AUTOMATED TOLL GATE SYSTEM

A MINOR PROJECT REPORT

for

231EEC411TL – MICROCONTROLLER AND ITS INTERFACING LABORATORY

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ABSTRACT

With the increasing number of vehicles on roads, traditional toll collection methods have become inefficient, leading to long queues, fuel wastage, and revenue leakage. Manual toll collection is time-consuming and prone to errors, making it necessary to implement an automated system that ensures smooth and accurate toll operations. This project proposes an Automated Tollgate System using Arduino and an Ultrasonic Sensor to streamline toll collection by detecting vehicles and controlling the gate without human intervention. The system operates using an ultrasonic sensor, which detects an approaching vehicle and sends signals to an Arduino Uno microcontroller. The Arduino processes the data and triggers a servo motor to open the barrier, allowing the vehicle to pass. After a short delay, the gate automatically closes, ensuring a seamless traffic flow. This automation significantly reduces congestion, minimizes human errors, and enhances operational efficiency. In addition to basic automation, the system can be further improved with RFID-based authentication, IoT-enabled payment systems, and number plate recognition for advanced toll management. These technologies help in reducing operational costs, enhancing security, and enabling contactless transactions, making toll collection faster and more reliable. The project demonstrates how integrating smart technology into toll systems can contribute to the development of intelligent transportation infrastructure. Implementing such automated toll systems can have a significant impact on traffic management, security, and environmental sustainability. By reducing vehicle stoppage times, fuel consumption, and manual labor costs, this system not only improves road efficiency but also supports the transition toward smart cities and intelligent transportation .

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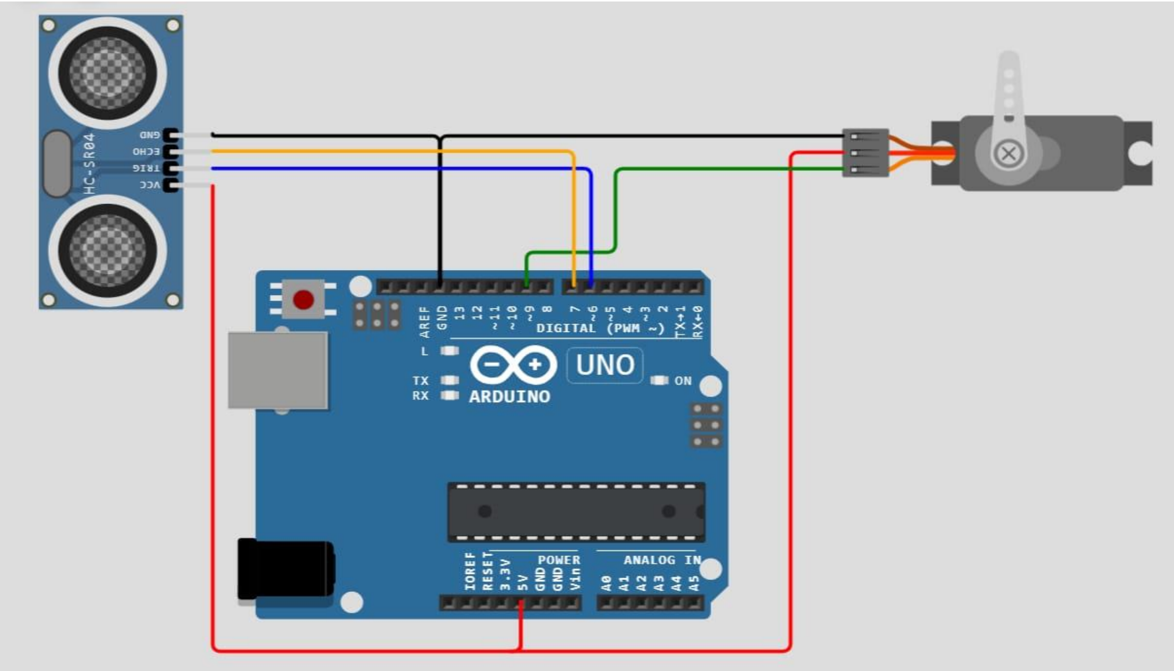
CHAPTER 1

