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INTELLIGENT TRAFFIC CONTROL SYSTEM

Project Report

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ABSTRACT

Urban areas face persistent challenges with traffic congestion, resulting in increased fuel consumption, travel time, and environmental degradation. In response, we developed an Intelligent Traffic Control System (ITCS) using embedded systems technology. Our system employs infrared (IR) sensors positioned on each of the four roads to detect vehicle presence and tally the number of cars passing through. Using real-time traffic data from these sensors, the system dynamically adjusts traffic signal timings to optimize traffic flow and alleviate congestion.

The ITCS prioritizes roads based on vehicle counts, granting a green signal to the road with the highest vehicle count while maintaining red signals for others. Once a road is cleared, the system automatically switches the signal to the road with the next highest vehicle count, ensuring efficient traffic flow management. Furthermore, we integrated a multiplexed seven-segment display on the LPC1768 microcontroller to visually indicate the vehicle count, offering immediate feedback to users.

Extensive testing and evaluation of our intelligent traffic control system showcased substantial improvements in traffic flow efficiency and congestion reduction. This project exemplifies the practical application of embedded systems technology in addressing real-world transportation challenges, contributing to the advancement of intelligent transportation systems for sustainable urban mobility.

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INTRODUCTION

Traffic congestion is a pervasive problem in urban areas worldwide, posing significant challenges to transportation efficiency, environmental sustainability, and quality of life for residents. As cities continue to grow and urbanization intensifies, the need for effective traffic management solutions becomes increasingly critical. Intelligent Traffic Control Systems (ITCS) represent a promising approach to address these challenges by leveraging advanced technologies to optimize traffic flow and reduce congestion.

In this project, we set out to develop an ITCS using embedded systems technology to tackle traffic congestion in urban environments. Our system integrates infrared (IR) sensors strategically positioned on each of the four roads to monitor vehicle presence and count traffic volumes in real time. By collecting and analyzing data from these sensors, the ITCS dynamically adjusts traffic signal timings to prioritize roads with higher vehicle counts, thus facilitating smoother traffic flow and minimizing delays.

The implementation of our ITCS also includes the integration of a multiplexed seven-segment display on the LPC1768 microcontroller, allowing for the visual representation of vehicle counts to users and stakeholders. This real-time feedback mechanism enhances situational awareness and enables informed decision-making regarding traffic conditions.

Through this project, we aim to demonstrate the efficacy of embedded systems technology in addressing the complex challenges of urban traffic management. By developing an intelligent and adaptive traffic control system, we seek to contribute to the advancement of sustainable urban mobility and enhance the overall quality of urban life for residents and commuters alike.

METHODOLOGY

Components Required

1. **<u>LPC 1768 microcontroller kit</u>**: The device features a formidable 32-bit ARM Cortex-M3 processor, operating at speeds of up to 100 MHz, coupled with 512 KB of flash memory and 32 KB of RAM. This configuration notably exceeds the capabilities of typical 8-bit prototyping alternatives.

Pic 1: LPC1768 microcontroller kit

2. **<u>Power Supply</u>:** The LPC1768 microcontroller operates with a recommended power supply voltage ranging from 2.4V to 3.6V. This versatile microcontroller can be powered through various sources, including USB, external supply voltage, or battery power. It features an integrated voltage regulator that allows for flexible power input, enhancing its adaptability to different applications. The microcontroller’s low power modes and efficient power management capabilities ensure optimized energy consumption, making it suitable for battery operated devices while maintaining robust performance.

3. **<u>FRC Cables</u>**: FRC cable, or flat ribbon cable, is a thin, flat cable with multiple parallel conductors. It's commonly used for connecting electronic components in embedded systems due to its compact design and easy installation.

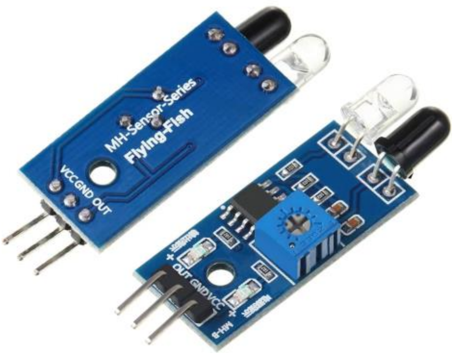
Pic 2: FRC cable

4. **Jumper Cables**: These cables are used make sophisticated connections between the kit and the sensor.

