# Department of I & CT

# MIT, Manipal


# Real-Time Obstacle Sensing and Detection using Ultrasonic Sensor

**ICT 3143 Embedded Systems lab mini project**

**Vth Sem B. Tech (CCE)**


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# ABSTRACT

In recent years, the demand for efficient and reliable obstacle detection systems has surged, driven by the growth of applications in fields such as robotics, autonomous navigation, and industrial automation. These systems are essential for enabling autonomous devices to detect obstacles within their environments and respond appropriately, ensuring both safety and efficiency. As autonomous technology becomes more integral to various industries, the importance of dependable obstacle detection has grown. This project addresses the rising need by developing an obstacle detection robot that not only identifies nearby obstacles but also provides real-time distance readings and alerts users when the robot is close to an obstruction. Through the integration of an LPC1768 microcontroller and an HC-SR04 ultrasonic sensor, the project demonstrates the potential of embedded systems to enable responsive and adaptable robotic solutions for dynamic environments.

The core of the obstacle detection robot is the LPC1768 microcontroller, which serves as the processing brain of the system. The HC-SR04 ultrasonic sensor measures the distance to nearby objects and relays this information to an LCD screen, providing users with real-time feedback on the robot's proximity to obstacles. When the robot detects an object within a set threshold of 10 cm, the system triggers a buzzer and LED lights to issue both visual and auditory alerts, ensuring the user is immediately aware of nearby obstructions. The choice of female-to-female jumper cables facilitates secure and stable connections between components, contributing to the reliability and durability of the setup. This design prioritizes simplicity and practicality, achieving an effective obstacle detection mechanism using essential components that work together seamlessly.

The project outcomes are significant in several ways. First, the robot achieves precise, real-time distance measurements, enabling it to monitor its environment effectively. Second, the system's design allows for intuitive user feedback through visual and auditory cues, ensuring that users are alerted to obstacles promptly. Finally, the obstacle detection system requires no complex directional adjustments, making it adaptable to various settings and highly effective in fast-paced environments where constant monitoring is crucial. By leveraging the LPC1768's robust processing capabilities, the project showcases how embedded systems can significantly improve the responsiveness and reliability of robotic applications. This project underscores the value of embedded technology in creating adaptable, safety-focused systems for real-world use, illustrating that even straightforward, affordable technologies can bring about meaningful improvements in user safety and automation efficiency overall, this project emphasises the potential of obstacle detection robots for various applications, from industrial automation to personal assistance. By focusing on core functionalities—precise distance measurement, clear alerts, and responsive feedback—this robot design represents a practical, achievable approach to enhancing safety and adaptability in dynamic settings. The success of this project demonstrates the practical applicability of embedded systems in robotics, highlighting their capacity to increase both the safety and reliability of autonomous technology in environments where human awareness and quick responses are paramount.

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# INTRODUCTION

As technology advances rapidly across virtually all sectors, the demand for autonomous systems has grown in both necessity and scale, driven by the need for efficiency, safety, and adaptability in complex environments. Industries such as transportation, manufacturing, and security now rely increasingly on automation, making systems that can navigate independently, detect obstacles, and respond in real time essential for smooth and safe operations. At the heart of these systems lies obstacle detection technology, which enables machines to perceive their surroundings, interpret potential hazards, and react immediately to prevent collisions or interruptions. This project addresses this critical requirement by designing an obstacle-detection robot built around the LPC1768 microcontroller. Our aim is to create a system that not only detects obstacles but also actively alerts users, showcasing a practical application of embedded systems paired with sensor technology in enhancing safety and reliability in automation.

Central to this system's functionality is the LPC1768 microcontroller, selected for its powerful and adaptable architecture. Operating on an ARM Cortex-M3 processor with a 100 MHz clock speed, the LPC1768 comes with 512 KB of flash memory and 32 KB of RAM, providing the necessary resources to handle real-time sensor data and execute fast responses. The obstacle detection component of this system relies on the HC-SR04 ultrasonic sensor, which calculates distances by emitting ultrasonic waves and measuring the time taken for these waves to reflect back from nearby objects. Ultrasonic sensing is particularly advantageous for autonomous systems, as it uses non-contact measurement to minimise wear and tear, thus reducing the risk of damage while offering greater durability and precision. This combination of accuracy and robustness makes ultrasonic sensing an invaluable asset in real-time applications, where high-speed data processing and reliable measurements are essential for safe and efficient navigation.

