B.M.S. COLLEGE OF ENGINEERING Bengaluru-560019.

Autonomous College, affiliated to
Visvesvaraya Technological University, Belgaum

Project Work-I
REPORT
ON

"LINE FOLLOWER, OBSTACLE DETECTION AND MINE DETECTION ROBOT"

Submitted in partial fulfillment of the requirement for completion of
PROJECT WORK –I [23ET5PWPMR]

Submitted by

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Academic Year

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CERTIFICATE

This is to certified that the Project work - I entitled **“LINE FOLLOWER, OBSTACLE DETECTION AND MINE DETECTION ROBOT”** is a Bonafide work carried out by **ANUSHKA SETHIA (1BM22ET009), APRAJITA GUPTA (1BM22ET010), PALASHA KAPIL KARE(1BM22ET041) and** UNGARALA **DHEERAJ (1BM22ET059)** submitted in partial fulfillment of the requirement for completion of PROJECT WORK - I [23ET5PWPMR] of Bachelor of Engineering in Electronics and Communication during the academic year 2024-25. The Project Work - I report has been approved as it satisfies the academic requirements.

Guide	**Head of Department**
Dr. GURURAJ C	**Dr. BALACHANDRA K**
Professor Department of ETE BMS College of Engineering	Professor and Head Department of ETE BMS College of Engineering

DECLARATION

We, **ANUSHKA SETHIA (1BM22ET009), APRAJITA GUPTA (1BM22ET010), PALASHA KAPIL KARE(1BM22ET041) and UNGARALA DHEERAJ (1BM22ET059)** hereby declare that the Project Work -I entitled **LINE FOLLOWER, OBSTACLE DETECTION AND MINE DETECTION ROBOT** is a Bonafide work and has been carried out by us under the guidance of **,** Professor, Department of Electronics and Telecommunication Engineering, BMS College of Engineering, Bengaluru submitted in partial fulfillment of the requirement for completion of PROJECT WORK - I [23ETPWPMR] of Bachelor of Engineering in Electronics and Telecommunication during the academic year 2023-24. The Project Work-I report has been approved as it satisfies the academic requirements in Electronics and Communication engineering, Visvesvaraya Technological University, Belagavi, during the academic year 2023-24.

We further declare that, to the best of our knowledge and belief, this Project Work -I has not been submitted either in part or in full to any other university.

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ABSTRACT

This project implements a dual-purpose robotic navigation on system using an Arduino Uno board, combining line detection, obstacle detection and mine detection for autonomous movement. IR sensors allow the robot to follow a predefined line by detecting contrasts, while an ultrasonic sensor identifies obstacles within a specified range, enabling the robot to halt or change direction as needed. This setup demonstrates an effective and low-cost solution for applications in automated navigation, industrial robotics, and educational projects, emphasizing the integra on of sensor-based feedback for enhanced robotic control.

Arduino UNO with microcontroller manages the operation of managing the vehicle. Arduino played a significant part in the control area and facilitated the conversion of digital and analogue signals into physical motion. The primary advantage of Bluetooth-based technology is that the remote can be changed at any moment – smartphones, tablets, and laptops – and physical barriers such as walls and doors have no effect on the automobile controls.

TABLE of CONTENTS

Chapter 1: Introduction

Human life has changed and made easy greatly after the invention of IC technology. This has become the base of modern communication technology, with advancements in robotics and automation, the development of multifunctional autonomous systems has become increasingly essential. These systems are capable of executing complex tasks, such as navigating environments, detecting obstacles, and identifying hazards, all without direct human control. Such capabilities are especially valuable in fields ranging from industrial automation and warehouse management to search-and-rescue operations and fire hazard monitoring. This project aims to create a cost- effective and adaptable robotic system using an Arduino Uno that integrates line following, obstacle avoidance, and fire detection functionalities.

Using infrared (IR) sensors, the robot detects and follows a predefined path, allowing for efficient and autonomous route navigation. The ultrasonic sensor enables obstacle detection by measuring distances to objects in the robot's path, prompting the Arduino to adjust direction and prevent collisions.

Additionally, a mine detector sensor provides metal detection capabilities, allowing the robot to recognize underground metal sources and respond accordingly for enhanced safety.

