

Design and Implementation of Smart Zebra Crossing using Arduino

**Aditi Mane¹, Chetana Bachhav², Kiran Alandkar³, Akanksha Agre⁴, Adarsh Chikate⁵,
Shubham Andhale⁶, Aditya Warange⁷, Aayushi Kumari⁸, Mrs. S.G. Madhikar⁹**

Student, Information Technology Department, Sinhgad College of Engineering, Pune, India¹

Student, Chemical Engineering Department, Sinhgad College of Engineering, Pune, India²

Student, Mechanical Engineering Department, Sinhgad College of Engineering, Pune, India^{3,6}

Student, Electronics & Telecommunication Department, Sinhgad College of Engineering, Pune, India^{4,5}

Student, Civil Engineering Department, Sinhgad College of Engineering, Pune, India⁷

Student, Computer Engineering Department, Sinhgad College of Engineering, Pune, India⁸

Assistant Prof., Electronics & Telecommunication Department, Sinhgad College of Engineering, Pune, India⁹

Abstract: A Zebra Crossing is used by pedestrians to cross a road safely, LEDs are used as traffic lights, LCD displays are used as a timer to the pedestrians as well as the vehicles meanwhile barriers are used to stop people for carelessly crossing the road. The project titled "Design and Implementation of Smart Zebra Crossing using Arduino" is a demonstration of all these devices incorporated into one model which is based on IoT technology. It uses the Arduino Uno R3 used as a microcontroller, 16x2 LCD display as a timer, an I2C module for easy connections, jumper wires for solderless connections, green and red LEDs for traffic light display, and servo motors along with barriers to enhance pedestrian safety and facilitate efficient traffic management.

Keywords: Zebra crossing, Barrier system, project report, IOT based project, engineering project.

I. INTRODUCTION

The project titled "Design and Implementation of Smart Zebra Crossing using Arduino" is a demonstration of Internet of Things (IoT) technology, which is the concept of a network comprising physical objects integrated with sensors, software, and other technologies to establish connections and exchange data with other devices and systems via the internet.

The core component of the project is the Arduino Uno R3, utilized as a microcontroller, which serves as the brain of the smart zebra crossing system. A 16x2 LCD display is employed to function as a timer, providing relevant information to pedestrians and drivers. To simplify the wiring connections between the Arduino and the LCD, an I2C module is incorporated.

The project employs male-to-female and male-to-male jumper wires to establish connections between various components. Green and red LEDs are utilized to display traffic lights, indicating when it is safe or unsafe to cross the road. Additionally, servo motors are employed to control the movement of barriers, ensuring the safety of pedestrians during road crossings.

Overall, this project showcases the practical implementation of IoT technology in the context of a smart zebra crossing. By leveraging the capabilities of Arduino and various components such as LCD displays, LEDs, and servo motors, the system enhances pedestrian safety and facilitates efficient traffic management.

A. Objective

The objective of this project is solving the problem faced by pedestrians while crossing the Zebra crossings on roads, this has been done by creating automatic barriers with LCD display timer along with traffic lights. Hence, lowering the

chances of someone being killed by speeding cars or even due to their own negligence while crossing the Zebra crossing.

B. Literature Survey

INDIA - Over 1.5 lakh Indians lost their lives in 4.1 lakh road accidents reported in the country in 2021, according to the Ministry of Road Transport and Highways (MoRTH)[1]. Most Indian roads are not designed keeping pedestrians in mind and they lack basic safety features such as footpaths, pedestrian crossings with barriers and street lights.

SWEDEN - The Swedish Vision Zero's goal was to eliminate traffic injuries. A study was done and they came up with a solution of reconstructing urban intersections (creating roundabouts at intersections) to eliminate speeding above 30km/hr. The results showed that Safe traffic behavior increased at the reconstructed intersections, and pedestrians could safely cross the street without getting into an accident[2].

