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AUTOMATED CAR PARKING MANAGEMENT SYSTEM USING IoT

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Abstract - *A fully automated parking management system utilizing FASTag technology integrated with Orion RFID tags and ultrasonic sensors to streamline vehicle entry, parking duration monitoring, and payment processing. The system captures the FASTag UID from both entry and exit points using Orion RFID tags. Ultrasonic sensors monitor vehicle presence within the parking slot, enabling real-time detection of entry and exit times. A microcontroller stores these timestamps and calculates the duration of parking using a timediff algorithm. Upon exit, the microcontroller verifies the FASTag UID at both entry and exit points. It processes the corresponding payment by transmitting the calculated parking fee to the vehicle owner's bank account linked to the FASTag system. The system ensures a seamless and automated transaction, with payment confirmation sent via standard bank notification methods. This project enhances parking efficiency, reduces human intervention, and facilitates secure, automated transactions.*

Key Words: Automated parking, FASTag, RFID tags, Ultrasonic Sensor, Microcontroller, Vehicle Detection, Parking Duration, Payment process.

1. INTRODUCTION

Automating parking management systems has become essential in modern urban environments to enhance efficiency and reduce manual intervention. Utilizing FASTag technology integrated with Orion RFID tags and ultrasonic sensors, this project presents a streamlined solution for capturing vehicle information, monitoring parking duration, and processing payments. At the entrance of the parking area, Orion RFID tags scan and capture the FASTag UID, storing it in a microcontroller. Once the vehicle reaches the parking slot, ultrasonic sensors detect the vehicle's presence and trigger a timestamp to capture the entry time. Similarly, when the vehicle exits the slot, the system detects the change, records the exit time with another timestamp, and stores both times in the microcontroller. The parking duration is then calculated using a timediff algorithm. Upon exiting, the FASTag UID is verified at the exit point, and the system processes the payment by sending the calculated amount to the linked bank account. This approach ensures efficient real-time tracking, secure data handling, and seamless automated transactions.

1.1 Integration of FASTag and RFID Technology

FASTag technology combined with Orion RFID tags allows for efficient, automated vehicle identification and entry. As vehicles approach the parking area, the RFID system automatically scans the FASTag UID, eliminating manual processes and reducing wait times. This not only minimizes human error but also streamlines traffic flow at parking entrances. The system's ability to capture the tag from a distance enables smooth entry, improving overall user convenience and operational efficiency.

1.2 Automated Payment and Duration Tracking

Ultrasonic sensors are used to accurately monitor the presence of a vehicle in the parking lot. These sensors detect the vehicle's entry and exit, allowing the system to calculate the total parking time. Upon exiting, the system automatically debits the parking fee from the linked FASTag account. This fully automated process ensures secure transactions and eliminates the need for manual payments, enhancing convenience for drivers while improving overall parking management.

2. Integrated System Setup and Execution

A Smart parking management system that integrates RFID and sensor technology to automate entry, parking duration tracking, and payment processing.

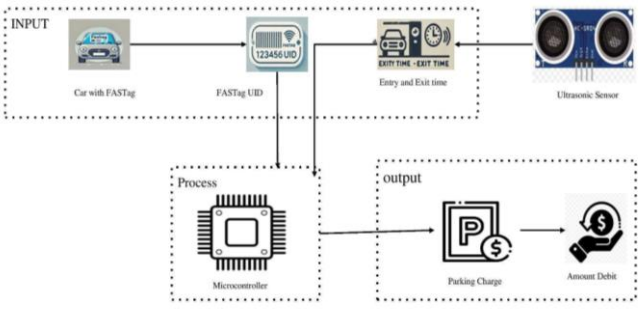

Fig: Architecture Diagram

The Above figure focuses on an automated parking fee collection system that uses RFID and ultrasonic sensors to track vehicles, calculate parking durations, and debit fees automatically. The architecture relies on capturing vehicle entry and exit times using ultrasonic sensors and FASTag UID through Orion RFID tags. This data is processed by a microcontroller, which calculates the parking duration and initiates the payment process via linked bank accounts.

1. Capturing FASTag UID

The Orion RFID tag scans the FASTag UID attached to the vehicle. This process begins when the car arrives at the parking area. The RFID system captures the unique identification of the car's FASTag and sends this information to the microcontroller. The microcontroller then stores the FASTag UID, which will be essential for further processing.