Chapter 2: Literature survey

1. **Title: "An Arduino-based Autonomous Robot for Indoor Navigation"**
   Year: 2019
   Author: Mary K. Johnson Abstract: This research introduces an Arduino Uno-powered robot capable of autonomous indoor navigation. Utilizing infrared sensors, the robot detects obstacles and adjusts its path accordingly. The study emphasizes the importance of a robust obstacle avoidance mechanism and explores the potential for applications in various indoor environments

2. **Title: "Arduino Uno Robotics: A Comprehensive Review" Year: 2021**
   Author: Sarah L. Anderson
   Abstract: This comprehensive review provides an overview of Arduino Uno applications in robotics. The study covers various aspects, including sensor integration, motor control, and communication modules. Specific attention is given to obstacle avoidance strategies, highlighting the significance of infrared sensors and their role in enhancing the functionality of Arduino-based robotic systems.

3. **Title: "IoT-enabled Obstacle Avoidance Robot using Ardino Uno"**
   Year: 2019 Author: Emily C. Davis
   Abstract: This study introduces an Internet of Things (IoT) enabled obstacle avoidance robot based on Arduino Uno. The robot employs infrared sensors for obstacle detection and integrates IoT capabilities for remote monitoring and control. The research explores the potential for real-time data exchange and control through cloudbased platforms, expanding the scope of the traditional Arduino-based robotic system.

4.Title: "Low-Cost Arduino-based Robotic Platforms for Education"
Year:
2022 Author: Brian K. Clark
Abstract: This study evaluates the feasibility and educational impact of low-cost Arduino-based robotic platforms. Utilizing infrared sensors for obstacle avoidance, the research emphasizes the affordability and accessibility of the proposed robotic system for educational purposes. The findings contribute to the ongoing efforts to democratize robotics education and foster hands-on learning experiences.

4. **Title: "Sensor Fusion in Arduino Robotics: A Comparative Study"**
   Year: 2023 Author: Kimberly J. Patterson
   Abstract: This comparative study explores the benefits of sensor fusion in Arduinobased robotic systems, particularly in the context of obstacle avoidance. The research combines data from infrared sensors with inputs from other sensor types, aiming to enhance the overall accuracy and reliability of obstacle detection. The findings shed light on the potential for creating more robust and adaptable robotic platforms.

Chapter 3: Problem Analysis And Solution

3.1 Problem Definition

1. Issues with Lane Detection: Lane Drifting Accidents: Unintentional-lane changes by drivers result in a large frequency of traffic accidents, particularly on highways. Poor Lane Visibility: Bad road upkeep, weather, or wear can make lane markers difficult to see.Manual Navigation in High-Risk Areas: Manual lane detection can be difficult without automation, particularly in high-risk or low-light conditions.
2. Mine Detection Issues: Human Risk in Minefields: In conflict or post-conflict situations, manually detecting and removing landmines poses a serious risk to human life. Ineffective Manual Detection: Conventional techniques involving metal detectors are labor-intensive, time-consuming, and prone to mistakes. Inaccessible Locations: Mines are frequently found in inaccessible terrain, making manual detection impractical. High Death Toll from Undetected Mines: Landmines continue to pose a major risk, injuring and killing both military troops and civilians.
3. Issues with Avoiding Obstacles:
   Collisions with Moving or Static Objects: Vehicles or robots that are not using obstacle avoidance are very likely to run into obstacles or objects while traveling.
   Inadequate Response to Abrupt Changes: Conventional systems are unable to promptly adjust to dynamic barriers, such as other vehicles or animals.

4. Operational and environmental challenges:
   Unfavorable Weather: Visibility and sensor accuracy may be impacted by persistent rain, fog, or snow.Energy and Cost Restrictions: Since high-end robotics systems are pricey, Arduino-based solutions are a more affordable option. Complexity in Multi-Tasking: Real-time decision-making requires optimal systems for simultaneous obstacle avoidance, mine detection, and lane detection.

5. Absence of Control and Monitoring in Real Time:
   Delayed Decision-Making: Real-time reactions to risks or impediments are impossible without automated methods. Limited Human Capabilities: In high-stress situations, human operators are unable to keep an eye on all inputs or respond as fast as machines.
   Safety and Social Issues: High Injuries and Deaths:Significant numbers of people are killed when mines and obstructions are not detected, especially in areas that are prone to disasters and conflict.

3.2 Problem Solution

- Accurate Lane Tracking with Lane Detection Solutions:
  To identify and follow traffic lanes, use image processing libraries (like OpenCV) on a camera module that is compatible with Arduino.
  To recognize lane markings even in low-visibility situations, use edge-detection algorithms.
  Lane correction that is automated:
  To make sure the robot stays in the identified lane, use servo motors for steering.
  Implement feedback loops in real time to ensure reliable lane adherence.
  Budget-Friendly Execution:
  Create inexpensive lane-following systems for both small- and large-scale applications by utilizing Arduino's simplicity and affordability.