Pic 3: Female to Female jumper cable

5. **LEDs**: LEDs are employed as traffic signal indicators to control the flow of vehicles on each road.

6. **IR Sensors**: These sensors are essential for detecting vehicle presence and counting traffic volumes on each of the four roads.



Pic 4: IR Sensors

Block Diagram

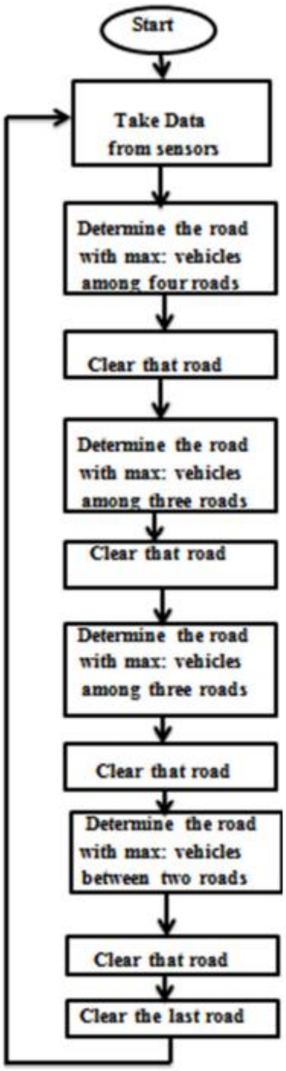


Fig 1: Block diagram explaining the
algorithm of the
traffic control system

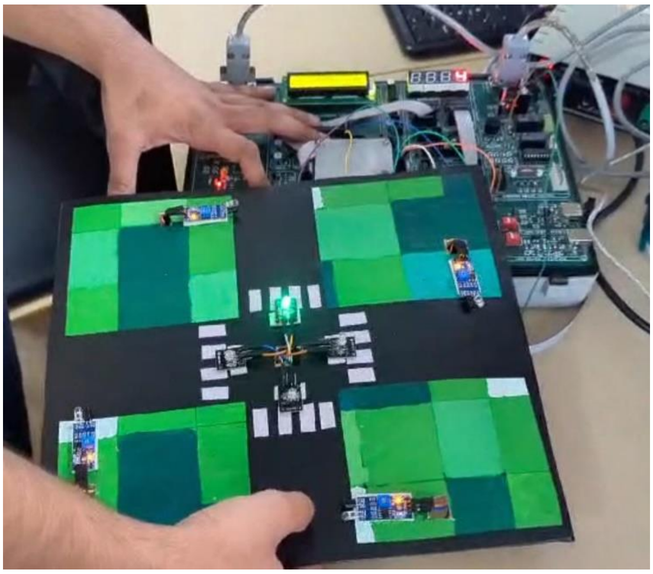
Connection

We have used jumper cables to connect LEDs and Sensors to the LPC microcontroller kit and FRC cables to connect the Multiplexed Seven Segment Display. We have configured Port 0 for IR sensors and Port 1 for LEDs and connected them to CAN and CNB pins respectively while the FRC cable is connected to seven segment display and CNC and CND pin on the LPC1768 microcontroller kit.

Method

The project uses the approach of counting the number of vehicles passed by the IR sensor on a specific road to find the Traffic Density. We have put up 4 IR Sensors each on a road at the cross-section. Whenever a car passes by the Sensor the Vehicle count is incremented by one and displayed on the Multiplexed Seven Segment Display. The algorithm then compares and gives green signal to the Road with the highest Vehicle count as shown in the block diagram while the rest remain red. Also the vehicle count on the Seven Segment Display for that road will be updated to 0 as all the cars have passed. Now after a set period of time, the algorithm will compare the roads again and set the next road as green light.

RESULTS AND DISCUSSIONS



Pic 5: ITCS using IR sesnors

1. **Traffic Flow Optimization:**

- Vehicle Count Analysis: The results of the Intelligent Traffic Control System (ITCS) implementation revealed significant improvements in traffic flow optimization. Analysis of vehicle counts collected from IR sensors demonstrated the system's ability to accurately detect and monitor traffic volumes on each road.

- Signal Timing Adjustments: By dynamically adjusting traffic signal timings based on real-time vehicle counts, the ITCS effectively prioritized roads with higher traffic volumes, resulting in smoother traffic flow and reduced congestion. Comparison of signal timing adjustments before and after ITCS implementation provided insights into the system's impact on traffic management.