SPAIN - SMART pedestrian crossings in Catalonia, Spain uses sensors to detect movement of pedestrians crossing and automatically activate light panels on the floor and two vertical panels on each side of the road. This initiative aimed to address the lack of visibility in pedestrian crossings situated in some busy zones, the main benefits are improved traffic safety and a decrease in the number of accidents[3].

II. METHODOLOGY

A. BLOCK DIAGRAM

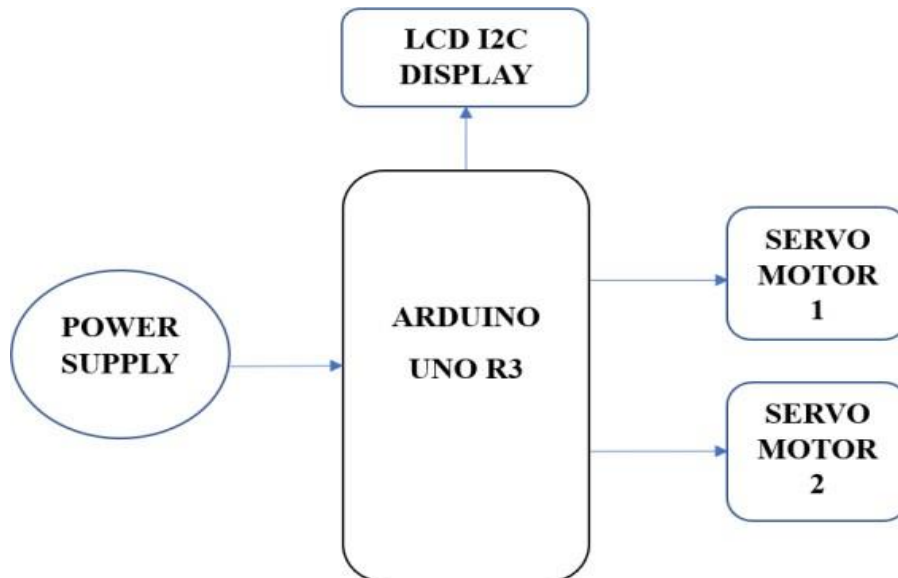


Fig – 1: Block Diagram of Smart Zebra Crossing System

OVERALL BLOCK DIAGRAM WORKING –

The ARDUINO USB CABLE is connected to the laptop which works on code written in ARDUINO IDE, this USB cable is connected to the Arduino UNO which provides instructions to the LCD I2C display and servo motors to work along with LEDs blinking.

Technically power supply comes through the USB cable from the laptop providing INPUT to Arduino and OUTPUT is LCD I2C display, servo motors & LEDs.

INPUT –

- ARDUINO UNO

OUTPUT –

- LCD I2C DISPLAY

- SERVO MOTORS
- LEDs

The basic building blocks of the Smart Zebra Crossing System are as follows:

(1) *ARDUINO UNO R3*:

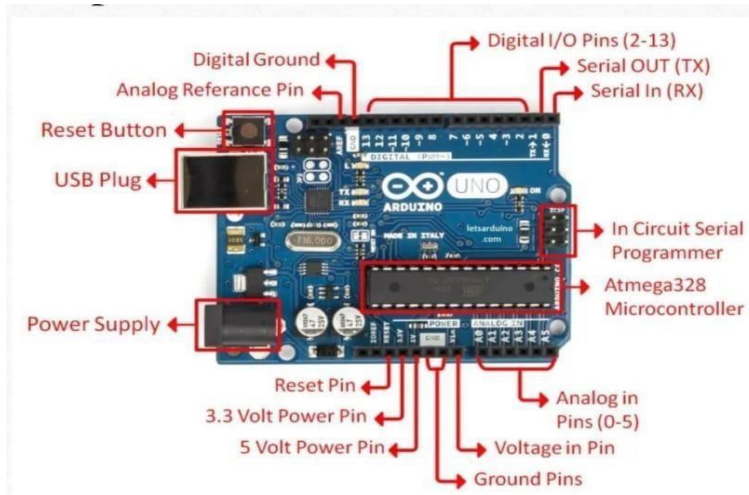


Fig - 2: Arduino Uno R3 pin diagram

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button, contains everything needed to support the microcontroller i.e., we need to simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. One of the perfect boards to get familiar with electronics and coding. This versatile microcontroller is equipped with the well-known ATmega 16U2 Processor[4]. The Arduino Uno we used for the model has a built-in microcontroller.