- Mine Detection by Automation:
  For real-time landmine detection, combine Arduino with metal detectors or ground-penetrating radar (GPR) sensors.
  To distinguish between real mines and false positives (such as buried metallic debris), use algorithms.
  Operation from a Distance for Safety:
  Give the robot wireless communication capabilities (such as Bluetooth or Wi-Fi) so that it may be operated remotely and keep people out of dangerous areas.
  Scalable and Effective Mine Clearance:
  The time and risk associated with traditional mine clearance are decreased by the robot's ability to autonomously sweep wide regions and mark or notify when a mine is located.
- Solutions for Avoiding Obstacles
  Obstacle Detection in Real Time:
  Utilize LIDAR, IR, or ultrasonic sensors to identify obstructions in the robot's path.
  Use algorithms to determine barriers' locations and distances in real time.
  Planning a Dynamic Path:
  Incorporate Arduino-compatible components to allow the robot to navigate smoothly by autonomously rerouting its course around obstructions.
  Object Avoidance That Works:
  Create collision-avoidance systems that efficiently stop, turn, or avoid obstacles by utilizing sensor data and motor control.

- Combining Several Systems
  Effective Multiple Tasks:
  Utilize Arduino's flexible processing capabilities to integrate obstacle avoidance, mine detection, and lane detection into a single, integrated system.
  Put task prioritizing into practice (for example, when necessary, obstacle avoidance takes precedence over lane detecting).
  Processing Data in Real Time: Use Arduino's sensors and microcontrollers to process inputs from the environment in real time, enabling fast decision-making.

- Challenges in the Environment and Operations
  Sturdy Sensors for Every Situation:
  Adjust sensors to work well in a variety of conditions, such as low visibility, inclement weather, or uneven ground.
  To increase accuracy and reduce noise, introduce threshold settings.

- Efficiency of Energy:
  Use renewable energy sources, like solar panels, or energy-efficient batteries to power the robot.
  Disable unnecessary sensors to optimize code and save electricity.