The objective of this project is to develop a robot that can detect obstacles within a specified range and alert users if an object approaches too closely—specifically, within a 10 cm threshold. To achieve this, the system will display the measured distance on an LCD screen, giving users real-time feedback on the proximity of obstacles in the surrounding environment. When an object enters this critical range, the system immediately activates LEDs and a buzzer, providing both visual and auditory alerts. This multi-layered feedback mechanism ensures that users are promptly and clearly informed of any potential hazards, which is particularly useful in dynamic or industrial environments where a quick response is essential for maintaining safety. This layered approach also serves to improve the user experience, as the information is easy to interpret and readily accessible, making it suitable for a variety of applications from factory floors to automated service robots.

This project addresses the need for obstacle detection while showcasing the broader potential of embedded systems and sensor integration in enabling adaptive, real-time navigation. By combining the processing capabilities of the LPC1768 microcontroller with the HC-SR04 ultrasonic sensor's precision, this system presents a forward-thinking approach to autonomous hazard detection. Embedded systems are essential in automation, offering responsive platforms that integrate sensors, process data, and provide immediate feedback. Such projects demonstrate how embedded technology can tackle real-world challenges, setting the stage for safer, more adaptable autonomous systems that shape a resilient, automated future.

# METHODOLOGY

This section outlines the components used, setup configurations, and the step-by-step process followed to achieve a responsive obstacle detection system with user alerts.

## a. Components Required

1. **LPC1768 Microcontroller Kit:**
   The LPC1768 is a 32-bit ARM Cortex-M3 processor, selected for its efficiency in handling real-time data processing. Operating at a clock speed of 100 MHz, the microcontroller is equipped with 512 KB of flash memory and 32 KB of RAM, making it ideal for processing continuous input from the ultrasonic sensor. Serving as the core of this obstacle detection system, the LPC1768 manages all incoming sensor data and controls the output display and alert components, ensuring quick responses to potential hazards.
2. **HC-SR04 Ultrasonic Sensor:**
   Central to the system's obstacle detection functionality, the HC-SR04 ultrasonic sensor enables accurate non-contact distance measurement. It works by emitting high-frequency ultrasonic sound waves that reflect off nearby objects. The time it takes for these waves to return allows the sensor to calculate the distance to the object, which is then sent to the microcontroller. Known for its reliability and precision, this sensor covers the range required for effective collision avoidance, making it suitable for real-time applications in autonomous systems.
3. **LCD Display:**
   The LCD provides real-time feedback by displaying the measured distance between the robot and detected obstacles. This continuous visual display is particularly beneficial for users who require immediate information about surrounding objects. By seeing the proximity of obstacles on the screen, users can easily track the robot's path and adjust accordingly if the robot is navigating a dynamic environment.
4. **LEDs and Buzzer:**
   For user alerting, LEDs and a buzzer are integrated into the system. When an obstacle is detected within a critical range of 10 cm, the microcontroller activates these components to warn the user. The LEDs provide clear visual feedback, while the buzzer emits a loud auditory signal, ensuring the user is promptly notified of any immediate hazards. This combination of visual and auditory alerts enhances situational awareness, especially in noisy or visually cluttered environments.
5. **Female-to-Female Jumper Cables and FRC Cables:**
   These cables serve as the connecting links between the components, enabling the ultrasonic sensor, LCD display, LEDs, and buzzer to interface seamlessly with the LPC1768 microcontroller. The cables help ensure a secure and stable connection, which is vital for maintaining reliable system operations, particularly in real-time applications where data accuracy and stability are essential.

## b. Block Diagram

The block diagram visually represents the interconnections between the LPC1768 microcontroller, ultrasonic sensor, LCD display, LEDs, and buzzer, illustrating the data flow and interaction within the system. Each component is shown in relation to the microcontroller, helping to clarify how sensor input triggers output responses and alerts.