SPECIFICATIONS[4]-

- ATmega328 microcontroller (m.in. 32 KB Flash memory - 2 KB occupied by bootloader, 2 KB RAM, 1 KB EEPROM).
- CH340 module - allows data transmission between the computer and the module.
- 14 I/O ports (6 of which can work in PWM mode).
- 6 analog inputs, 6-pin ISP programming connector.
- Can be powered from USB or additional power supply.
- Microcontroller Reset button.
- Working voltage: 5V, Quartz crystal 16 MHz.

(2) *SERVO MOTOR*:

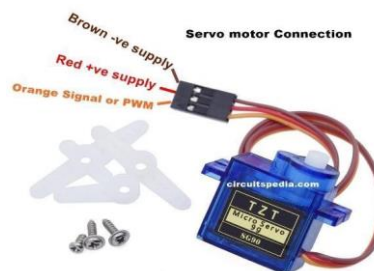


Fig - 3: Servo Motor Connections display

Servo motor SG90 is tiny and lightweight with high output power, it can rotate approximately 180 degrees (90 in each

direction), and works just like the standard kinds. We can use any servo code, hardware or library to control these servos. Good and easy to use for beginners who want to make stuff move without building a motor controller with feedback & a gear box, especially since it will fit in small places. It comes with 3 horns (arms) and hardware[5].

SPECIFICATIONS[5]-

- Torque and speed of servo motor produces depend on the current and voltage that are applied.
- Wires connected to servo motor – Brown (GND), Red (VCC) and Yellow (digital pin)
- Speed: 0.05 to 0.2 s/60 degree.
- Torque: 2.5 N-cm
- Weight: 14.7 g
- Voltage: 4.8V - 6V

(3) 16X2 LCD+I2C MODULE:

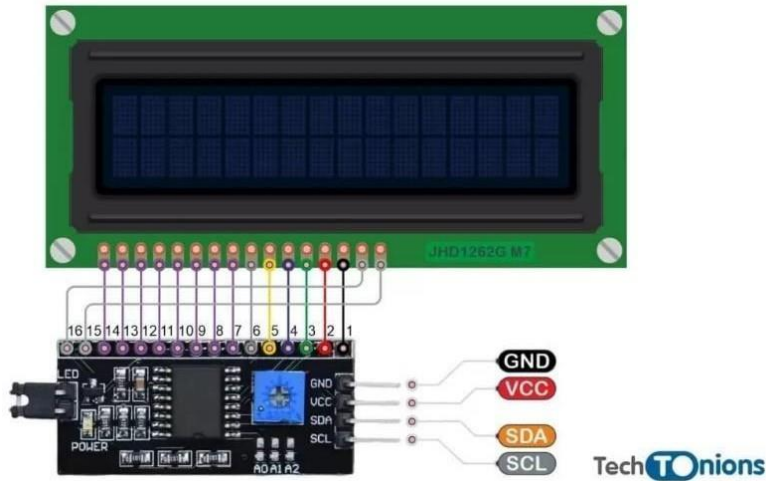


Fig – 4: LCD-I2C Module Connections



Fig - 5: I2C Module pin diagram

which has been done to reduce the number of connections. The I2C Module has an inbuilt PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display along with four main pins SCL (serial clock), SDA (serial data), VCC AND GND. It is supplied with a default I2C address of either 0x27 or 0x3F. If there are 3 sets of pads labelled A0, A1, & A2 then the default address is 0x3F else the default address will be 0x27[6].