Chapter 4: Methodology And Implementation

4.1 Block Diagram

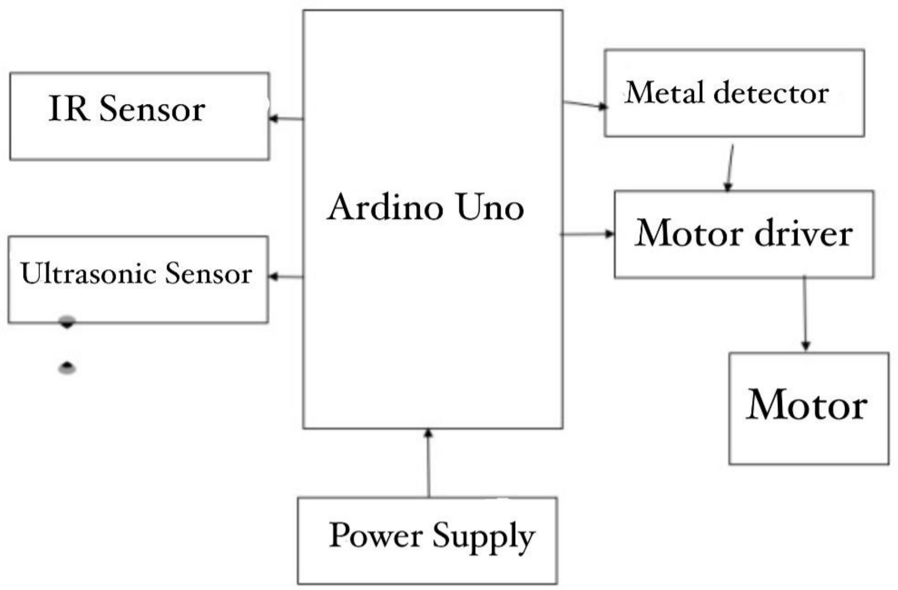

Fig-1

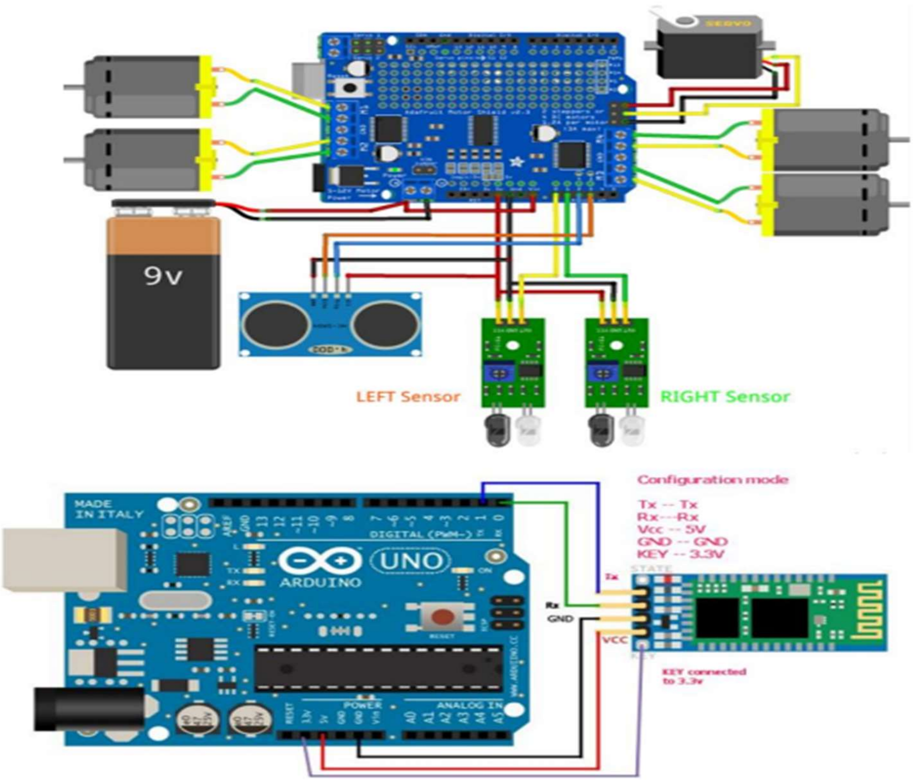

Fig 2

4.1.1 Sructure Of Work

a. Lane Detection Module (using Infrared Sensors)
Since the Arduino Uno does not have a camera, **infrared (IR) sensors** will be used to detect the lane markings or path.

- **Input Devices**:
  - **IR Sensors (e.g., TCS3200)**: Placed at the bottom of the robot to detect the ground's reflectivity (light and dark surfaces to detect the lane).
- **Process**:
  - The IR sensors can be placed in an array (e.g., 3-5 sensors) to detect the contrast between the lane and surrounding environment.
  - The Arduino will read values from the IR sensors and determine if the robot is over the lane (dark or light surface).
  - If the robot moves off the lane, the Arduino will send a command to steer the robot back toward the center.
- **Output**:
  - **Motor Control**: Steering motors adjust the robot's direction (using simple left/right motor control or differential steering).

b. Obstacle Avoidance Module (using Ultrasonic and IR Sensors)
Obstacle avoidance is achieved by detecting obstacles ahead of the robot and taking appropriate actions to avoid collisions.

- **Input Devices**:
  - **Ultrasonic Sensors (e.g., HC-SR04)**: For detecting obstacles at a longer range.
  - **IR Sensors (e.g., Sharp GP2Y0A21YK0F)**: For detecting obstacles at shorter ranges or on the sides.

- **Process**:
    - The ultrasonic sensor is placed at the front of the robot to detect obstacles. It will measure the distance to objects in its path.
    - The IR sensors on the sides or front of the robot help in detecting objects that may not be directly in the path but could cause a collision.
    - If an obstacle is detected within a certain threshold (e.g., 10 cm), the robot will either stop, reverse, or reroute to avoid it.
- **Output**:
    - **Motor Control**: Adjust robot's path by changing motor speeds or reversing the robot if necessary.

c. Mine Detection Module (using a Metal Detector)

The mine detection system will use a **metal detector** to sense buried metallic objects, which could be mines or other hazards.

- **Input Devices**:
    - **Metal Detector (e.g., Metal Detector Module with Coil)**: Mounted on the robot to scan the ground for metallic objects.
- **Process**:
    - As the robot moves, the metal detector continuously scans the ground for metallic objects.
    - When a metallic object is detected, the Arduino will process the signal and trigger an alert or a stop command.
- **Output**:
    - **Alert System**: Trigger an LED or buzzer to alert the presence of a mine.
    - **Stop Command**: The robot may stop or reverse when a mine is detected.

