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SMART PARKING MANAGEMENT SYSTEM USING ARDUINO WITH RFID-BASED PAYMENT

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Abstract : The Smart Parking Management System Using Arduino with RFID-Based Payment automates parking operations efficiently. Initially, the LCD screen displays the number of available slots, and the Green LED signals that a car can enter. If the Red LED glows, it indicates a car is entering or exiting, signaling others to wait. When a vehicle arrives, IR Sensor 1 detects it and prompts RFID card scanning. If the prepaid RFID card is authenticated, the balance is displayed, and the servo motor gate opens. During this process, the Red LED glows to prevent multiple entries. Once the gate closes, the Green LED turns on for the next car. The system supports four parking slots. If all are occupied, the LCD updates availability to zero, preventing additional entries. At exit, IR Sensor 2 detects the vehicle, opening the gate while the Red LED glows to restrict entry. Since the servo motor gate is shared for both entry and exit, no vehicle can enter while another is leaving. Once the car exits, the available slots update on the LCD screen, increasing by One. This system ensures automated, secure parking with real-time availability updates, improving efficiency in malls, offices, hospitals, and residential complexes.

IndexTerms **- Smart Parking System, Arduino Microcontroller, RFID-Based Payment, IR Sensors, Servo Motor, LCD Display, Automatic Gate Control, Parking Slot Management.**

I. INTRODUCTION

Traffic congestion is a transportation condition marked by reduced vehicle speeds, extended travel times, and increased vehicle queuing. Traffic congestion on urban road networks has increased substantially since the 1950s, resulting in many of the roads becoming obsolete.[1] When traffic volume becomes high enough to increase vehicle interaction, the overall traffic flow slows, resulting in congestion. Traffic congestion happens when too many vehicles are on the road, and they get in each other's way, which makes the traffic move slowly. Although congestion can happen in any form of transportation, it is most commonly associated with cars and other vehicles on public roads.

Finding available parking spaces in busy cities consumes valuable time, contributes to fuel wastage, and increases air pollution. To address these challenges, smart parking systems have emerged as an essential component of modern smart cities. Smart city applications manage urban flows and allow for real-time responses.[2] The Smart Parking Management System developed in this mini project aims to provide automated vehicle entry based on slot availability using RFID technology. Radio-frequency identification (RFID) uses radio waves to automatically detect and monitor tags that are attached to different objects. An RFID system includes a compact radio transponder known as a tag, as well as a radio receiver and a transmitter. When activated by a radio signal from a nearby RFID reader, the tag sends back digital information typically a unique identification number to the reader. This number can be used to track inventory goods.[3] If the prepaid RFID card is successfully verified by the system, the user's balance information is shown on the display screen, and the servo motor-controlled gate automatically opens to allow the vehicle to enter. This process removes the need for manual checking or ticketing, making the parking system faster, more convenient, and fully automated. It also ensures that only authorized users with sufficient balance can access the parking area, improving both security and efficiency in managing parking spaces.

The system uses LED lights to show whether parking slots are free or full. It runs on a program written in Arduino C/C++ and works automatically, without needing anyone to control or monitor it manually.

The main objective of this system is to stop unauthorized vehicles, make parking more efficient, and manage the slots automatically in real time. When a vehicle comes to the parking area, the system first checks if any slot is free. Then it scans the RFID card to confirm if it is valid. If everything is correct, the servo motor opens the gate to let the vehicle in. If the card is not valid or no slots are available, the gate stays closed. This helps save time, reduce confusion, and make the parking process simple and organized.

This system is affordable and simple to set up, making it a good choice for many parking areas. It can be used in places like shopping malls, offices, schools, hospitals, and apartment buildings where parking is often crowded. Because it works automatically, it reduces the need for staff and saves time for drivers. The use of RFID cards and sensors makes it more secure and reliable. It also helps avoid confusion by clearly showing which slots are free or full. Since it runs on Arduino, it can be easily maintained or upgraded when needed. Overall, it is a smart and convenient solution for managing parking spaces efficiently.

