Project LIGTAS: Hazard Detecting Pick-and-Place Robot

Overview

Safety is a crucial factor to consider in situations where hazardous gas releases, temperature fluctuations, VOC emissions are possible. Asa a result, a reliable monitoring system should be established at such locations to identify irregularities and prevent undesirable mishaps. This study describes a robot equipped with a microcontroller-based anomaly detection and warning system with a pick-and-place function. The robot roams the workplace, constantly inspecting its surroundings. If any anomalies are identified in the environment, control is transferred to a warning and alerting system. GSM is used to send an alarm SMS to appropriate authorities.

Objectives

The goal of Project LIGTAS is to create a hazard detection robot with a pick-and-place function. The robot will also be outfitted with a variety of sensors. This research aims to aid in the development of an indoor monitoring robot capable of detecting hazardous materials and assisting in the cleanup of the workplace.

This robot is designed specifically for use in workplaces and laboratories. It is common in workplaces for the room to be filled with hazardous objects that could injure the person working or anyone who enters the room. Cleaning, on the other hand, would be much more efficient, faster, and easier with Project LIGTAS.

As a result, Project LIGTAS aims to ensure the safety of those working in or visiting laboratories and other work environments.

Statement of the Problem

Main Problem:

How effective is Project LIGTAS: Hazard Detecting Pick-and-Place Robot?

Sub-Problems:

I. **Hazard detection**

1. What types of hazards can Project LIGTAS: Hazard Detecting Pick-and-Place Robot detect?
    a. How accurate is Project LIGTAS's Hazard Detection?

II. **Motion control**

1. What are the Autonomous Robot's parameters?
    a. How far can the Autonomous Robot move?
    b. Will there be any restrictions on how the Autonomous Robot moves?
2. How effective is the Autonomous Robot's obstacle detection?
    a. How quickly can it avoid an obstacle?
    b. How accurate does it respond to an obstacle?
    c. How durable is the Autonomous Robot?

III. **Pick and place**

1. How durable is the mechanical arm?
    a. What is the mechanical arm's weight capacity?
2. How effective is the connection between the user and pick-and-place robot in sending SMS messages via the GSM Module?
    a. How far can is send the SMS message?

b. Will the sending of SMS messages become slower as the distance increases?

3. How powerful is the mechanical arm?

    a. How much strength does the gripper have?

    b. What is the maximum weight that the gripper can carry and/or hold?

    c. If the hazard is liquid, how effective is the mechanical arm's suction function?

Review of Related Literature

I. Hazardous Objects

1.1 Indoor Air Quality Monitoring

A real-time air quality monitoring system has been designed. The difficulties of creating and deploying an integrated system for monitoring indoor air quality are addressed. The system is designed to monitor the levels of seven gases in real time particularly: 03, C0, NO2, S02, CO2, and as well as particulate matter.

1.2 Zigbee based VOC Monitoring WSN

In the monitoring of VOCs in indoor settings, a low power zigbee sensor network was used. The network is made up of end device sensors equipped with light ionization detectors. The design is basically based on the ATmegaI6 and Atmel RF230 Zigbee module.

1.3 Embedded System for Hazardous Gas Detection

The dangerous gases, LPG and Propane are considered here. A PIC16F877 microcontroller is used in the embedded system. Both LPG and Propane were presented on the LCD, An alarm is provided to the authorized user if the gas level exceeds the nominal amount.

II. GSM (Global System for Mobile communication)

GSM commands, in addition to the standard AT commands, modems support a wide range of AT commands. The GSM standards define these extended AT commands. You can use the extended AT commands to do things like:

Reading, writing, and deleting SMS messages.

- ✓ Sending SMS messages
- ✓ Monitoring the signal strength
- ✓ Monitoring the charging status and the charge level of the battery
- ✓ Reading, writing, and searching phone book entries.

III. AMR (Autonomous Robot)

Most navigation systems presented up to now use 2D sensors in combination with a 2D map for localization and path planning. First and foremost behavior of robot to move towards destination without collision with object on their path so here several possible method has been described to overcome those obstacles.

There are several methods to detect the obstacles based on the sensor which is used. Path planning for autonomous vehicles requires that the map of all potential obstacles be produced in real time using available sensor data. For Indoor it is easy to design a map and feed into robot to facilitate about the permanent obstacles.