SPECIFICATIONS[6]-

- Compatible with Arduino/ Genuino UNO, Mega, Micro, Nano, Mini
- I2C Address: 0x20-0x27(0x20 is default)
- Supply voltage: 5V

- Interface: I2C/TWI x1, Gadgeteer interface x2
- Adjustable contrast (potentiometer)
- Size: 82 x 35 x 18 mm (3.2x1.4x0.7 in)
- Black text on the green background
- Interface Address: 0x27
- Character Color: White
- Backlight: Green
- The LCD along with the I2C module is used for the main purpose of reducing the number of connections.

(4) *LED*:

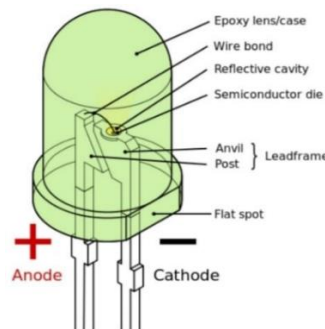


Fig - 6: LEDs with labelling

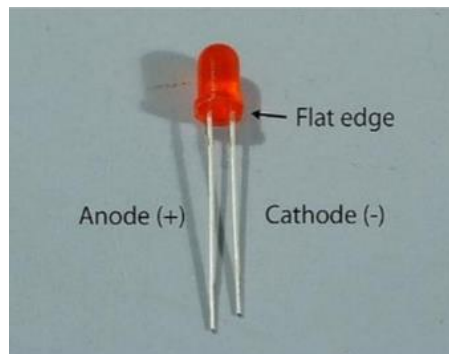


Fig - 7: Red LED label

A semiconductor light source called a light-emitting diode (LED) produces light when current passes through it. LEDs have various benefits, such as lower power consumption, a longer lifespan, increased physical resilience, smaller size, and quicker switching. In this concept, LED is employed as the traffic signal for both drivers and pedestrians, with red LED designating a stop and green LED designating a pass[7].

SPECIFICATIONS[7]-

- Long Life: LEDs can last over 100,000 hours and fast turn on/off time.
- No annoying flicker like fluorescent lamps.
- LEDs have unbreakable glass.
- Solid-State, shock and vibration resistant.
- For wavelength range(nm) = 500 – 570, colour of LED is green with forward voltage 1.9 - 4.0 V and material used Gallium phosphide (GaP), Aluminium gallium indium phosphide (AlGaInP) and Aluminium gallium phosphide (AlGaP).
- For wavelength range(nm) = 610 – 760, colour of LED is red with forward voltage 1.6 - 2.0 V and material used Aluminium gallium arsenide (AlGaAs), Gallium arsenide phosphide (GaAsP), Aluminium gallium indium phosphide (AlGaInP) and Gallium phosphide (GaP).

B. Circuit Diagrams

(1) Simulator Circuit Diagram:

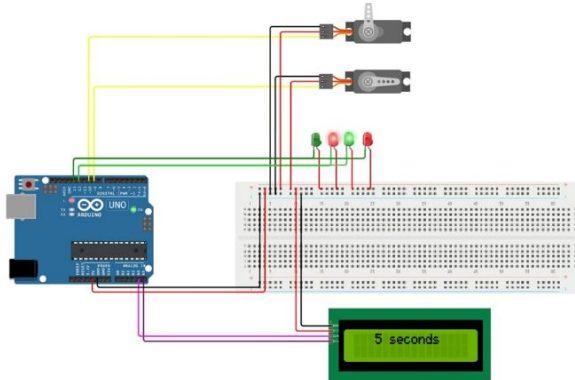


Fig - 8: Simulation diagram showing connections

The figure shows a simulation circuit diagram made with a software website called wokwi.com which is capable of doing simulations with the code along with the already built-in electronics easily.