2. Detecting Entry Time via Ultrasonic Sensors

Once the vehicle reaches the parking slot, an ultrasonic sensor detects its presence by measuring the distance to the car. A predefined threshold value helps the system identify the car's arrival. When the vehicle crosses this threshold, the microcontroller captures the entry time using a timestamp. This data is stored in the microcontroller, which plays a vital role in tracking the parking duration.

3. Capturing Exit Time and Duration Calculation

When the vehicle leaves the parking slot, the ultrasonic sensor detects the exit by noticing the threshold value change. The microcontroller captures the exit time using another timestamp. To calculate the total time the vehicle was parked, the system uses the Timediff algorithm. The duration of the parking session is stored, allowing the microcontroller to determine the applicable parking fee.

3.1 TimeDiff Algorithm

Timediff		
Entry Time	**Exit Time**	**Difference(in mins)**
2492ms	13154ms	10 MINS
3456ms	5456ms	2 MINS

- **Inputs:** It takes two time points (Start Time TI and End Time T2)
- **Calculation:** The difference is found using the formula: Time difference = T2 - TI
- **Output:** The result can be in minutes.

4. FASTag Scanning at Exit

As the car approaches the exit, the Orion RFID tag scans the FASTag UID once again. The microcontroller compares this UID with the one captured during entry. This matching ensures that the correct car is being processed for payment, avoiding errors in billing.

5. Fee Calculation and Payment Process

After calculating the parking duration, the microcontroller determines the fee to be debited from the linked FASTag account. It sends the required information, including the FASTag UID and the amount, to the bank. The bank processes the transaction, and the car owner receives a notification regarding the fee deduction, completing the automated parking system.

The automated parking system uses Orion RFID tags and ultrasonic sensors to capture a vehicle's FASTag UID and detect its entry and exit times. The microcontroller stores the FASTag UID and calculates the parking duration using timestamps. At the exit, the RFID tag scans the FASTag again to verify the vehicle, and the microcontroller calculates the parking fee. The fee is then automatically debited from the vehicle owner's FASTag-linked bank account, completing the process billed. After verification, the microcontroller calculates the parking fee based on the duration and sends the necessary data (FASTag UID and fee) to the bank, where the amount is automatically debited from the vehicle owner's linked FASTag account. The owner then receives a confirmation, completing the fully automated, human-free parking fee collection process.

3. LIST OF MODULES

- Entry FASTag UID log.
- Object detection through sensor.
- Exit time charge computation.
- UID authentication transaction process.

3.1 Entry FASTag UID log

The Entry FASTag UID Log module is a vital part of the parking management system, responsible for capturing and logging the FASTag UID of vehicles entering the facility. When a vehicle approaches, the Orion RFID reader activates, creating an electromagnetic field that

interacts with the FASTag attached to the vehicle. The FASTag responds by sending its unique UID to the reader in an instantaneous process, allowing for seamless vehicle identification without the need for manual intervention. This automated entry system improves the user experience, reducing congestion and speeding up vehicle entry.

Once the FASTag UID is scanned, it is transmitted to the microcontroller, which handles data collection and securely stores the UID for future reference. This secure logging of entry data is critical for tracking the vehicle's entry time and later calculating parking fees based on the duration of the stay. By linking the vehicle to its parking session, the system ensures accurate and fair billing upon exit.

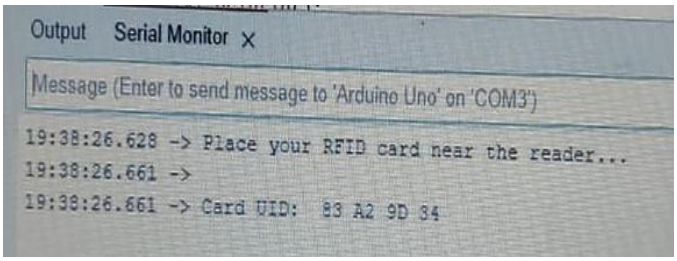

Fig: capture FASTag UID

3.2 Object Detection through Sensor

To enhance the effectiveness of the Entry FASTag UID Log module, car presence detection is integrated using ultrasonic sensors. When a vehicle approaches, the sensor detects its presence by measuring the distance to the vehicle and signals the microcontroller to log the entry time. This immediate detection is crucial for calculating parking fees based on the duration of the vehicle's stay. The system ensures only properly positioned vehicles are detected by setting a specific threshold distance, minimizing false readings.