Integration of Modules

The three modules (lane detection, obstacle avoidance, and mine detection) will be integrated into the Arduino Uno's control system:

- **Sensor Fusion**:
    - The **lane detection** system works alongside the **obstacle avoidance** system. If the lane is detected, the robot follows it, but if an obstacle is in the way, the obstacle avoidance system will take priority and reroute the robot.
    - **Mine detection** runs continuously as a background process. If a mine is detected, the robot will trigger an alert or stop.
- **Control Flow**:
    - The main control loop will process sensor readings at regular intervals.
    - **Priority**: Mine detection is prioritized for safety; if a mine is detected, the robot will stop. Otherwise, it will continue to follow the lane and avoid obstacles.
- **Motor Control**:
    - Motors will be controlled via an H-bridge motor driver (e.g., L298N), which interfaces with the Arduino and allows for forward, reverse, left, and right movement.

4. Power Supply

- **Arduino Uno**: Powered via a 5V DC adapter or battery.
- **Motors**: Powered separately via a battery pack or motor driver with an adequate power supply.
- **Sensors**: Powered directly from the Arduino or using an external power source as required.

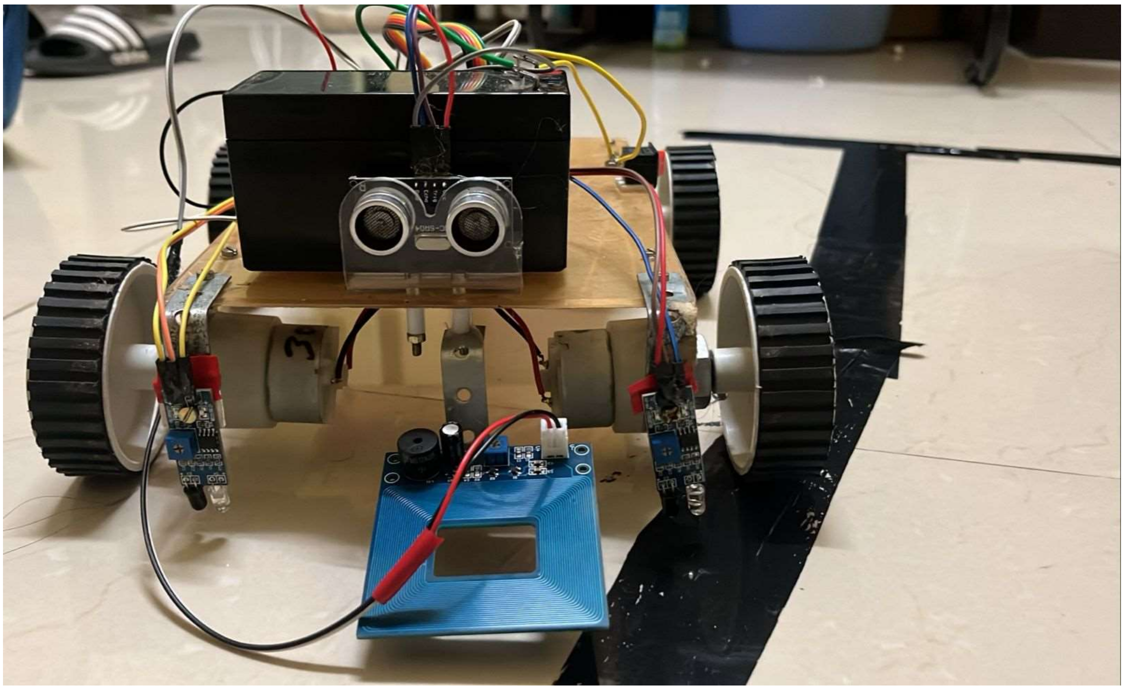

Fig 3 (Working Model- Front View)