INTRODUCTION

The rapid increase in vehicular traffic has put immense pressure on existing toll collection systems, leading to traffic congestion, delays, revenue losses, and environmental concerns. Traditional toll collection methods involve manual handling of cash or card payments, which slows down the process, increases fuel consumption, and leads to human errors. Additionally, security risks associated with cash handling and toll evasion pose significant challenges. To address these issues, modern transportation systems are shifting toward automated toll collection methods that enhance efficiency, reduce costs, and improve road safety. The Automated Tollgate System using Arduino and Ultrasonic Sensor aims to provide a seamless, cost-effective, and efficient alternative to manual toll collection. The system uses an ultrasonic sensor to detect approaching vehicles and an Arduino Uno microcontroller to process sensor data. Upon detection, a servo motor automatically opens the toll barrier, allowing the vehicle to pass without human intervention. This eliminates unnecessary delays and ensures a smooth and faster toll collection process. This project offers several advantages, including minimizing human involvement, reducing fuel wastage, and improving security by preventing unauthorized access. Additionally, the system can be enhanced with RFID technology for automatic vehicle identification, IoT-enabled payment systems for cashless transactions, and number plate recognition for advanced toll management. These upgrades make it suitable for highways, private roads, and gated communities where fast and reliable toll collection is essential. By implementing an automated toll collection system, traffic congestion can be significantly reduced, improving overall road efficiency and safety. As smart city initiatives and intelligent transportation systems continue to develop, automation in toll collection will play a crucial role in enhancing infrastructure, optimizing revenue collection, and ensuring a smoother driving experience for road users.

CHAPTER 2

CIRCUIT DIAGRAM AND KEY COMPONENTS



KEY COMPONENTS:

1. **ARDUINO UNO:** The Arduino Uno is the central processing unit of the tollgate system, acting as the command center that manages and coordinates all operations. It reads input signals from the ultrasonic sensor and, based on programmed thresholds and logic, sends appropriate control signals to the servo motor to actuate the barrier. Its versatility allows it to process real-time data and perform conditional operations—if the sensor detects a vehicle within the defined distance, the Arduino initiates the barrier-opening sequence; otherwise, it maintains the barrier in its closed state. This microcontroller is also designed to handle future upgrades such as RFID modules or IoT connectivity, making it a scalable solution that can evolve as the tolling system requires additional functionalities.

2. **ULTRASONIC SENSOR:** The ultrasonic sensor is pivotal for detecting the presence of vehicles approaching the tollgate. It functions by emitting high-frequency sound waves and then measuring the time taken for these waves to bounce off an object (like a vehicle) and return to the sensor. This time-of-flight measurement is used to compute the distance to the object accurately. In the context of the tollgate system, the sensor continuously monitors the area in front of the barrier and relays the distance data to the Arduino. When the detected distance falls within a preset range—indicating that a vehicle is in the proper position—the sensor triggers the Arduino to start the gate-opening procedure. This non-contact method of detection ensures reliability and accuracy even in varying environmental conditions.
3. **SERVO MOTOR:** The servo motor is responsible for the physical movement of the toll barrier. When the Arduino sends a command based on the sensor's input, the servo motor rotates to a specific angle to lift the barrier, allowing the vehicle to pass. After a predetermined delay, the motor reverses its rotation to lower the barrier back into place. The precision of the servo motor is crucial because it ensures that the barrier opens just enough to clear the vehicle while still remaining secure when closed. Its ability to operate with high repeatability and low power consumption makes it ideally suited for continuous operation in an automated toll collection system.

4. **BREAD BOARD AND JUMPER WIRES:** The breadboard and jumper wires form the essential physical infrastructure that ties all electronic components together. The breadboard provides a platform for creating temporary, yet reliable, circuit connections without the need for soldering, which is particularly useful during the development and prototyping stages. Jumper wires are used to connect the Arduino to the ultrasonic sensor and

the servo motor, ensuring that data and power are efficiently transmitted between components. This modular setup allows for easy modifications and troubleshooting—if one component needs to be replaced or upgraded, changes can be made quickly without affecting the entire system. The flexibility provided by these connection tools is crucial in establishing a stable and scalable circuit design that can be adapted as new functionalities are added.

CHAPTER 3
WORKING AND CODE EXPLANATION

The automated tollgate system operates through a seamless interaction between various components, including the Arduino Uno, ultrasonic sensor, servo motor, breadboard, and jumper wires. The system is designed to detect an approaching vehicle, process the signal, and control the movement of the barrier gate automatically, ensuring a smooth and efficient toll collection process. The ultrasonic sensor (HC-SR04) plays a crucial role in vehicle detection. It continuously emits high-frequency sound waves and measures the time taken for the waves to bounce back after hitting an obstacle (such as an approaching vehicle). Using this time delay, the sensor calculates the distance between itself and the detected object. If a vehicle enters the sensor's predefined detection range, the sensor sends a signal to the Arduino Uno, indicating that a vehicle is present at the tollgate.

Upon receiving the signal from the ultrasonic sensor, the Arduino Uno processes the input and makes a decision based on programmed conditions. If the detected distance is within the set threshold (e.g., less than 20 cm), the Arduino sends a command to the servo motor to rotate, lifting the toll barrier. The barrier remains open for a few seconds to allow the vehicle to pass through. This time delay can be adjusted in the program, depending on traffic conditions or specific toll requirements. Once the vehicle has successfully crossed the tollgate, the system initiates the closing sequence. The Arduino sends a reverse command to the servo motor, causing it to rotate in the opposite direction and lower the barrier back to its original position. This ensures that unauthorized vehicles cannot pass through without detection. The system then resets and returns to standby mode, continuously scanning for the next vehicle to repeat the process.