IV. YOLO for Object Detection

However, for a robot to react correctly to its environment, it must be autonomous and intelligent. In this context, we are interested in presenting a general view and methods related to the localization of autonomous robots, and subsequently, we will make a

> combination of research on artificial intelligence technology applied to robotics. We can automate a robot by using specific sensors. The robot must have the choice of three main sensors: cameras, radar, and LiDAR. (Zimmermman, 2021)

YOLO is an algorithm that uses neural networks to provide real-time object detection. This algorithm is popular because of its speed and accuracy. It has been used in various applications to detect traffic signals, people, parking meters, and animals.

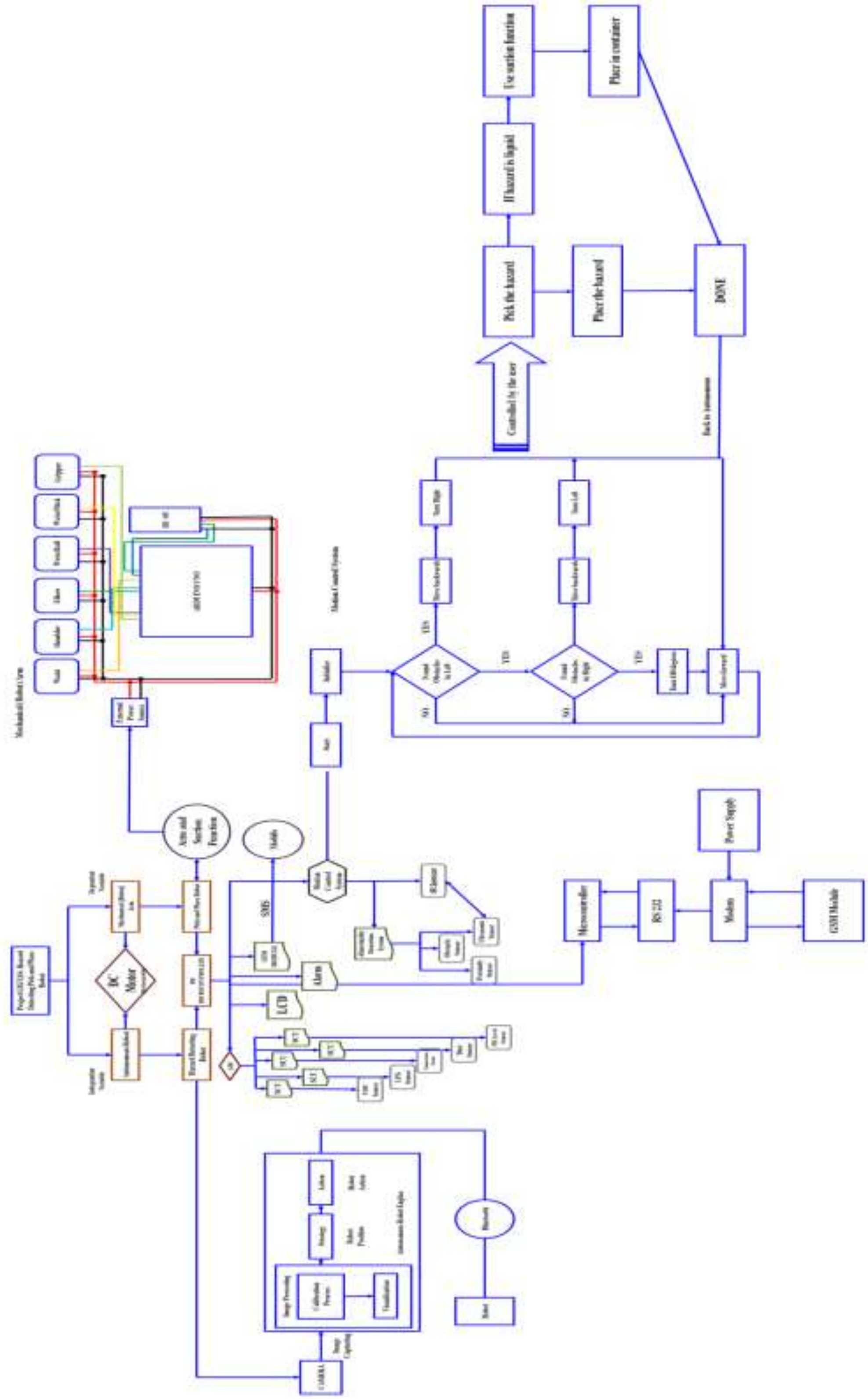

Figure 1. Schematic Diagram

METHODOLOGY

I. Materials

	Quantity
1. Hazard Detecting Robot	1
2. Pick and Place Robot [Mechanical Arm]	1
3. DC Motor	1
4. PIC Microcontroller	1
5. VOC Sensor	1
6. LPG Sensor	1
7. Temperature Sensor	1
8. Dust Sensor	1
9. PH Level Sensor	1
10. IR Sensor	1
11. Ultrasonic Sensor	1
12. Abnormality Sensor	1
13. Obstacle Sensor	1
14. Proximity Sensor	1
15. GSM Module	1
16. Arduino UNO	1
17. Alarm	1
18. LCD	1
19. Container	1

II. Procedures

A. Motion Control System