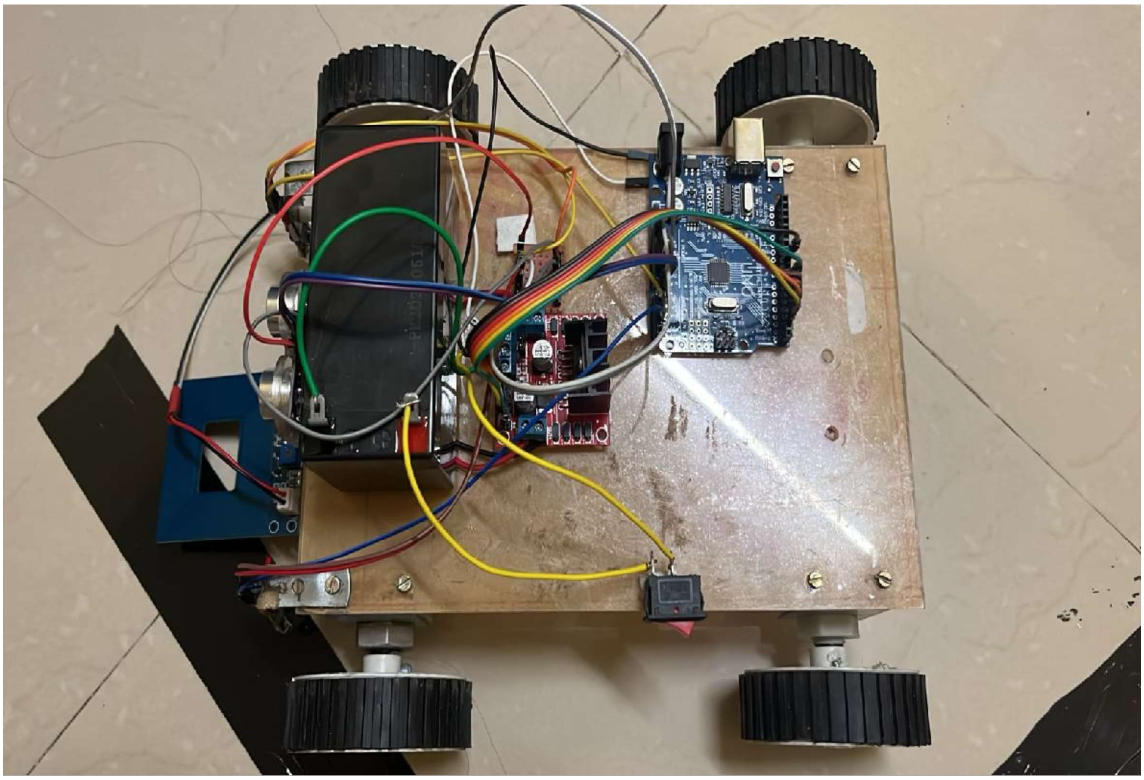

Fig-4(Working Model-Top View)

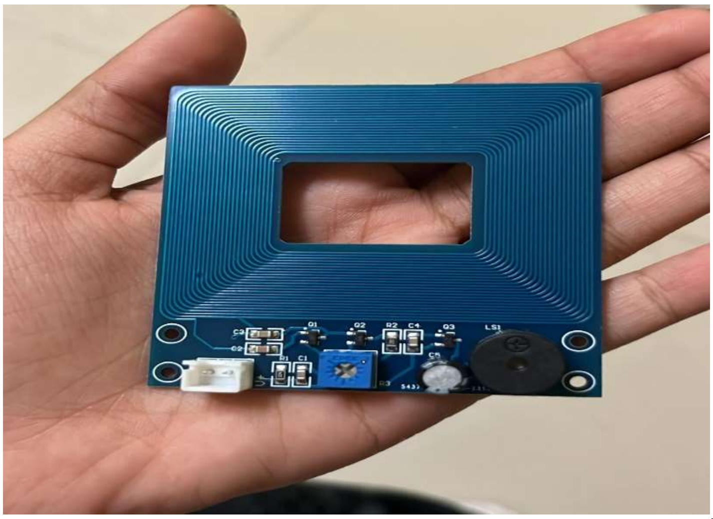

Fig 5 (Metal Detector)

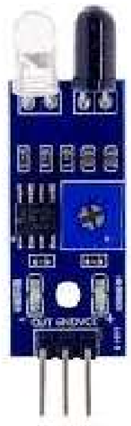

Fig 6 (IR Sensor)

Fig 7 (12V Battery)