- Power Supply: This module provides the power requirements to all the components in the system, especially to the LPC1768 microcontroller, ultrasonic sensor, LCD display, LEDs, and buzzer, ensuring proper working of the device.

- HC-SR04 Ultrasonic Sensor: This device is used for obstacle avoidance in the path of a robot. It sends an ultrasonic wave and calibrates the distance to be measured from the obstacles by analyzing the time taken for the incoming waves to return. Sensor sends distance data to microcontroller LPC1768 for processing.

- LPC1768 Microcontroller: The LPC1768 is the CPU of the system. It accepts distance data from the ultrasonic sensor and processes this data to decide the proximity of obstacles. If an obstacle is sensed within a critical range, for example, less than 10 cm, the microcontroller sends an alert signal to the LEDs and buzzer to activate them as warnings. It also sends data to the LCD display for real-time visual feedback.

- LCD Display: It is connected to the LPC1768 microcontroller. It will show real-time distance between sensor and detected obstacles. So users can view the distance through it visually; they get good feedback on the robot's environment.

- LEDs: Whenever the microcontroller comes to know that the obstacle has come into the critical range, then it sends a signal of alert to LEDs so that they will light up in order to show visually the presence of obstacles.

- Buzzer: Just like LEDs, the buzzer is HIGH with an alarm signal through LPC1768 if the obstacle detected lies wi thin some defined range. This loud signal emanates from the buzzer given to the people for acute vision about the object.

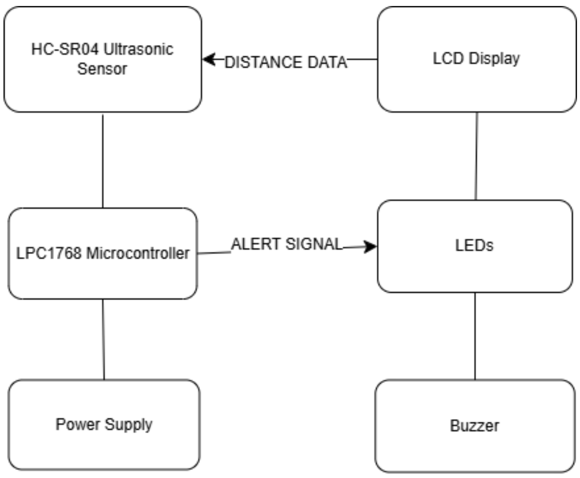



Fig. 1. Block Diagram

## c. Connections Descriptions

1. **Ultrasonic Sensor:**
   The HC-SR04 ultrasonic sensor is connected to designated GPIO (General Purpose Input/Output) pins on the LPC1768 microcontroller via jumper cables. The VCC and GND pin of the ultrasonic sensor is connected to VCC and GND pin on LPC1768. Trigger pin is connected to P0.15 and Echo pin is connected to P0.16 on the kit. This setup allows the sensor to send measured distance data to the microcontroller for processing, enabling accurate monitoring of the surroundings in real-time.
2. **LCD Display:**
   The LCD is wired to connector D on the microcontroller using the FRC cable to continuously display the distance measured by the ultrasonic sensor. By showing the distance on-screen in real-time, the LCD enables users to stay informed about the robot's proximity to obstacles, providing a clear visual reference for distance monitoring.
3. **LEDs and Buzzer:**
   The LEDs and buzzer are connected to specific GPIO pins on the LPC1768. When the distance measured by the sensor falls below the preset threshold of 10 cm, the microcontroller immediately activates these components. This prompt activation provides immediate visual and auditory feedback, alerting users to nearby hazards and enhancing the safety of the operating environment.