The Motion control system is responsible for the movement of robot mounted with detection system in the working environment. The IR sensor is employed in the detection of obstacles in the moving pathways. DC motors are involved in the movement of robot. Two sets of sensors are used in this obstacle avoidance process namely left and right sensors. The robot initializes to move in the working area. If found any obstacle by the left sensor, then the robot is tend to move backwards and take right turn. If found by right sensor, then robot moves backwards and take left turn. If both sensors found the obstacle then the robot turns 180˚ and continues to move forward.

Furthermore, if a hazard is discovered, an SMS message will be sent to the user, and the user will be given control of the robot. The user has the option of picking and placing the hazard. Finally, use the suction function if the object/hazard is a fluid or liquid. After placing the hazard, the user can press "DONE" to return the robot to autonomous mode. The flowchart below demonstrates this point clearly.

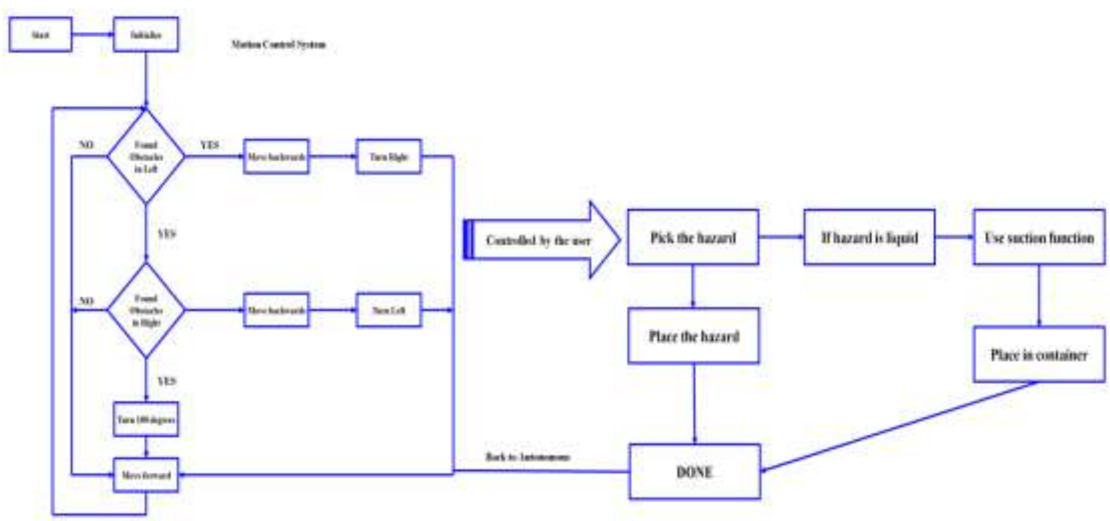

Figure 2. Motion Control System

B. Abnormality Detection System

The abnormality detection system consists of:

- ✓ VOC sensor
- ✓ LPG sensor
- ✓ Temperature sensor
- ✓ Dust sensor
- ✓ PIC microcontroller unit
- ✓ LCD display
- ✓ Alarm
- ✓ GSM module

Sensors are linked to signal conditioning units, which are linked to ADCs. The sensors constantly scan the working environment for anomalies. When an abnormality is detected, the microcontroller sends an alert message to the authorized person via the GSM module. The monitoring values are displayed continuously on the LCD display. If the values exceed the nominal values, an alarm will sound.