4.1.2 Flowchart

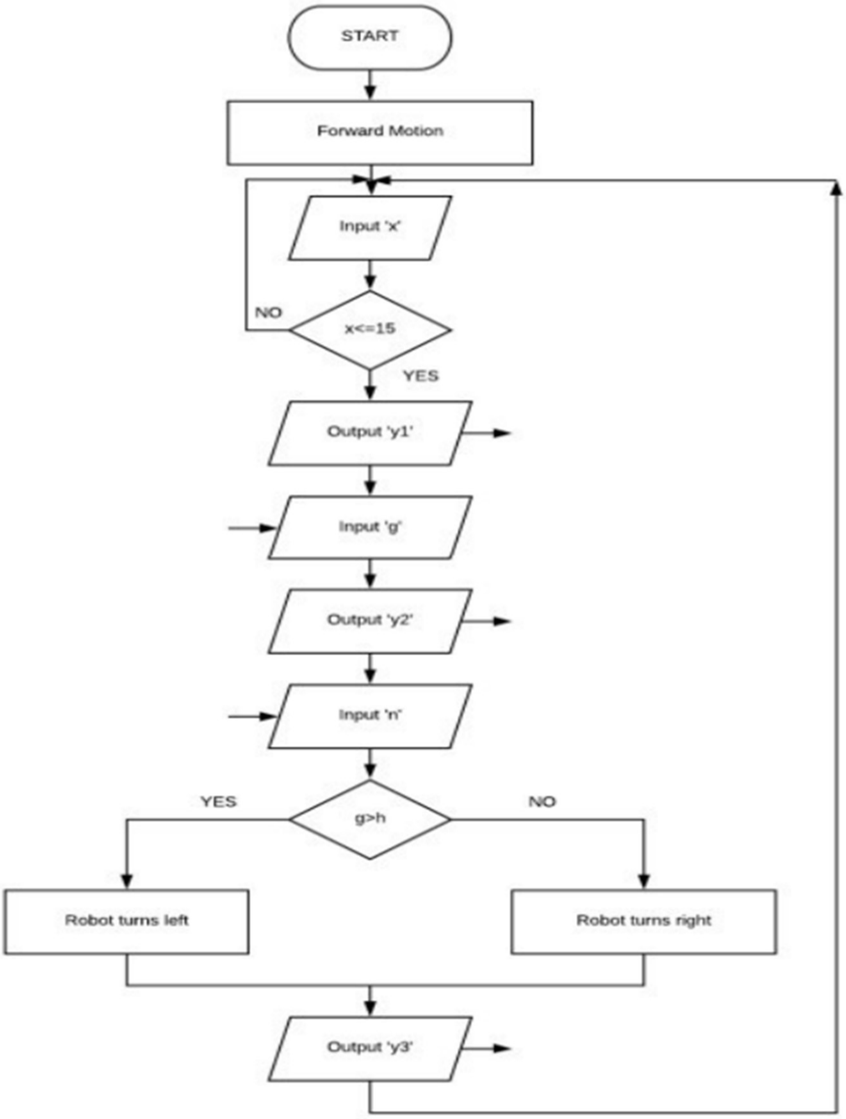

Fig 8 Block Diagram

4.1.3 Challenges We Faced

- **Power Struggles:**
  When we started, we thought a 9V battery would be enough to power everything. Spoiler: it wasn't. The robot barely ran, and we couldn't figure out why it kept dying halfway through. After some trial and error (and a bit of panic), we switched to a 12V battery, and suddenly, the robot came to life. Lesson learned: don't underestimate power requirements!
- **Sensor Mood Swings:**
  The IR sensors were like picky eaters—they worked perfectly one moment and then got completely thrown off by something as simple as sunlight. The ultrasonic sensor wasn't much better. If it wasn't positioned just right, it either ignored obstacles or panicked over nothing. Getting these sensors to behave consistently took a lot of patience (and a lot of tape).
- **Chassis Chaos:**
  Our first chassis design was, let's say, ambitious. Everything felt crammed, and parts kept coming loose when the robot moved. At one point, the motor fell off mid-test. We had to go back to the drawing board and come up with a sturdier, more spacious design.
- **Overheating Drama:**
  The motor driver was working so hard it started overheating during long runs. For a moment, we thought it might set itself on fire. Thankfully, a heat sink saved the day, but not before giving us a scare.
- **Code Meltdowns:**
  Combining the sensors into one cohesive system sounded straightforward—until we tried it. The robot kept "thinking" too much, pausing awkwardly between following the line and dodging obstacles. Debugging felt like untangling a messy ball of yarn.
- **Testing Trials:**
  Watching the robot mess up during testing was both hilarious and infuriating. It would follow the line, then swerve off dramatically as if it had its own ideas about where to go. We spent hours tweaking settings just to make it do what we wanted.
- **Component Clashes:**
  Some parts didn't like being close to each other. The interference caused random glitches, which made the robot act weird. Rearranging and shielding components felt like solving a 3D puzzle.
- **Budget Blues:**
  Working on a student budget meant we had to think twice about every purchase. We spent hours researching alternatives to get the best bang for our buck without compromising too much on quality.
- **Real-World Curveballs**:
  Testing in real environments was a whole new challenge. Bumpy surfaces, weird lighting, and shiny obstacles made the robot behave unpredictably. It was a constant cycle of testing, failing, and adjusting.