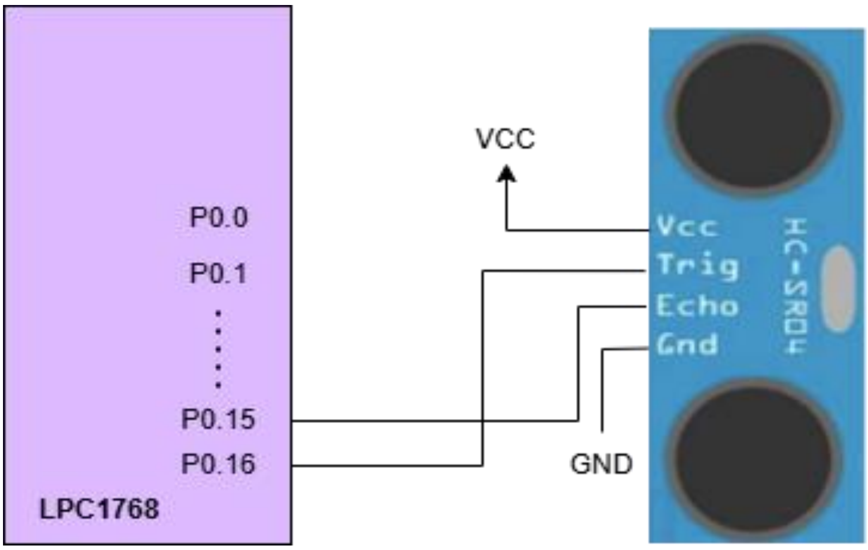



Fig. 2. Circuit Diagram

## d. Method

1. **Obstacle Detection:**
   The ultrasonic sensor is programmed to continuously emit ultrasonic waves, scanning for objects within its range. As soon as an object is detected, the sensor measures the distance by calculating the time taken for the sound waves to reflect back. This distance data is then transmitted to the LPC1768 microcontroller, where it is processed.
2. **Distance Analysis:**
   Once the distance data is received, the microcontroller compares it to the preset threshold of 10 cm. If the detected distance is greater than 10 cm, the system will simply display the distance on the LCD without triggering any alerts. This allows the robot to navigate freely until it encounters an obstacle within the critical range.
3. **Alert Activation:**
   When an obstacle is detected within the 10 cm threshold, the microcontroller immediately triggers the LEDs and buzzer, alerting users to the potential hazard. The LEDs light up as a visual cue, while the buzzer provides an auditory warning, ensuring that the alert reaches the user even if the LCD display is not in view or if there are distractions in the environment.
4. **Display Output:**
   The LCD screen is updated continuously, reflecting any changes in the detected distance in real time. This feature gives users a constantly refreshed visual reference, allowing them to track changes in proximity to obstacles. This ongoing feedback is particularly useful in dynamic settings, where the distance to obstacles may change rapidly.