II. BLOCK DIAGRAM

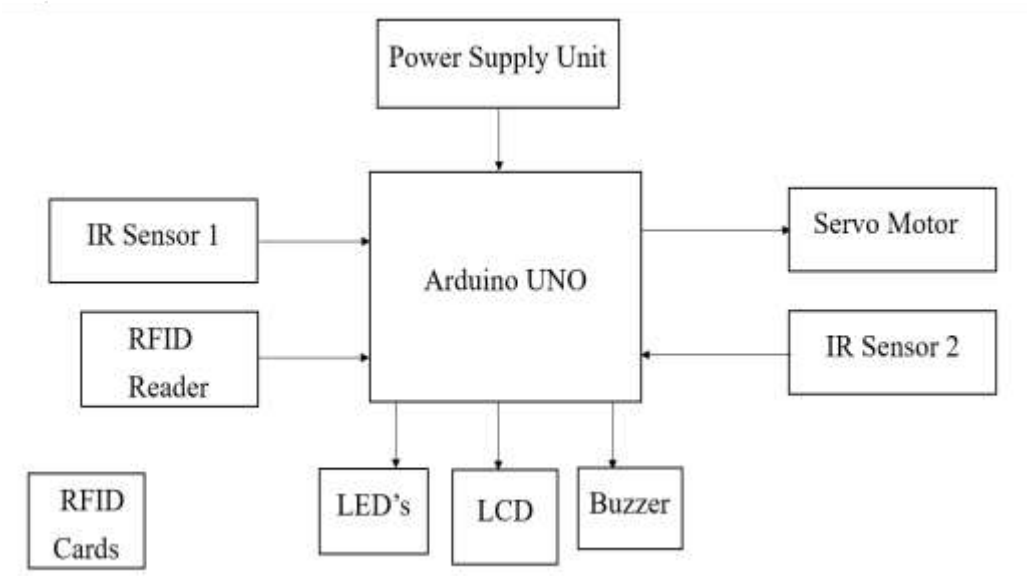

Fig. 1 : Block Diagram for Smart Parking Management System Using Arduino with RFID-Based Payment

The block diagram represents the working flow of the Smart Parking Management System Using Arduino with RFID-Based Payment. The Arduino UNO acts as the main controller, receiving power from the power supply unit and signals from IR sensors and the RFID reader. When a vehicle is detected by IR Sensor 1, the Arduino activates the RFID reader to verify the card. If the RFID card is valid, the Arduino sends a signal to the servo motor to open the gate. The LCD display shows slot availability and card balance, while the LEDs and buzzer provide visual and sound alerts. Once the vehicle exits, IR Sensor 2 updates the slot count on the LCD, ensuring smooth and automated parking management.

Description of Components

2.1 Arduino UNO

The Arduino Uno is an open-source microcontroller development board based on various microcontroller unit (MCU) architectures. It was initially developed and released by Arduino company in 2010.[5][6] The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.[4] The word "uno" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software.[7]

2.2 IR Sensor

The IR sensor emits infrared light to detect the presence or movement of nearby objects. When an object comes close, the reflected light is sensed and converted into an electrical signal. It can detect both motion and distance, making it useful for automatic systems like vehicle detection at entry and exit points.

2.3 Servo Motor

The Tower Pro SG90 is a micro servo motor commonly used for small automation projects. It operates on 5V DC and can rotate up to 180 degrees, providing precise control over movement. In this project, the SG90 servo motor is used to control the parking gate's opening and closing mechanism. When the RFID card is verified, the Arduino sends a signal to the servo motor to lift the gate, and once the vehicle passes, it returns to its original position, ensuring smooth and automated gate operation.

2.4 RFID Reader & RFID Cards

RFID stands for Radio Frequency Identification, a technology used for automatic identification and data transfer using radio waves. In this project, the RFID reader module (EM-18) reads the unique ID stored in the RFID card when it is brought near the reader. Each RFID card has a distinct identification number linked to a user's prepaid account. When scanned, the reader sends the card's ID to the Arduino for authentication. If the card is valid and has sufficient balance, the system grants access by opening the parking gate.

2.5 LCD Screen

The 2x16 LCD display is used to show important information such as the number of available parking slots, user balance, and system status. It has two rows and sixteen columns, allowing it to display up to 32 characters at a time. In this project, the LCD is connected to the Arduino to provide real-time updates during vehicle entry and exit. It helps users easily view parking details and ensures smooth monitoring of the entire system.

2.6 Buzzer

A buzzer or beeper is an audio signaling device,[8] which may be mechanical, electromechanical, or piezoelectric (*piezo* for short). The buzzer is an electronic sound-producing device used to give audio alerts or notifications. In this project, the buzzer is connected to the Arduino and is used to indicate events such as vehicle entry, exit, or invalid RFID card detection. When triggered, it produces a short beeping sound to alert the user or signal a system action. The buzzer helps in providing quick and clear feedback, ensuring smooth and error-free parking operation.