D9, D10, D12, D13, A4 AND A5 pins of Arduino Uno are connected to myservo, myservo1, led1, led, SDA LCD, SCL LCD respectively, along with multiple appropriately connected 5V and GND connections.

The system uses servo motors to create barriers for vehicles and pedestrians. When motor1 turns 90 degrees, vehicles pass, while motor2 stays at 0 degree creating a barrier and vice versa. LCD displays numbers backward from 10 to 1, with green and red LEDs for pedestrians and cars. The process continues in a loop.

(2) Eagle Circuit Diagram:

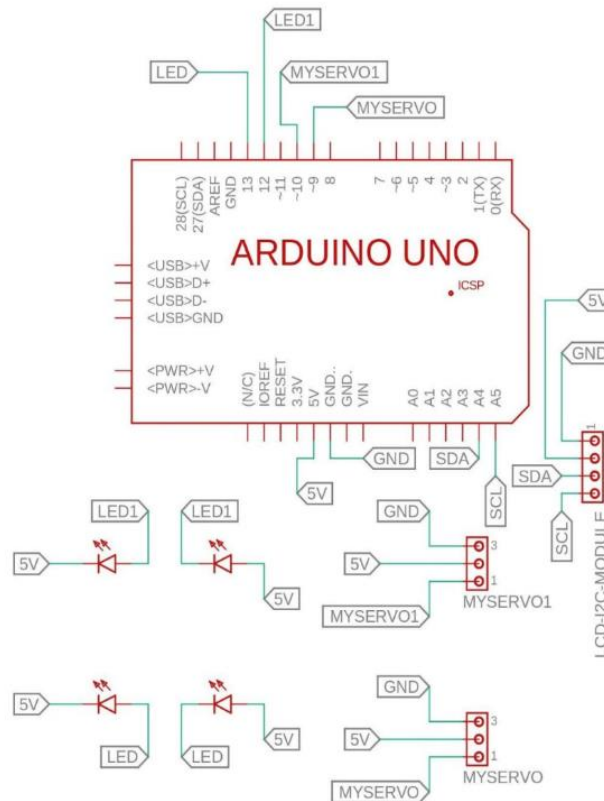


Fig - 9: Circuit diagram showing connections

C. Pin Connections

TABLE I ARDUINO UNO PIN CONNECTION

Arduino Pin Number	Connected to
D9	myservo (servo motor)
D10	myservo1(servo motor)
D12	CATHODE OF led (1red+ 1green)
D13	CATHODE OF led (1red+ 1green)
A4	SDA (LCD I2C pin)
A5	SCL (LCD I2C pin)
5A	5V Breadboard
GND	GND Breadboard

TABLE II BREADBOARD PIN CONNECTION

Breadboard Pin	Connected to
5V	Red wire (5V myservo)
	Red wire (5V myservo1)
	Anode of LED
	Anode of LED1
	VCC (LCD I2C Pin)
GND	Black wire (GND myservo)
	Black wire (GND myservo1)
	GND (LCD I2C Pin)

D. PROCEDURE OF WORKING

1. Include Liquid crystal I2C and servo libraries in Arduino IDE (allowing Arduino board to work with servo motors and LCD I2C module)
2. Initialize led to D13 and led1 to D12 (led i.e., 1 green & 1 red led connected to digital pin 13 acts as an output pin and led1 i.e., 1 green and 1 red led connected to digital pin 12 acts as another output pin)
3. Initialize LCD display and turn backlight on (LCD on)
4. Initialize myservo to D9 and myservo1 to D10 (myservo i.e. (yellow wire) servo motor connected to digital pin 9 and myservo1 (yellow wire) i.e., another servo motor connected to digital pin 10)
5. myservo turns 90 degrees (for cars to pass through) and myservo1 stays at 0 degrees (creating a barrier for pedestrians)
6. At the same time a loop iteration takes place displaying numbers from 10 to 1 “seconds” starting from the 3rd column and 1st row of LCD, with a 1 second delay between each number display with led ON. (Green led on for cars and red led on for pedestrians, both at the same time connected to D13 at HIGH i.e., 5V)
7. led turns OFF (LOW i.e., 0V) and both myservo and myservo1 stay at 0 degrees followed by 1 sec delay.
8. myservo1 turns 90 degrees (for pedestrians to cross zebra crossing) and myservo stays at 0 degrees (creating a barrier for cars)