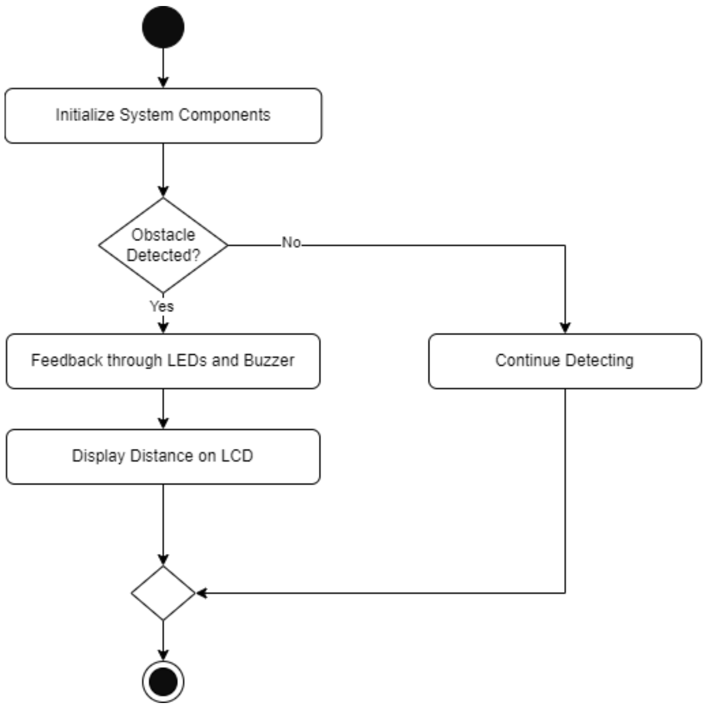
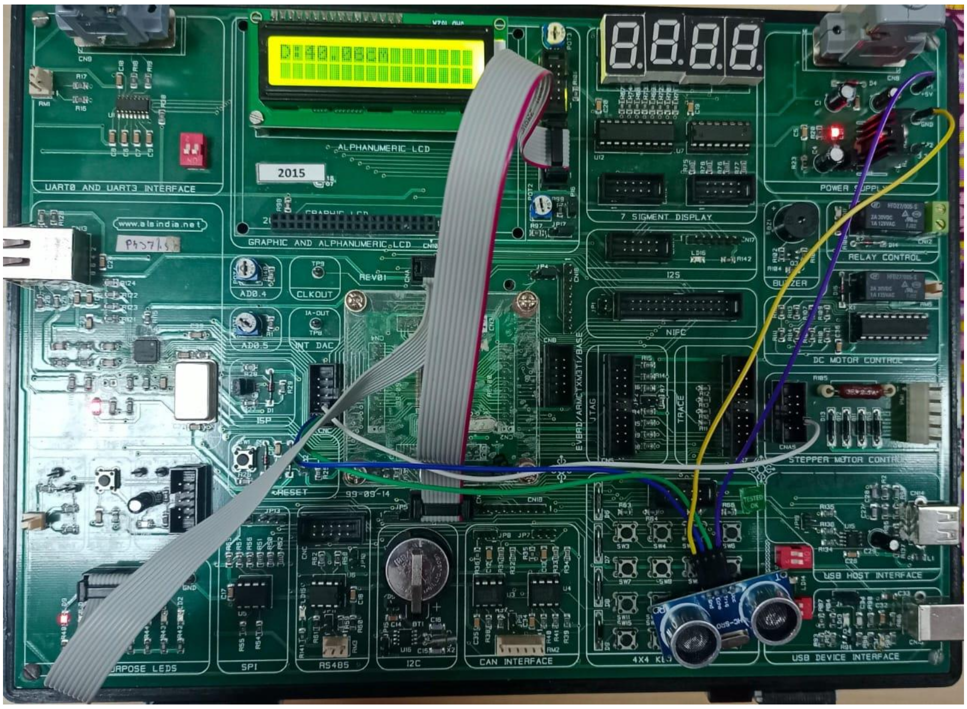



Fig. 3. Flow Diagram

This systematic approach integrates various components and feedback mechanisms, enabling the robot to detect obstacles in real-time and deliver timely alerts. By combining sensor data processing, distance display, and user notifications, this obstacle detection system is highly responsive and adaptable for diverse applications. The methodology demonstrates how embedded systems, in conjunction with sensors and user interfaces, can provide practical solutions for safe navigation in automation. Overall, this project not only meets immediate obstacle detection needs but also establishes a scalable foundation for more complex autonomous systems reliant on real-time feedback for safe operation.