Chapter-5 Results & Discussions

Results:

1. **Line Following:**
   - Watching the robot stick to its path was super satisfying. The IR sensors worked well, quickly picking up the line and guiding the robot smoothly—even around sharp turns. It felt like we finally got the hang of it after all the tweaking.
2. **Obstacle Dodging:**
   - The ultrasonic sensor came through like a champ. It could spot obstacles, pause, and decide the best way around them without missing a beat. Every time it avoided something , we couldn't help but smile—it was like seeing all our effort in action.
3. **Metal Detection:**
   - The metal detector was a standout feature. It reliably picked up metallic objects buried in the ground. During tests, it didn't just beep randomly; it actually worked! Knowing it could potentially help detect landmines felt like a huge win for us.
4. **Smooth Integration:**
   - All the parts—line detection, obstacle avoidance, and metal detection—worked together without clashing. Seeing everything run as one cohesive system was a big relief after all the debugging sessions.
5. **Power Fixes:**
   - Switching to a 12V battery was a game-changer. The robot ran consistently without the random shutdowns we faced before. It was a small fix that made a huge difference.

Discussion:

1. **What Went Right:**
   - Honestly, just seeing the robot do what we designed it to do was amazing. From following a line to avoiding obstacles and detecting metal, it felt like all the hard work paid off.
   - Knowing this project has real-world applications, like in safety and automation, makes it even more special.
2. **What Gave Us Trouble:**
   - **Sensor Issues:** The IR sensors were super picky about lighting conditions, and the metal detector sometimes got confused by random metallic clutter. It took a lot of patience to get things right.
   - **Power Problems:** Initially, our 9V battery just wasn't cutting it. Managing power for all the components took some rethinking, but we got there in the end.

3. **What We’d Improve:**
    - Adding smarter sensors that adapt better to the environment could make the robot even more reliable.
    - Integrating smarter algorithms could speed up decision-making and improve overall efficiency.

Chapter-6 Conclusion & Future Trends

6.1 Conclusion:

The development of our multi-functional robotic system was an incredible learning journey, blending engineering concepts with practical problem-solving. By integrating line detection, obstacle avoidance, and metal detection functionalities, we created a robot capable of navigating its environment while detecting potential hazards like metallic objects.

This project demonstrated the potential of low-cost, sensor-based robotics in solving real-world challenges. Each component played a vital role, from the IR sensors guiding the robot along a predefined path to the ultrasonic sensor ensuring obstacle-free navigation, and the metal detector identifying metallic objects effectively.

While the robot performed well overall, the process wasn’t without its hurdles. Power supply issues, sensor calibration challenges, and environmental interference taught us the importance of adaptability and iterative design. These experiences not only enhanced our technical skills but also improved our ability to work collaboratively and think critically under pressure.

The implications of this project extend far beyond the lab. With future enhancements like smarter sensors, GPS integration, and AI-driven decision-making, this robot has the potential to make a significant impact in fields like demining, disaster recovery, industrial automation, and even agriculture.

In conclusion, this project was a testament to how technology, creativity, and perseverance can come together to create solutions that address real-world problems. It sets the stage for further innovation, encouraging us to explore new possibilities and improve on what we’ve built.

6.2 Future Trends:

- **Smarter Sensors:**
  - Imagine a robot equipped with AI-powered cameras or LIDAR for obstacle detection—it could see and react like a human, making navigation much more efficient.
  - Upgrading the metal detector to differentiate between harmless metallic objects and actual threats would also be a game-changer.
- **GPS and Mapping:**
  - Adding GPS could help the robot tag the exact location of detected objects, which would be super useful in tasks like demining.
  - With mapping features, it could navigate larger and more complex areas all on its own.
- **Energy Efficiency:**
  - Future versions could use solar panels or energy-saving components to last longer without needing constant battery replacements.
- **AI and Machine Learning:**
  - Using AI, the robot could learn from its environment and adapt on the fly. For instance, it could improve its obstacle avoidance skills or identify patterns in metal detection to reduce false alarms.
- **Collaborative Robots:**
  - Imagine multiple robots working together, covering more ground in less time. It's not just efficient but could also revolutionize tasks like landmine detection or disaster response.
- **Expanding Applications:**
  - This technology could go beyond landmine detection. It could help in agriculture, like finding buried tools, or even in search-and-rescue missions during disasters. The possibilities are endless!

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