Once the vehicle is detected, the system continuously monitors its status, ensuring it remains parked. When the vehicle leaves, the sensor continuously reads the distance to check the other car to present.

3.2.1 Ultrasonic Sensor

To detect the car presence

Emitting Sound Waves:

- The sensor consists of two main parts: the transmitter (emits high-frequency sound waves) and the **receiver** (captures the echo of the sound waves bouncing back after hitting an object).

- The transmitter sends out ultrasonic sound waves at a frequency higher than humans can hear (typically around 40 kHz).

Echo Return:

- When the sound waves hit an object (e.g., a car), they reflect back towards the sensor. The sensor then measures the time it takes for the echo to return to the receiver.

Distance Calculation:

- The distance to the vehicle is calculated using the time taken for the sound wave to travel to the object and back, along with the known speed of sound in air (~343 meters per second at room temperature).

- `The formula to compute the distance is:

$$\text{Distance} = \text{Time} \times \text{Speed of Sound} / 2$$

The division by 2 accounts for the sound traveling to the vehicle and then back to the sensor.

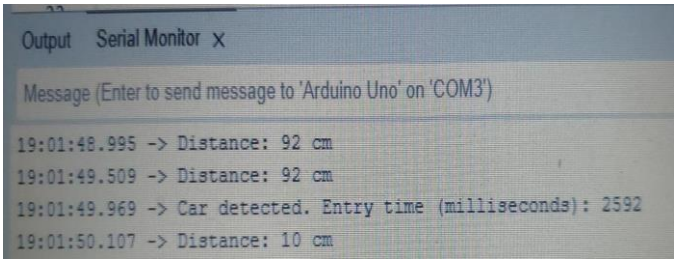

Fig: car detected and capture entry time

3.3 Exit time charge computation

In the parking management system, the Exit Time and Charge Calculation module ensures accurate tracking of vehicle departures and parking fees. Ultrasonic sensors monitor the distance to detect when a vehicle leaves its parking slot. Once the vehicle exits the threshold range, the system logs the exit time and retrieves the stored entry time. The parking duration is calculated by subtracting the entry time from the exit time, ensuring precise billing based on the exact duration of the stay.

The system is pre-programmed with a rate structure to compute the fee. For example, if the rate is 10 per minute and the car was parked for 1 minute , the fee would be 10 rupees. Automated processing ensures real-time logging, accurate calculations, and fair pricing. Once the fee is determined, it is logged and linked to the user's FASTag account for seamless debit during the final transaction. The automated system ensures consistency, minimizes errors, and facilitates auditing for accurate record-keeping and revenue management.

3.3.1 TIMEDIFF Algorithm

The TIMEDIFF algorithm plays a crucial role in parking management systems by calculating the exact parking duration, which is then used for fee calculation. Similar to how an ultrasonic sensor is used for vehicle detection, the TIMEDIFF function operates at the data level, determining the time difference between a vehicle's entry and exit.

Purpose of the TIMEDIFF Algorithm

The primary function of the TIMEDIFF algorithm is to compute the difference between two time points: the entry time and the exit time. This difference represents how long the vehicle was parked and is critical for calculating parking fees, especially in systems where fees are based on the duration of stay.

Data Points Required

The algorithm requires two specific data points:

- **Entry Time**: The timestamp when the vehicle enters the parking facility, logged when the vehicle is detected by an ultrasonic sensor.
- **Exit Time**: The timestamp when the vehicle exits the parking facility, triggered by either an ultrasonic sensor when the vehicle approaches the exit.

Calculation Process

The algorithm calculates the difference between the two timestamps using the following formula:

$$\text{Parking Duration} = \text{Exit Time} - \text{Entry Time}$$

This calculation is performed at the level of seconds, minutes, hours, and even days if necessary. The result provides an exact duration, which can then be converted into a usable format such as total minutes or hours.