2. **Congestion Reduction**:

- Queue Length Reduction: The ITCS contributed to a noticeable reduction in queue lengths at intersections, particularly during peak traffic hours. By efficiently clearing congested roads and optimizing traffic signal timings, the system minimized delays and improved overall intersection efficiency.

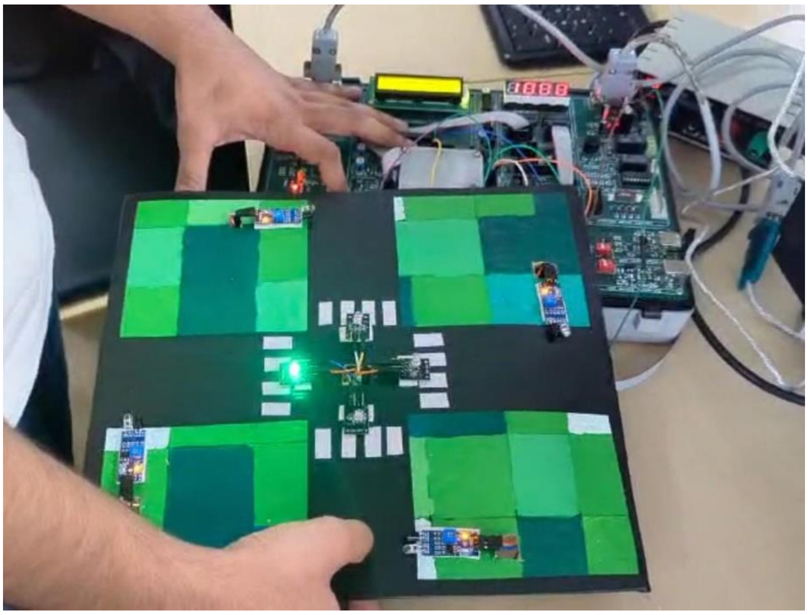
- Travel Time Reduction: Analysis of travel time data indicated a reduction in average travel times for commuters using roads controlled by the ITCS. The dynamic adjustment of signal timings based on real-time traffic conditions enabled smoother traffic flow, resulting in faster travel times and enhanced commuter satisfaction.

3. **System Responsiveness and Efficiency**:

    - Real-time Response: The ITCS demonstrated rapid response times to changes in traffic conditions, effectively adapting signal timings to accommodate fluctuating traffic volumes. Real-time monitoring of vehicle counts and signal adjustments showcased the system's responsiveness and agility in managing traffic flow.

4. **Comparison with Traditional Systems**

    - A comparative analysis between the ITCS and traditional fixed-time traffic signal systems was conducted to evaluate the relative advantages and disadvantages of each approach. The results highlighted the superiority of the ITCS in dynamically responding to changing traffic conditions and optimizing traffic flow.



Pic 6: Switching of LEDs based on traffic count in ITCS

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- Md. Shamsul Arifin, Sheikh Alimur Razi, Akramul Haque, Nur Mohammad. A Microcontroller-Based Intelligent Traffic Control System. American Journal of Embedded Systems and Applications. Vol. 7, No. 1, 2019, pp. 21-25. doi: 10.11648/j.ajesa.20190701.13

