ensuring efficient use of renewable energy sources. Research has also focused on integrating energy storage solutions, such as batteries and supercapacitors, to enhance system flexibility and resilience.

5. Inductive Wireless Charging for EVs:
Studies have examined user perceptions, preferences, and behaviors related to electric vehicle charging infrastructure. Research has explored factors influencing charging station accessibility, usability, and convenience, as well as user attitudes towards

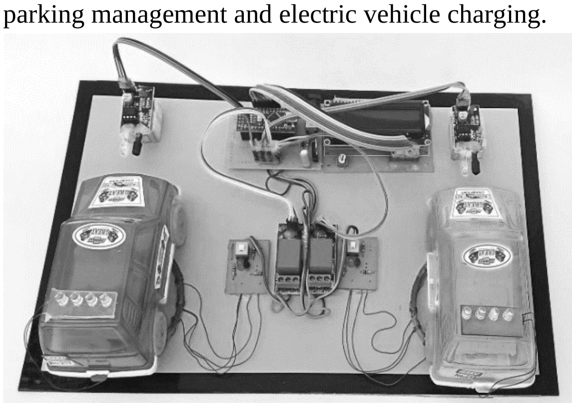
renewable energy and wireless charging technology. Understanding user needs and preferences is crucial for designing charging infrastructure that promotes widespread adoption of electric vehicles.

6. Sensor-Based Automatic Gate Parking System:
Some parking projects use IR or ultrasonic sensors to open and close a gate automatically when a car is detected. The gate mechanism typically uses a servo motor or DC motor controlled by Arduino.

7. Smart EV Charging Stations:
Recent studies and projects have focused on building smart EV chargers with features like energy monitoring, payment systems, and IoT control.

V. METHODOLOGY

The methodology for implementing the proposed system, the mechanical components of the Smart Car Parking System and Wireless EV Charging Station are essential for the physical operation of the system, particularly the movement of the parking gate and support of sensors and indicators. The Smart Car Parking System and Wireless E-Vehicle Charging Station operates by integrating sensors, microcontroller logic, and actuators to automate parking management and electric vehicle charging.



The system detects vehicles in real time, manages gate operations, displays slot availability, and activates wireless charging when a car occupies a designated slot. This automation ensures efficient space utilization, reduces manual intervention, and provides a safe, convenient charging solution for electric vehicles.

Vehicle Detection by IR Sensor:
The IR (Infrared) sensor is the primary detection component of the Smart Car Parking System. It operates on the principle of infrared light reflection. The sensor emits infrared light toward a parking slot. When no vehicle is present, the light does not reflect back, and the sensor outputs a LOW signal. When a vehicle enters the slot, the reflective surface of the car reflects the IR light back to the sensor, generating a HIGH signal. Each slot has a dedicated IR sensor connected to the Arduino input pins. The sensor's output is read continuously by the Arduino to determine slot occupancy. Proper calibration of the sensor is essential the sensitivity must be adjusted to detect vehicles reliably without false readings caused by sunlight, shadows, or small moving objects like pedestrians.

Signal Processing in Arduino:
The Arduino Uno acts as the central control hub, processing all signals from IR sensors and generating commands for actuators and displays. When the IR sensors detect vehicles, the Arduino reads these digital inputs and interprets them according to the programmed logic. It then determines: which slots are vacant, which slots are occupied, and whether the gate should be opened or closed. The Arduino also manages wireless charging. When a vehicle is in a charging slot, it sends a HIGH signal to the BC547 transistor, activating the wireless charging coil. The real-time processing capability of Arduino ensures that decisions like gate operation, display updates, and charging activation happen instantly without delay.
For instance, if Slot 3 is occupied while Slot 2 remains free, the Arduino updates the LCD to show the available slots and activates charging only for Slot 3. This processing ensures that the system is both efficient and error-free, making the parking and charging experience seamless for users.

Gate Control by Servo Motor:
The 9g servo motor controls the physical barrier at the parking entrance. It receives Pulse Width Modulation (PWM) signals from the Arduino, which dictate the exact angle of rotation. When a vacant slot is detected, the Arduino commands the servo to rotate the gate arm to the open position, allowing vehicle entry. Once the vehicle enters, the servo rotates the gate back to the closed position. The servo motor must be properly

calibrated to avoid mechanical stress and ensure smooth operation. For example, if the gate arm is set to open at 90°, but the mechanical design requires only 80°, continuous operation can damage the servo or gate. Smooth operation of the servo is critical for safety, as it prevents accidents with vehicles or pedestrians. This automatic gate mechanism eliminates the need for manual parking attendants and provides a secure and organized parking system, particularly useful in high-traffic areas.