2.7 Transistor

The BC557 is a PNP transistor used in this project for switching and control operations. It allows current to flow when a low signal is applied to its base, enabling the Arduino to control connected components such as LEDs or the buzzer. The transistor acts as an electronic switch, helping to drive devices that require more current than the Arduino can supply directly. Its reliable performance and low-power operation make it suitable for smooth and efficient functioning of the parking system.

2.8 PCB & Dotted PCB

The Printed Circuit Board (PCB) is used to connect the Arduino and other components in an organized way, ensuring stable and reliable performance. A dotted PCB (zero PCB) is also used to link parts like the RFID reader, buzzer, resistors, and LEDs. It allows easy soldering and neat wiring through its copper dots, keeping the circuit compact and efficient.

2.9 Arduino Shield

An Arduino shield is a modular circuit board designed to be placed directly onto an Arduino development board to extend its functionality. They are designed with headers that align with the pins on the Arduino board, allowing for easy connection without the need for extensive wiring.

2.10 Resistors

The resistors in this project are used to control the flow of electric current to protect components like LEDs and the LCD. They limit excessive current, preventing damage and ensuring stable operation. In the LEDs, resistors help maintain proper brightness, while in the LCD, they adjust contrast and improve display clarity. Here 100,220,1000 and 3300 ohms of ±5% tolerance resistors are used.

2.11 LED's

The red and green LEDs in this project are used as visual indicators for parking status. The green LED lights up when parking slots are available, signaling that a vehicle can enter. The red LED glows during entry or exit, or when all slots are full, indicating that vehicles should wait. These LEDs help guide users easily and improve the overall efficiency of the parking system.

2.12 Jump Wires

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.[9]

2.13 Power Supply Unit

The power supply unit used in this project is a 12V 1A Switching Power Supply (SMPS) that converts 220V AC mains power into a stable 12V DC output. This module provides a reliable power source for operating the Arduino and other electronic components in the system. It ensures consistent voltage and current, preventing fluctuations that could damage sensitive parts and allowing the smart parking system to function smoothly and efficiently.

III. CONTROLLER DESIGN & IMPLEMENTATION

The controller used in this Smart Parking Management System is an Arduino microcontroller, which functions as the central processing and decision-making unit. It continuously receives input signals from the RFID reader, entry and exit IR sensors, and monitors the status of parking slots in real time. The Arduino processes these inputs based on predefined logic and takes appropriate actions such as validating vehicle entry, managing slot availability, and ensuring controlled access. According to the decision made by the controller, it operates the servo motor for gate opening and closing, activates LED indicators to guide vehicles, triggers the buzzer for alerts, and updates messages on the LCD display for user interaction.

The Arduino controller is powered by a regulated 5V DC supply, which is obtained from a 12V, 1A Switched Mode Power Supply (SMPS) through voltage regulation. This regulated power ensures stable and reliable operation of the microcontroller and

peripheral devices. The RFID reader is interfaced with the Arduino using serial communication, allowing the controller to read unique tag IDs for authentication and payment processing. The IR sensors are connected to digital input pins to detect vehicle presence at the entry and exit points. Similarly, the servo motor, LEDs, and buzzer are connected to digital output pins, enabling precise control of gate movement, visual indications, and audible alerts.

The control algorithm is implemented using Arduino C/C++ programming, where logical conditions are defined for vehicle entry, exit operations, parking slot counting, and access authorization. When a vehicle is detected at the entry gate, the controller first checks the availability of parking slots and then prompts the user to scan the RFID card. If the scanned RFID card is valid and sufficient balance is available, the controller deducts the parking fee, opens the gate using the servo motor, and updates the available slot count. During vehicle exit, the controller detects the vehicle using the exit IR sensor, opens the gate, increments the slot count, and signals system readiness for the next vehicle. This structured control logic ensures safe, efficient, and automated parking management without manual intervention.