This automated process reduces the need for human intervention, enhances efficiency, and minimizes traffic congestion at toll stations. By integrating additional features such as RFID-based payment or number plate recognition, the system can be further enhanced to support cashless transactions and better security measures.

```
#include <Servo.h>

Servo myservo;

int pos = 0;

int cm = 0;

long readUltrasonicDistance(int triggerPin, int echoPin)
{
  pinMode(triggerPin, OUTPUT);
  digitalWrite(triggerPin, LOW);
  delayMicroseconds(2);
  digitalWrite(triggerPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(triggerPin, LOW);
  pinMode(echoPin, INPUT);
  return pulseIn(echoPin, HIGH);
}
void setup() {
```

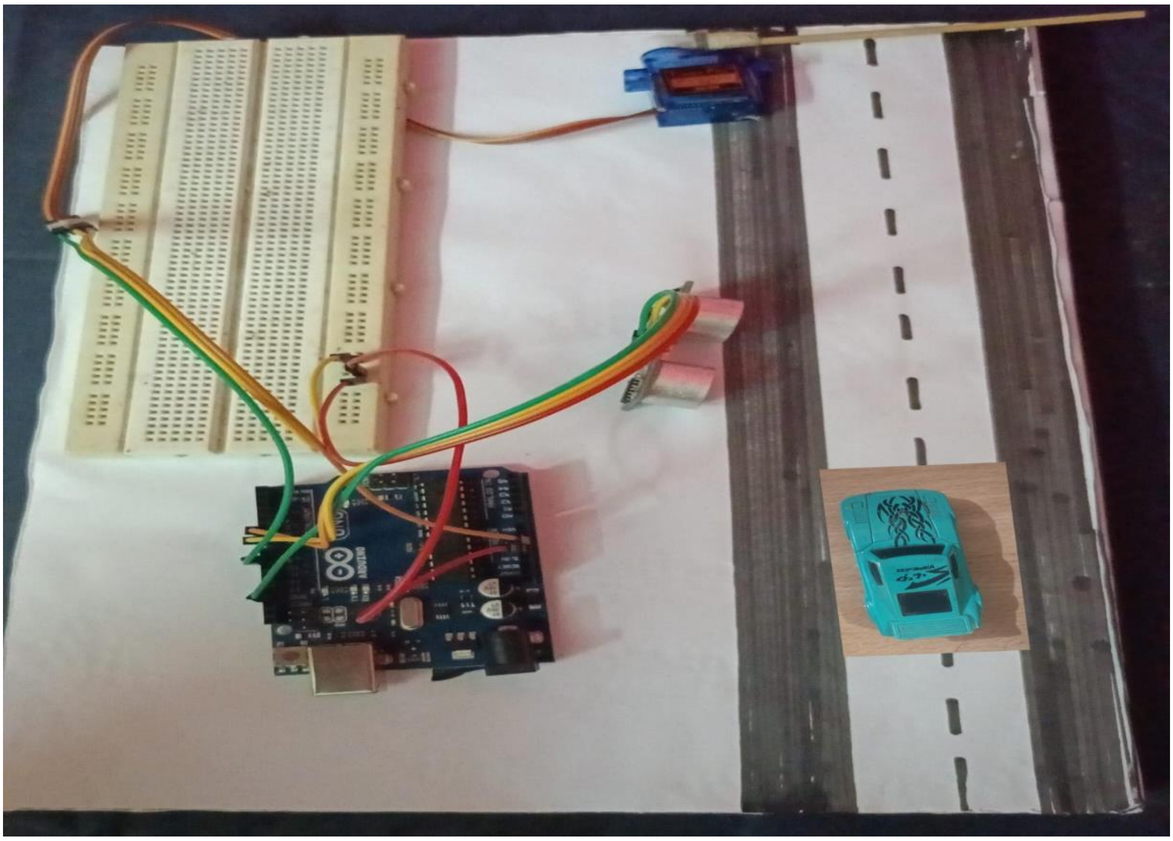
```
  digitalWrite(12,LOW);
  myservo.attach(9);
  Serial.begin(9600);
}
void loop() {
   cm = 0.01723 * readUltrasonicDistance(6, 7);
   if(cm<30){
   Serial.print(cm);
   Serial.println("cm");
 for (pos = 0; pos <= 120; pos += 1) {
    myservo.write(pos);
   delay(15);
  }
  delay(500);
 for (pos = 120; pos >= 0; pos -= 1) {
    myservo.write(pos);
    delay(15);
  }
  delay(5000); //add delay how much you want
  }
}
```

This Arduino program is designed to control an automated tollgate system using an ultrasonic sensor (HC-SR04) and a servo motor. The system detects an approaching vehicle and automatically lifts the gate, allowing passage before lowering it back into place. The code begins by including the Servo.h library, which is necessary for controlling the servo motor. A servo object named myservo is created, along with variables pos (to store the position of the servo) and cm (to store the measured distance from the ultrasonic sensor). These variables are essential for managing the movement of the gate based on real-time sensor readings.