9. At the same time a loop iteration takes place displaying numbers from 10 to 1 “seconds” starting from the 3rd column and 1st row of LCD, with a 1 second delay between each number display with led1 ON. (Green led1 on for pedestrians and red led1 on for cars, both at the same time connected to D12 at HIGH i.e., 5V)
10. led1 turns OFF (LOW i.e., 0V) and both myservo and myservo1 stay at 0 degrees followed by 1 sec delay.

E. FLOWCHART OF CODE:

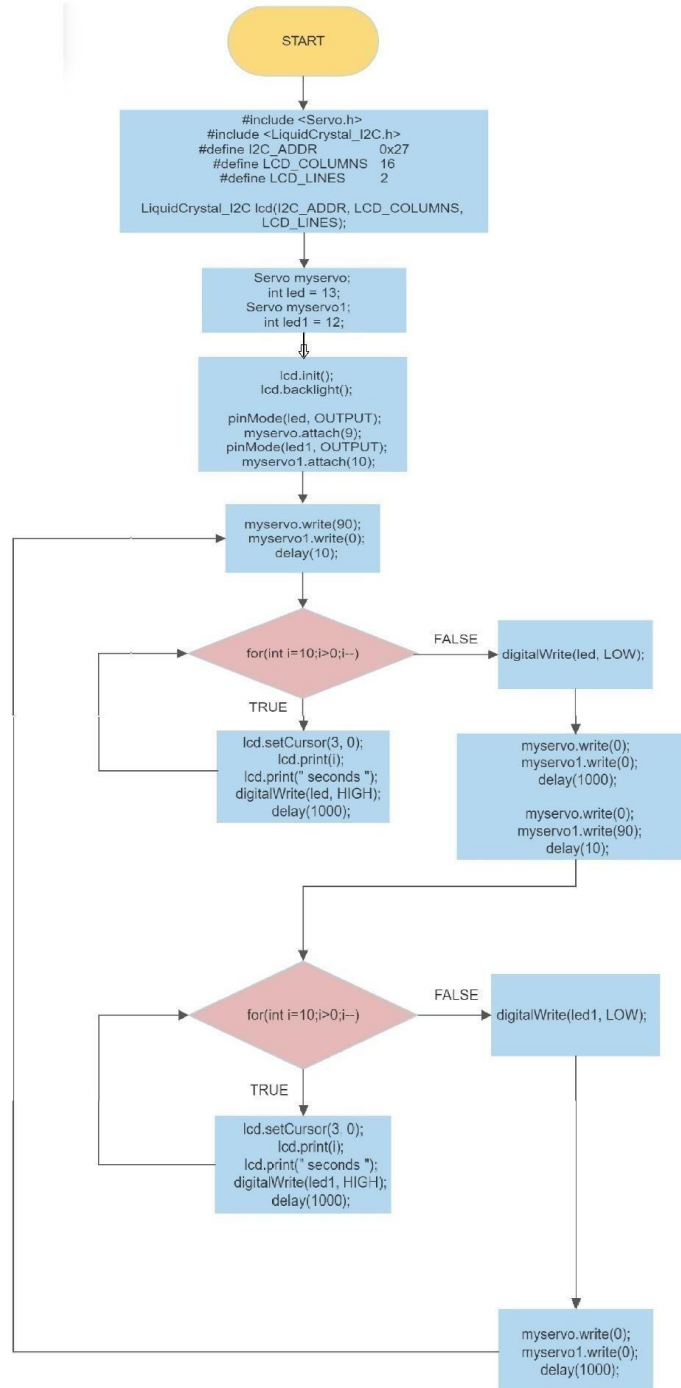


Fig - 10: Flowchart of Code

F. LINE INTERPETATION

TABLE III INTERPRETATION TABLE OF CODE

SR No.	INTERPETATION OF	MEANING
1.	#include <Servo.h>	allows an Arduino to control servo motor
2.	#include <LiquidCrystal_12C.h>	Allows an Arduino to print messages to LCD screen using 12C
3.	#define 12C_ADDR 0X27 #define LCD_COLUMNS 16 #define LCD_LINES 2	Defines 12C address, no. of LCD columns and lines/rows for usage of 12C with LCD
4.	LiquidCrystal_12C lcd(12C_ADDR,LCD_COLUMNS, LCD_LINES);	Calls the constructor from LiquidCrystal_12C library
5.	lcd.init();	Initializes display
6.	Lcd.backlight();	Turns LCD backlight on
7.	pinMode(pin_no,input/output);	To configure a specific pin to behave either as an input or an output pin
8.	myservo.attach(pin_no);	Tells the servo library which pin it should be writing to
9.	myservo.write(angle in degrees);	Writes a value which will set the angle of the shaft (in degrees)