# RESULTS AND DISCUSSION

a. Photographs of the Working System



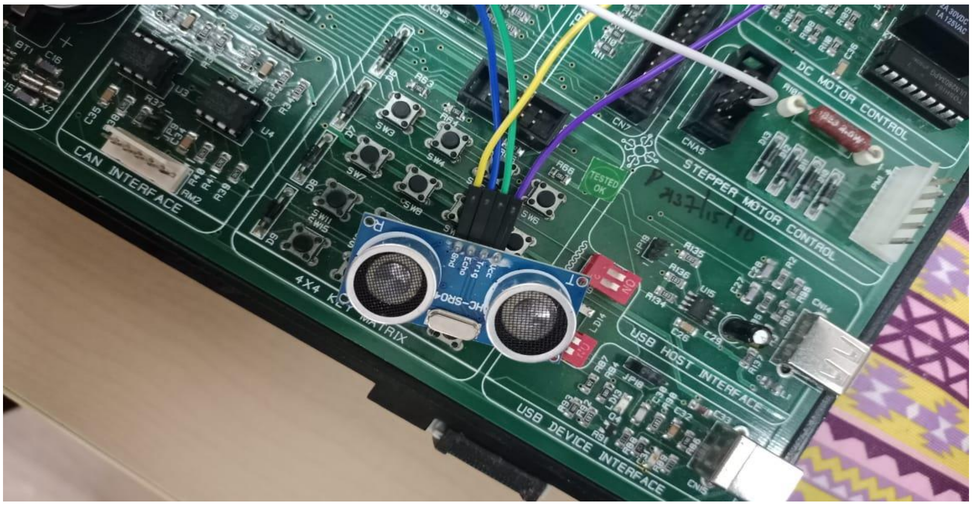



Fig. 4. Photographs of the system

### b. Working and Relevance of the System

The obstacle detection robot effectively met all project objectives, accurately measuring distances to nearby objects, displaying these on an LCD screen, and alerting users when an object entered a critical proximity. When an obstacle was detected within 10 cm, the LEDs and buzzer responded reliably, giving immediate visual and auditory feedback. This functionality confirmed the robot's capability for real-time detection and prompt user alerts. The LPC1768 microcontroller enabled swift data processing and responsive obstacle management, showcasing the strengths of embedded systems in building safety-focused, responsive applications. Overall, this project demonstrates the practical value of embedded technology for obstacle detection, paving the way for future advancements in autonomous navigation solutions.

## REFERENCES

**[1] interfacing hcsr04 ultrasonic sensor with lpc1768 - Keil forum - Support forums - Arm Community**

**[2] LPC1768 reference manual**

**[3] Obstacle Detection with Ultrasonic Sensors and Signal Analysis Metrics, Transportation Research Procedia Volume 28, 2017, Pages 173-182, Elsevier.**