1. PIC 16F874A

It is a 40 pin microcontroller having the following features:

Peripheral Features:

- ✓ Timer0: 8-bit timer/counter with 8-bit prescaler

- ✓ Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- ✓ Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- ✓ Two Capture, Compare, PWM modules
- ✓ Synchronous Serial Port (SSP) with SPI (Master mode) and I2C™ (Master/Slave)
- ✓ Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- ✓ Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only)
- ✓ Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- ✓ 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- ✓ Brown-out Reset (BOR)
- ✓ Analog Comparator module with: Programmable input multiplexing from device inputs and internal voltage reference

2. DC Motor

A 12V DC geared motor is simple to use and comes in standard sizes. The nut and threads on the shaft are easily connected, and the internal threaded shaft is easily connected to the wheel. The 12V DC Geared Motor, which is available in a wide range of RPM and Torque, is used in a variety of robotics applications.

3. GSM Modem

The Global System for Mobile Communication (GSM) is a digital cellular communication standard that is universally accepted. GSM is the abbreviation for a standardization group formed in 1982 to develop a common European mobile telephone standard that would define specifications for a pan-European mobile cellular radio system operating at 900 MHz. GSM provides recommendations rather than requirements. The GSM specifications go into great detail about the functions and interface requirements, but they don't address the hardware.

The reason for this is to limit designers as little as possible while still allowing operators to purchase equipment from various suppliers. The GSM network is composed of three major systems: the switching system (SS), the base station system (BSS), and the operation and support system (OSS) (OSS). A GSM modem is a wireless modem that connects to a GSM network. A wireless modem functions similarly to a dialup modem. The primary distinction is that a dial-up modem sends and receives data over a fixed telephone line, whereas a wireless modem sends and receives data over radio waves.

A GSM modem can be a standalone device or a PC Card/PCMCIA Card. An external GSM modem is typically connected to a computer via a serial or USB cable. A PC Card / PCMCIA Card GSM modem is intended for use with a laptop computer. It should be inserted into one of a laptop computer's PC Card / PCMCIA Card slots. A GSM modem, like a GSM phone, requires a SIM card from a wireless carrier to function.

AT commands are used by computers to control modems. GSM modems and dial-up modems both support the same set of standard AT commands. The researchers can use a GSM modem in the same way that a dial-up modem would.

GSM modems support an expanded set of AT commands in addition to the standard AT commands. The GSM standards define these extended AT commands. The researchers can use the extended AT commands to do things like:

- ✓ Reading, writing and deleting SMS messages.
- ✓ Sending SMS messages.
- ✓ Monitoring the signal strength.
- ✓ Monitoring the charging status and charge level of the battery.
- ✓ Reading, writing and searching phone book entries.

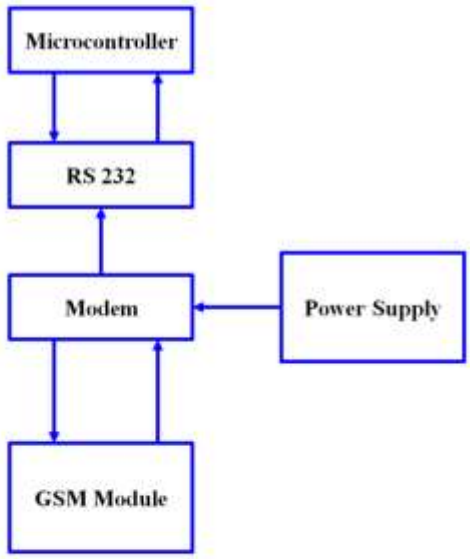

Figure 3. Architecture of GSM Network

4. The UART

The Universal Asynchronous Receiver/Transmitter (UART) controller is a critical component of a computer's serial communications subsystem. The UART takes bytes of data and sequentially transmits the individual bits. A second UART at the destination reassembles the bits into complete bytes.

Serial transmission is most commonly associated with modems and non-networked communication between computers, terminals, and other devices.

Serial transmission is classified into two types: synchronous and asynchronous. The name of the communication sub-system will typically include an A if it supports Asynchronous communications and a S if it supports Synchronous communications, depending on the modes supported by the hardware.