IV. RESULTS & DISCUSSION

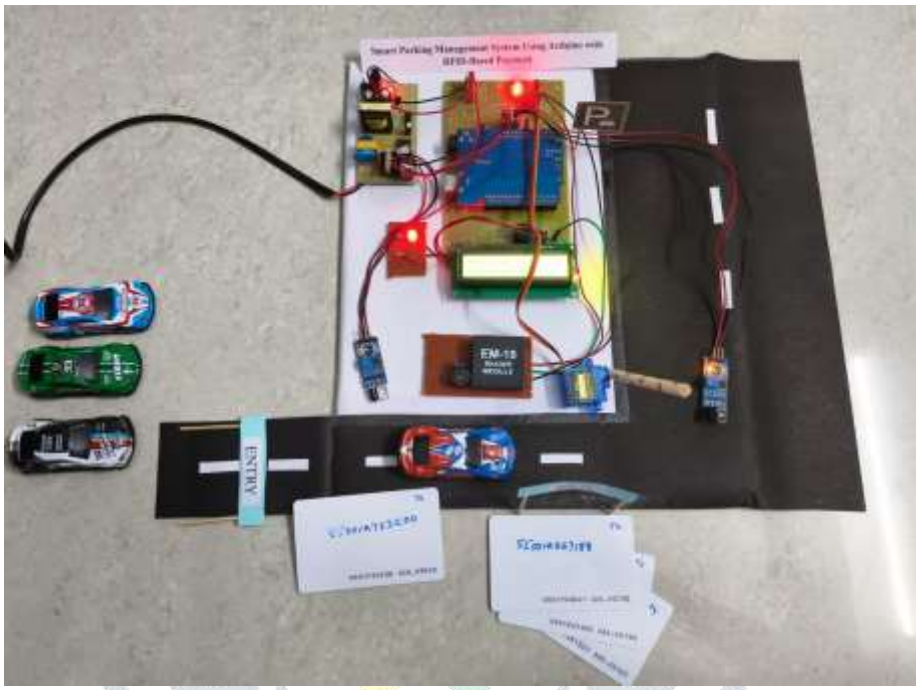

Fig. 2 : When a car enters the parking area

When a vehicle approaches the entry gate, the entry IR sensor detects the vehicle and sends a signal to the Arduino. During this process, the red LED glows, indicating that a vehicle is currently entering the parking area, so other vehicles are informed to stop and wait at the entry or exit gate. The driver scans the RFID card using the EM-18 RFID reader, and the Arduino verifies the card details. If the card is valid and parking slots are available, the servo motor opens the gate and the LCD displays the entry status.

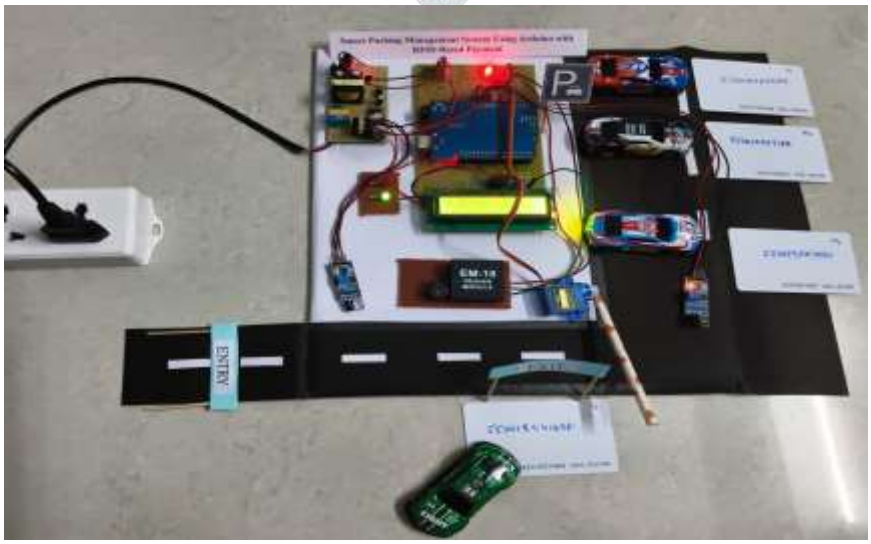

Fig. 3 : When the car left the parking area

When a vehicle reaches the exit gate, the exit IR sensor detects the car and sends the information to the Arduino. The servo motor opens the exit gate to allow the vehicle to leave smoothly. The system updates the parking slot count after the vehicle leaves the parking area. Once the exit process is completed, the green LED glows, indicating that the parking area is free and other vehicles can now enter or exit. The LCD updates the available slot information and the system becomes ready for the next vehicle.

V. CONCLUSION

In conclusion, the Smart Parking Management System using Arduino with RFID-Based Payment is a simple and smart solution to modern parking problems. It helps reduce human effort and errors by automating the process of vehicle entry, exit, and slot management. The system uses RFID technology to allow only authorized vehicles with prepaid cards to enter, ensuring secure access. IR sensors detect vehicles at the entry and exit points, while the servo motor opens and closes the gate automatically. The LEDs and LCD display give clear information about parking availability, making it easy for drivers to find free slots. The system works smoothly using Arduino C/C++ programming and does not require manual control. It is cost-effective, easy to install, and suitable for places like malls, schools, hospitals, and apartments. Overall, this project shows how technology can make parking faster, safer, and more efficient in busy areas.

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