The function readUltrasonicDistance() is responsible for measuring the distance between the sensor and an approaching vehicle. It works by first setting the trigger pin LOW and then HIGH for 10 microseconds, which sends out an ultrasonic pulse. This pulse travels until it encounters an obstacle (such as a vehicle), reflects back to the echo pin, and the function calculates the time it took to return. Using this time, the distance is determined by multiplying it by 0.01723, which converts the time into centimeters. This function provides continuous distance readings, allowing the system to detect vehicles in real time.

In the setup() function, the servo motor is attached to pin 9, and the serial communication is initialized at a baud rate of 9600, enabling debugging and monitoring of sensor readings. The loop() function continuously checks the distance detected by the ultrasonic sensor. If a vehicle is within 30 cm, the Arduino processes the signal and initiates the gate-opening sequence. The servo motor gradually moves from 0° to 120°, lifting the toll barrier. This gradual movement ensures a smooth and controlled motion. A 500-millisecond delay is introduced, allowing the vehicle sufficient time to pass. Once the vehicle has crossed, the system begins the gate-closing sequence. The servo motor rotates in the opposite direction, returning from 120° to 0°, effectively closing the barrier. Another delay of 5000 milliseconds (5 seconds) is added before the system resets, ensuring the barrier remains closed before scanning for the next vehicle. The automated loop ensures continuous operation, reducing the need for human intervention and improving traffic flow at toll plazas.

CHAPTER 4
RESULTS AND DISCUSSIONS



The automated tollgate system was successfully tested, demonstrating effective vehicle detection and smooth barrier operation. The ultrasonic sensor (HC-SR04) accurately detected vehicles within the predefined range of 30 cm, triggering the Arduino Uno to activate the servo motor, which lifted the gate. The response time was minimal, allowing the gate to open and close efficiently, reducing delays at the tollgate. The system operated consistently under controlled conditions, ensuring accurate vehicle detection and proper barrier movement.

During testing, the ultrasonic sensor provided stable distance readings, but minor fluctuations occurred due to environmental factors such as reflections from nearby objects or varying surface materials of the detected vehicles. The servo motor performed reliably, smoothly rotating between 0° and 120° to open the gate and returning to 0° to close it after a setdelay.The system's ability to reset and continuously scan for approaching vehicles ensured seamless operation.

One of the key findings was the system's efficiency in handling multiple vehicles sequentially without requiring manual intervention. This significantly reduced wait times and the need for toll booth operators. However, some challenges were identified, including the possibility of false triggers due to sudden environmental changes or obstacles near the sensor. Additionally, the system relies on a stable power supply, and any interruption could impact its performance.

Overall, the Arduino-based automated tollgate system proved to be an effective and low-cost solution for improving toll management. The system successfully automated vehicle detection, gate operation, and reset functions, demonstrating its potential for real-world applications. Further improvements, such as integrating RFID payment systems or number plate recognition, could enhance its functionality and reliability.

CHAPTER 5

CONCLUSION

The automated tollgate system using Arduino Uno, an ultrasonic sensor, and a servo motor has proven to be an effective and reliable solution for automating toll collection. The system successfully detected approaching vehicles, triggered the barrier gate, and ensured smooth traffic movement with minimal waiting time. By eliminating manual toll collection, the system reduces congestion and improves efficiency, making it a cost-effective and scalable alternative to traditional toll booths. The ultrasonic sensor provided accurate distance measurements, while the servo motor performed smooth and controlled gate operations, ensuring proper functionality. Despite its success, the system faced some challenges, such as false triggers caused by environmental factors and the need for a stable power supply to ensure uninterrupted operation. These issues can be mitigated by optimizing sensor calibration, implementing filtering techniques to reduce false detections, and integrating a backup power source. Additionally, the system can be enhanced by incorporating RFID-based payment systems, number plate recognition, and IoT-based monitoring, making it more advanced and user-friendly. The project highlights the potential of automation in toll management, offering a fast, efficient, and low-cost solution for modernizing toll plazas. The findings suggest that with further improvements and integrations, this system can be deployed on a larger scale to improve traffic management, reduce operational costs, and enhance the overall toll collection process.

CHAPTER 6

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