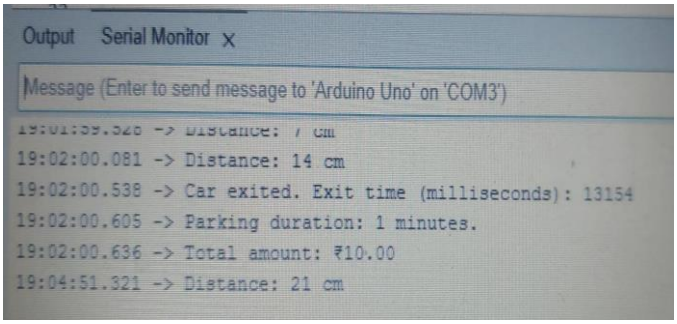

Fig: capture exit time and calculate parking duration and amount calculation

3.4 UID authentication transaction process

The Exit Authentication and Payment Processing module is a critical component of the parking management system, ensuring secure and efficient verification of vehicles leaving the parking area and automatically charging the correct fees. This module utilizes RFID technology to authenticate vehicles at the exit and initiates the payment process based on the calculated parking fee.

As the vehicle approaches the exit point, the Orion RFID reader is activated. It emits radio waves to scan the FASTag attached to the vehicle's windshield. The FASTag contains a unique identifier (UID) that was logged during the vehicle's entry. Upon scanning the FASTag at the exit, the system retrieves the UID and compares it with the entry data. This process ensures the vehicle leaving is the same one that entered, preventing unauthorized exits and enhancing security.

By matching the entry and exit UIDs, the system verifies the vehicle's authenticity and ensures accurate fee calculation. This automated process eliminates potential errors that could arise from manual checks or mismatches in vehicle identification. The RFID-based system also offers a seamless user experience, allowing vehicles to exit quickly without the need for manual intervention, significantly reducing delays.

Once the exit is authenticated, the system retrieves the pre-calculated parking fee, which is based on the duration of the vehicle's stay. The fee structure is pre-programmed according to the parking facility's rate policy. After the parking fee is determined, the system initiates an automatic payment process by debiting the appropriate amount from the user's FASTag account. This cashless transaction enhances convenience and speeds up the exit process.

The system logs all relevant information, including the vehicle's FASTag UID, entry and exit times, parking duration, and calculated fee, for auditing and record-keeping purposes. This automated logging ensures consistency and accuracy across all transactions, while also providing a reliable method for auditing and revenue management. By eliminating human intervention, the system reduces errors, enhances transparency, and provides a more efficient parking management experience.

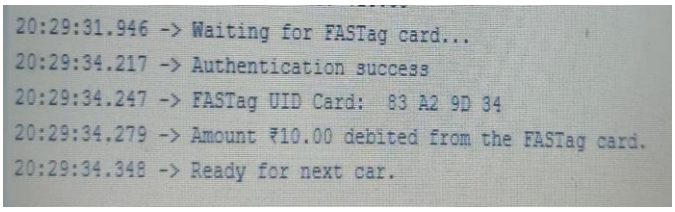

Fig: Fastag UID authentication and payment process.

3. CONCLUSIONS

The integration of Orion RFID tags into the parking management system allows for the automatic identification of vehicles by reading their FASTag UIDs at both entry and exit points. This ensures that vehicles are accurately tracked throughout their stay in the parking facility. By using RFID technology, the system eliminates human error, providing a seamless and reliable process where vehicle data is captured and stored in real time. Additionally, ultrasonic sensors are used to log entry and exit times automatically. These sensors detect when a vehicle arrives or departs from a parking spot, ensuring precise tracking of parking duration without the need for manual input. This automation improves efficiency and reduces delays, enabling the system to calculate parking fees accurately.

The Timediff algorithm plays a crucial role in determining parking fees by calculating the difference between the entry and exit times. This ensures that customers are only charged for the exact time their vehicle is parked, promoting fairness and transparency in fee assessments. By linking FASTag UIDs to vehicle owners' bank accounts, the system facilitates automatic fee deduction, removing the need for manual payments. This streamlines the payment process, making it faster and more secure by eliminating cash or card transactions.

Overall, this automated parking management system is user-friendly, scalable, and adaptable to various parking environments. It reduces operational costs by minimizing human intervention and errors, while providing a transparent, efficient, and secure solution for both users and facility operators.

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