10.	delays(time_milliseconds);	Delays the program for a specified time in milliseconds
11.	lcd.setCursor(column,row);	Moves the LCD cursor’s position to new position (column, row)
12.	lcd.print();	Prints text to LCD
13.	digitalWrite(pin_no,LOW/HIGH);	To write a HIGH (5V) or a LOW (GND) value to a digital pin

III. RESULTS



Fig - 11: Barrier for Vehicles

Figure shows red led on for cars, along with a barrier to stop cars from crossing the road, meanwhile green led is on for pedestrians to cross the road safely on the zebra crossing, along with the barrier open, incorporated with a 10 seconds backward LCD display.

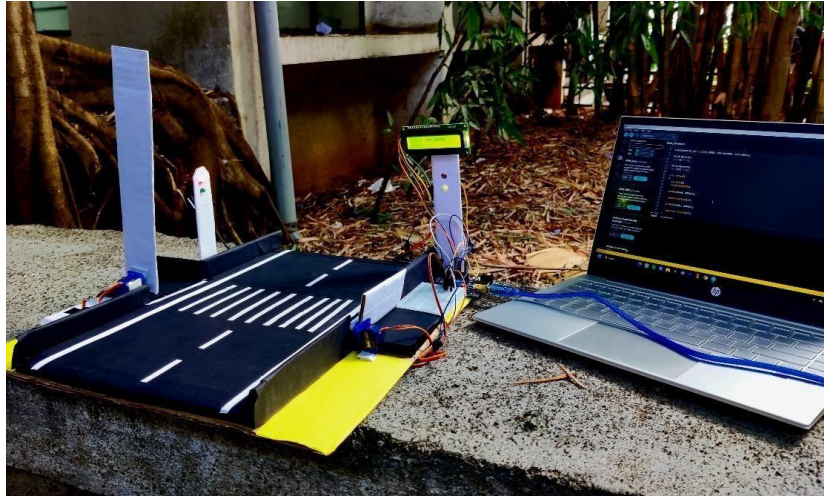


Fig - 12: Barrier for Pedestrians

Figure shows green led on for cars, along with an open barrier to let cars pass through, meanwhile red led is on for pedestrians to stop them from crossing the road, along with a closed barrier, incorporated with a 10 seconds backward LCD display.

IV. ADVANTAGES & LIMITATIONS

A. *ADVANTAGES*

1. Reduced number of Accidents.
2. Helps to manage urban traffic, reducing traffic jams and pollution.
3. Adaptable to different types of traffic situations.
4. LED can be turned on and off manually on Demands.
5. Barrier capable and strong enough to stop speeding cars.
6. Distracted pedestrians would not be killed due to the barrier.
7. LCD display timer tells car/pedestrian in what duration of time will they be able to cross the road.