Display of Parking Status on LCD:
The I2C 16×2 LCD displays real-time parking information for users. It shows which slots are vacant, which are occupied, and whether charging is active in a particular slot. The I2C interface allows simplified wiring with only two communication lines (SDA and SCL), reducing circuit complexity. The Arduino continuously updates the LCD based on IR sensor readings. For example, if Slots 1 and 4 are occupied and Slot 3 is charging, the display shows: Slot 1: Occupied Slot 2: Vacant Slot 3: Charging Slot 4: Occupied Slot 5: Vacant This clear visualization allows users to quickly identify free slots without searching manually. Proper contrast adjustment ensures the display is readable under varying lighting conditions. This feature enhances user convenience and reduces time wasted in locating parking spots.

Wireless Charging Activation:
The wireless charging system uses a BC547 transistor to control the activation of the charging coil. When the Arduino detects a vehicle in a designated charging slot via the IR sensor, it sends a HIGH signal to the transistor. This allows current to flow to the transmitter coil, which transfers energy inductively to the vehicle's receiving coil. Wireless charging eliminates the need for manual cable connections, reducing wear and tear, and enhances safety by minimizing the risk of electric shock. When the vehicle leaves the slot, the sensor detects the vacancy, and the Arduino sends a LOW signal to deactivate the charging. For example, when an EV parks in Slot 3, the system automatically starts charging, and the corresponding LED indicator lights up.

Indicator LED Operation:
Red LEDs are installed to provide a quick visual cue for slot occupancy and charging status. The Arduino controls these LEDs based on sensor readings. When a slot is occupied, the corresponding LED lights up. If the EV in a charging slot is actively charging, another LED indicates this status. For example, Slot 3's red LED turns on as soon as the vehicle is parked, and a separate LED turns on when wireless charging starts. This feature allows drivers and parking attendants to monitor the parking area at a glance, enhancing safety and efficiency. LED operation is synchronized with sensor detection and Arduino processing to ensure real-time response. This simple visual feedback is especially useful in larger parking areas or low-light conditions.

VI. RESULTS

Testing is a critical phase in the development of the Smart Car Parking System and Wireless EVehicle Charging Station. It ensures that all components—IR sensors, servo motor, LCD displays, LEDs, and the wireless charging unit—function accurately and reliably in real-world conditions. During testing, the system is evaluated for vehicle detection accuracy, gate operation, slot status display, and automatic charging activation. The results help verify the efficiency, reliability, and practicality of the system, ensuring it meets the design objectives. By systematically analyzing test outcomes, any errors or inconsistencies can be identified and corrected to optimize performance before real-world deployment.

The results of the Solar Powered Wireless Electric Vehicle (EV) Charging System demonstrate significant advancements in sustainable transportation infrastructure and energy management. Through rigorous testing and validation, the system has achieved remarkable outcomes in terms of efficiency, reliability, and environmental impact. One of the key findings is the system's ability to harness solar energy effectively, with solar panels demonstrating high energy capture rates and consistent power output. This solar energy is seamlessly integrated into the charging infrastructure, providing a renewable and eco-friendly source of power for electric vehicles. Moreover, the wireless charging technology employed by the system has proven to be highly efficient and user-friendly, offering a convenient and hassle-free charging experience for electric vehicle owners.

Wireless charging pads have demonstrated robust performance in transferring energy to electric vehicles wirelessly, eliminating the need for physical cables and connectors.

This wireless charging capability not only enhances user convenience but also reduces wear and tear on charging equipment, leading to lower maintenance costs and increased operational reliability. Overall, the results of the Solar Powered Wireless EV Charging System underscore its potential to revolutionize electric vehicle charging, promoting sustainability, energy independence, and enhanced user experiences in transportation.

VII. CONCLUSION

The Smart Car Parking System and Wireless E-Vehicle Charging Station project successfully demonstrates the integration of automation, sensor technology, andWireless energy transfer to solve modern urban parking and electric vehicle charging challenges. The project effectively combines IR sensors, servo motors, LCD displays, LEDs, and a wireless charging module, all controlled by an Arduino Uno, to create a reliable, real-time parking management system. This project contributes significantly to the development of smart parking solutions for modern urban areas. It reduces congestion, improves parking space utilization, and simplifies EV charging for users.

The integration of automation, real-time monitoring, and wireless power transfer makes it a practical and innovative solution for sustainable urban transportation infrastructure. The Smart Car Parking System and Wireless E-Vehicle Charging Station demonstrates how modern technology can improve urban infrastructure by providing efficient, safe, and automated solutions. With minor enhancements and scalability considerations, this system can evolve into a commercially viable product, supporting smart city initiatives and promoting the adoption of electric vehicles

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