C. Experimentation

The researchers would conduct an experiment to test the durability and capacity of the autonomous robot and the mechanical arm.

The autonomous robot would be tested against various obstacles to determine its durability and obstacle detection.

While the mechanical arm would be tested by carrying or gripping various objects of varying weights to determine its durability and the maximum amount of weight it could carry. This experiment would also put the mechanical arm's strength and power to the test.

Finally, the researchers will assess the distance and effectiveness of the connection between the user and the pick and place robot, which is linked via the GSM Module for SMS message transmission.

D. Possible Working Algorithms

1. Temperature Sensor

Initialize the LCD {Monitor the temperature from the temperature sensor

{If (temp<set value) {check the water content

{If (water content<set) switch ON the motor and send the info. to smart phone ELSE

{Motor is OFF}}}

2. Proximity Sensing

```
X[i – 1] = X[0]

l[i – 1] = 0


loop 1:

        D[i] = X[i] – X[i – 1]

Is (ABS (D[i]) greater than DT)?

        true: l[i – 1] + D[i]

        else: l[i] = l[i – 1]

Is (l[i] ≥ IT)

        true:

                Object detected

                l[i – 1] = l[i]

        else:

                Object not detected

                l[i – 1] = l[i] * L
```

a. Parameters

IT = Integration threshold

DT = Derivative threshold

L = Leakage factor

X[i] = current sample point

X[i – 1] = previous sample point

D[i] = Derivative

l[i] = Integral of Derivative

l[i – 1] = Previous Integral of Derivative

3. Ultrasonic Distance Sensor

```
//Hookup HC-SR04 with Trig to Arduino Pin10, Echo to Arduino pin13

//Maximum Distance is [ --- ] cm


#define TRIGGER_PIN10

#define ECHO_PIN13

#MAX_DISTANCE [ --- ]


New Ping Sonar (TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

float duration, distance;

void setup (   ){

        serial begin (9600);

}

void loop (   ){
```

duration = sonar.ping (   );

#Determine distance from duration

#Use 343 metres per second as speed of sound

distance = (duration/2)*0.0343;

//send results to Serial Monitor

Serial.print (“Distance = ”):

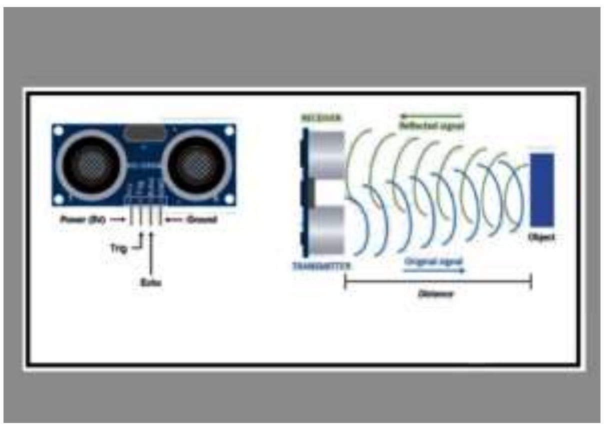

Figure 4A. Ultrasonic Distance Sensor

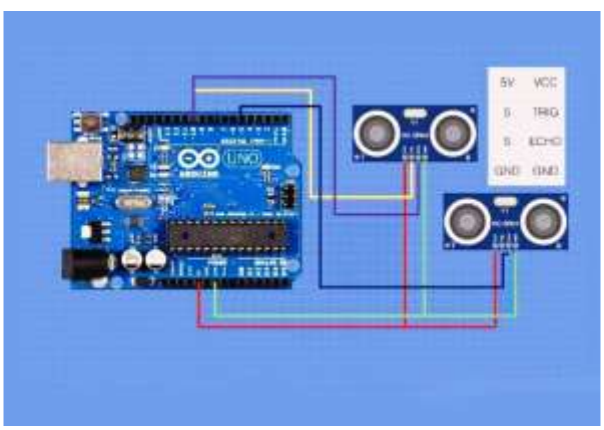

Figure 4B. Architecture of Ultrasonic Distance Sensor

a. Parameters

VCC – 5 volt power connection

TRIG – Trigger pin (input)

ECHO – Echo pin (output)

GND - Ground

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