B. *LIMITATIONS*

1. Can lead to delays and injuries in case of a malfunction in the barrier system.
2. Highly dependent on electricity and can get problematic due to power outage or electrical failure.
3. Barrier gates can be expensive including installation and maintenance cost.
- 4.

V. CONCLUSION, FUTURE SCOPE & APPLICATIONS

A. *CONCLUSION*

1. The problem faced by pedestrians while crossing the traditional zebra crossing can be summarized as the following, which are carelessness of road users, less sensitivity to the signals given and lack of barriers.
2. By establishing barriers, it is evident that speeding vehicles would be forced to stop and pedestrians will easily be able to cross the road, on the other hand if distracted pedestrians are carelessly crossing the road the barrier would stop them from going further and get run over by vehicles.
3. The LEDs and LCD timer display acts as a warning clock for both the vehicles and pedestrians.
- 4.

B. *FUTURE SCOPE*

1. Single luminaire illuminating pedestrian crossing.
2. Intelligent traffic light controller with sound sensors for ambulance.
3. Installing AI camera to detect traffic rule violations.
4. Make the system work on solar panels.
5. Sensors to automatically detect people crossing the road.

6. Manual working of barriers in case of power outage.
7. Establishing “Barrier ahead” signs at least a km before the Smart barrier zebra crossing system.

C. APPLICATIONS

1. Barriers are available at toll plazas to stop cars from going without paying for the toll.
2. System is implemented at Railway crossings.
3. At the entry and exit of parking and societies.

REFERENCES

- [1] Bobins Abraham, updated on 25 January 2023, “India times”, accessed on 16 August 2023, <<https://www.indiatimes.com/news/india/one-third-road-accident-deaths-in-india-are-pedestrians-how-did-they-become-death-traps-591086.html>>
- [2] Charlotta Johansson from Lulea University of Technology, January 2003, “Research gate”, accessed on 16 August 2023, <https://www.researchgate.net/publication/245560814_Toward_Vision_Zero_at_Zebra_Crossings_Case_Study_of_Traffic_Safety_and_Mobility_for_Children_and_the_Elderly_Malmo_Sweden>
- [3] Carnegie Mellon University, “Mobility 21”, accessed on 16 August 2023, <<https://mobility21.cmu.edu/cullera-boosts-road-safety-with-smart-pedestrian-crossings/>>
- [4] “Arduino.cc”, accessed on 16 August 2023, <<https://docs.arduino.cc/static/d6e3f4bae3e5df694cb7dd493ce3e58c/A000066-datasheet.pdf>>
- [5] “Components101”, 18 September 2017, accessed on 16 August 2023, <<https://components101.com/motors/servo-motor-basics-pinout-datasheet>>
- [6] “Rhydolabz”, accessed on 16 August 2023, <<https://www.rhydolabz.com/displays-c-88/16x2-character-i2c-lcd-module-with-yellow-light1602a-p-2743.html>>
- [7] “Make-it.ca”, accessed on 16 August 2023, <<https://www.make-it.ca/led-specifications/>>

BIOGRAPHY**Aditi Mane**

BE in Information Technology,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Chetana Bachhav**

BE in Chemical Engineering,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Kiran Alandkar**

BE in Mechanical Engineering,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Akanksha Agre**

BE in Electronics & Telecommunication,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Adarsh Chikate**

BE in Electronics & Telecommunication,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Aayushi Kumari**

BE in Computer Engineering,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Shubham Andhale**

BE in Mechanical Engineering,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Aditya Warange**

BE in Civil Engineering,
Currently a second-year student,
Studying at Sinhgad College of Engineering, Pune.

**Mrs. S.G. Madhikar**

Assistant Professor,
Department of Electronics & Telecommunication,
Sinhgad College of Engineering, Pune, Maharashtra