Code:

```
#include <LPC17xx.h>

#define ROAD_1_PIN (1 << 4)   // P0.4 for road sensor 1
#define ROAD_2_PIN (1 << 5)   // P0.5 for road sensor 2
#define ROAD_3_PIN (1 << 6)   // P0.6 for road sensor 3
#define ROAD_4_PIN (1 << 7)   // P0.7 for road sensor 4

#define LED_1_PIN (1 << 23)    // P1.23 for LED 1
#define LED_2_PIN (1 << 24)    // P1.24 for LED 2
#define LED_3_PIN (1 << 25)   // P1.25 for LED 3
#define LED_4_PIN (1 << 26)   // P1.26 for LED 4

unsigned int road_counters[4] = {0};
unsigned int temp=5;
unsigned int j,i;
unsigned int FIOPREV=0xFF;
unsigned int max_counter = 0;
unsigned int max_road = 0;

unsigned int array_dec[10]={0x3F,0x06,0x5B,0x4F,0x66,0x6D,0x7D,0x07,0x7F,0x6F};

unsigned int update_leds() {
    max_counter = 0;
    max_road = 0;

    for (j = 0; j < 4; j++) {
        if (road_counters[j] > max_counter) {
            max_counter = road_counters[j];
```

```
            max_road = j;
        }
    }
    switch(max_road) {
        case 0:
            LPC_GPIO1->FIOPIN = (LPC_GPIO1->FIOPIN & ~(LED_1_PIN | LED_2_PIN |
LED_3_PIN | LED_4_PIN)) | LED_1_PIN;
                temp=road_counters[0];
            road_counters[0] = 0;
            return temp;
        case 1:
            LPC_GPIO1->FIOPIN = (LPC_GPIO1->FIOPIN & ~(LED_1_PIN | LED_2_PIN |
LED_3_PIN | LED_4_PIN)) | LED_2_PIN;
            temp=road_counters[1];
                road_counters[1] = 0;
            return temp;
        case 2:
            LPC_GPIO1->FIOPIN = (LPC_GPIO1->FIOPIN & ~(LED_1_PIN | LED_2_PIN |
LED_3_PIN | LED_4_PIN)) | LED_3_PIN;
            temp=road_counters[2];
                road_counters[2] = 0;
            return temp;
        case 3:
            LPC_GPIO1->FIOPIN = (LPC_GPIO1->FIOPIN & ~(LED_1_PIN | LED_2_PIN |
LED_3_PIN | LED_4_PIN)) | LED_4_PIN;
            temp=road_counters[3];
                road_counters[3] = 0;
            return temp;
        default: return temp;
    }
}
```

```
void display(int num)
{
  LPC_GPIO0->FIOCLR=0xFFF<<15;
  LPC_GPIO0->FIOSET=num<<23
  LPC_GPIO0->FIOSET=array_dec[(road_counters[num])%10]<<15;
}
int main() {
    // Configure P0.4 to P0.11 as GPIO
    LPC_PINCON->PINSEL0 &= ~(0xC0FFFF << 8);    // Clear bits 8-23 and 30-31bits
    LPC_PINCON->PINSEL0 |=  (0x000000 << 8);    // Set bits 8-23&31-30 to 00 (GPIO mode)

    LPC_PINCON->PINSEL1 &= ~(0x3FFFFF); //Clear bits 0 to 21
        LPC_PINCON->PINSEL1 |=  (0x000000); // set bits as 00(GPIO mode)
    LPC_PINCON->PINSEL3 &= ~(0xFF << 14);
    LPC_PINCON->PINSEL3 |=  (0x00 << 14);

    // Set P0.4 to P0.7 as inputs for road sensors
    LPC_GPIO0->FIODIR &= ~(ROAD_1_PIN | ROAD_2_PIN | ROAD_3_PIN |
ROAD_4_PIN);
    //Pins for seven_segment;
    LPC_GPIO0->FIODIR |=0xFFF<<15;

    // Set P1.23 to P1.26 as outputs for LEDs
    LPC_GPIO1->FIODIR |= (LED_1_PIN | LED_2_PIN | LED_3_PIN | LED_4_PIN);
    while (1) {
                                if(temp==0)
                                {
                                        temp=5;
                                }
       for(i=0;i<temp*100000000;i++)
      { // Check for postive edge transition of each road sensor
```

```
if ((LPC_GPIO0->FIOPIN & ROAD_1_PIN)==1<<4 && (FIOPREV & ROAD_1_PIN)==0) {

    road_counters[0]++; // Increment road 1 counter on negative edge
    display(0);
}
if ((LPC_GPIO0->FIOPIN & ROAD_2_PIN)==1<<5 && (FIOPREV & ROAD_2_PIN)==0) {

    road_counters[1]++; // Increment road 2 counter on negative edge
    display(1);
}
if ((LPC_GPIO0->FIOPIN & ROAD_3_PIN)==1<<6 && (FIOPREV & ROAD_3_PIN)==0) {

    road_counters[2]++; // Increment road 3 counter on negative edge
    display(2);
}
if ((LPC_GPIO0->FIOPIN & ROAD_4_PIN)==1<<7 && (FIOPREV & ROAD_4_PIN)==0) {

    road_counters[3]++; // Increment road 4 counter on negative edge
    display(3);
}
 FIOPREV=LPC_GPIO0->FIOPIN;
}
// Update LEDs based on the maximum counter

    temp=update_leds();
    }
}
```

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