## C code with comments

```
#include <stdio.h>
#include <LPC17xx.h>
#include <math.h>
 #include<string.h>
 #define PRESCALE 29999999
 #define BUZZER (1 << 17)
 #define LED 0xff // P0.4-0.11
 #define RS_CTRL 0x08000000 // P0.27 To inform whether it is command or
 #define EN_CTRL 0x10000000 // P0.28 Enable Pin first goes high then low
 #define DT_CTRL 0x07800000 // P0.23 to P0.26 data lines
 #define TRIG (1 << 15) // P0.15
 #define ECHO (1 << 16) // P0.160
 char ans[20] = "";
 char ans1[20] = "0xC0";
 int temp, temp1, temp2 = 0;
 int flag = 0, flag1;
 int i, j, k, l, r, echoTime = 5000;
 float distance = 0;
 void clear_ports(void);
 void lcd_write(void);
 void port_write(void);
 void lcd_display(unsigned char *buf1);
 void delay(unsigned int r1);
 void clearDisplay(void);
 void startTimer0(void);
 float stopTimer0();
 void initTimer0(void);
 void delayUS(unsigned int microseconds);
 void delayMS(unsigned int milliseconds);
 void delayUS(unsigned int microseconds) // Using Timer0
 {
         LPC_SC->PCLKSEL0 &= ~(0x3 << 2); // Set PCLK_TIMER0 to divide by
         LPC_TIM0->TCR = 0x02; // Reset timer
         LPC_TIM0->PR = 0; // Set prescaler to 0
         LPC_TIM0->MR0 = microseconds - 1; // Set match register for 10us
         LPC_TIM0->MCR = 0x01; // Interrupt on match
         LPC_TIM0->TCR = 0x01; // Enable timer
         while ((LPC_TIM0->IR & 0x01) == 0); // Wait for interrupt flag
         LPC_TIM0->TCR = 0x00; // Disable timer
         LPC_TIM0->IR = 0x01;
 }

 void delayMS(unsigned int milliseconds) // Using Timer0
```

```
{
        delayUS(milliseconds * 1000);
}

void initTimer0(void)
{
        // Timer for distance
        LPC_TIM0->CTCR = 0x0;
        LPC_TIM0->PR = 11999999;
        LPC_TIM0->TCR = 0x02; // Reset Timer
}

void startTimer0(void)
{
        LPC_TIM0->TCR = 0x02; // Reset Timer
        LPC_TIM0->TCR = 0x01; // Enable timer
}

float stopTimer0()
{
        LPC_TIM0->TCR = 0x0;
        return LPC_TIM0->TC;
}

void delay (unsigned int r1)
{
        for (r = 0; r < r1; r++);
}

void clear_ports(void)
{
         /* Clearing the lines at power on */
        LPC_GPIO0->FIOCLR = DT_CTRL; // Clearing data lines
        LPC_GPIO0->FIOCLR = RS_CTRL; // Clearing RS line
        LPC_GPIO0->FIOCLR = EN_CTRL; // Clearing Enable line
        delay (100000);
        return;
}

void port_write()
{
        int j;
        LPC_GPIO0->FIOPIN = temp2 << 23;
        if (flag1 == 0)
        {
                LPC_GPIO0->FIOCLR = 1 << 27;
```

```
	}
	else
	{
		LPC_GPIO0->FIOSET = 1 << 27;
	}
	LPC_GPIO0->FIOSET = 1 << 28;
	for (j = 0; j < 50; j++);
	LPC_GPIO0->FIOCLR = 1 << 28;
	for (j = 0; j < 10000; j++);
}

void lcd_write()
{
	temp2 = (temp1 >> 4) & 0xF;
	port_write();
	temp2 = temp1 & 0xF;
	port_write();
}

int main()
{
	int ledflag=0;
	int command[] = {3, 3, 3, 2, 2, 0x01, 0x06, 0x0C, 0x80};
	char message1[] = "danger!";
	char message2[] = "safe ";
	float rounded_down;
	SystemInit();
	SystemCoreClockUpdate();
	initTimer0();
	LPC_GPIO0->FIODIR |= BUZZER;
	LPC_PINCON->PINSEL0 &= 0xfffff00f; // Interface LEDs P0.4-P0.11
	LPC_PINCON->PINSEL0 &= 0x3fffffff; // Interface TRIG P0.15
	LPC_PINCON->PINSEL1 &= 0xfffffff0; // Interface ECHO P0.16
	LPC_GPIO0->FIODIR |= TRIG | 1<<17; // Direction for TRIGGER pin
	LPC_GPIO1->FIODIR |= 0 << 16; // Direction for ECHO PIN
	LPC_GPIO0->FIODIR |= LED << 4; // Direction for LED
	LPC_PINCON->PINSEL1 |= 0;
	LPC_GPIO0->FIODIR |= 0XF << 23 | 1 << 27 | 1 << 28;
	flag1 = 0;
	for (i = 0; i < 9; i++)
	{
		temp1 = command[i];
		lcd_write();
		for (j=0; j<100000; j++);
	}
	flag1 = 1;
```

```
i = 0;
flag = 1;
LPC_GPIO0->FIOCLR |= TRIG;
while (1)
{
        LPC_GPIO0->FIOSET = 0x00000800;
        // Output 10us HIGH on TRIG pin
        LPC_GPIO0->FIOMASK = 0xFFFF7FFF;
        LPC_GPIO0->FIOPIN |= TRIG;
        delayUS(10);
        LPC_GPIO0->FIOCLR |= TRIG;
        LPC_GPIO0->FIOMASK = 0x0;
        while (! (LPC_GPIO0->FIOPIN & ECHO)) {// Wait for a HIGH on ECHO pin
}
startTimer0();
while (LPC_GPIO0->FIOPIN & ECHO); // Wait for a LOW on ECHO pin
echoTime = stopTimer0(); // Stop Counting
distance = (0.0343 * echoTime) / 40;
sprintf(ans, " D:%.2fcm", distance);
delay(999999);
flag1 = 1;
i = 0;
flag1 = 0;
temp1 = 0x01;
lcd_write();
flag1 = 1;
while (ans[i]!= '\0')
{
        temp1 = ans[i];
        lcd_write();
        for (j=0; j<100000;j++);
        i++;
}
if(distance < 20 && distance > 15) {
        LPC_GPIO0->FIOSET=LED<<4;
        LPC_GPIO0->FIOSET=1<<17;
        delay(9999);
}
if(distance < 15 && distance > 10){
        LPC_GPIO0->FIOSET=LED<<4;
        LPC_GPIO0->FIOSET=1<<17;
        delay(9999);
}
if (distance < 10) {
        LPC_GPIO0->FIOSET=LED<<4;
        LPC_GPIO0->FIOSET=1<<17;
```

```
            LPC_GPIO0->FIOSET = BUZZER;
            delay(5555);
        }
        else
        {
            LPC_GPIO0->FIOCLR=LED<<4;
            LPC_GPIO0->FIOCLR=1<<17;
            LPC_GPIO0->FIOCLR = BUZZER;
            delay(9999);
        }
    }
}
```

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