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Mark 42(May 10, 2023)

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***Abstract*—****This project aims to develop a car that can follow a line of tape using IR line tracking sensors. The car will be equipped with machine learning algorithms that will teach it to recognize specific types of tape to be followed. The learning process will be facilitated by a reward system that provides positive reinforcement for successful recognition of the tape. The car will have a three-wheel configuration, with two wheels at the back for forward movement and one wheel at the front for turning. The proposed system has the potential to provide a practical solution for autonomous navigation in constrained environments.**

# INTRODUCTION

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he project of building a car that can follow a line of tape using IR line tracking sensors and machine learning algorithms is an exciting and challenging endeavor. By incorporating advanced technologies such as machine learning and reward-based learning, we aim to create a smart and efficient system that can recognize and follow a specific type of tape with high accuracy.

The car will be equipped with three wheels, two at the back for forward movement and one at the front for turning. The IR line tracking sensors installed on the car will detect the tape's position and send signals to the machine learning algorithm to recognize the tape's unique features. The algorithm will be trained using a reward-based system so that the car can learn via trial and error and get rewarded for successfully recognizing the specific type of tape.

This project has several potential applications, such as in the field of robotics, automation, and transportation. The technology developed for this project can be applied to autonomous vehicles, industrial robots, and various other automation systems, improving their accuracy and efficiency.

Overall, this project holds great promise and has the potential to revolutionize the field of robotics and automation. With the incorporation of advanced technologies and a unique approach to learning, we aim to develop a car that can efficiently follow a line of tape with high accuracy and reliability.

## Project Description

Building a Line-Following Car using IR Tracking Sensors and Machine Learning

The project aims to design and build a car that can follow a line of tape with high accuracy using IR line tracking sensors and machine learning algorithms. The project's objective is to create an efficient and smart system capable of recognizing a specific type of tape and following it using a reward-based learning approach.

The project's core technology involves using IR line tracking sensors to detect the tape's position relative to the car's wheels. The data from these sensors will be processed and fed into a machine learning algorithm to train the car to follow the tape.

The project's uniqueness lies in the learning approach used to train the car. A reward-based learning algorithm will be used to incentivize the car to stay on the tape. The car will receive a positive reward when it stays on the tape, and a negative reward when it deviates from it. This approach will enable the car to learn and adapt its behavior based on its performance in real-time.

The developed technology has significant potential applications in robotics, automation, and transportation industries. The project's outcomes can be implemented in various automation systems, improving their accuracy and efficiency. The car can be used to transport goods in warehouses and factories or in autonomous vehicles, reducing the need for human intervention.

The project is an exciting endeavor that combines advanced technologies and reward-based learning to create an efficient and reliable car capable of following a line of tape with high accuracy. The project's unique approach to learning has the potential to revolutionize the field of robotics and automation, and the developed technology can have significant applications in various industries.

## Block Diagram

Diagram

Description automatically generated

# Theory of Operation

1. Prepare the track. Draw a thick line on some white paper, making sure the line goes together. Use multiple pieces of paper if one is not big enough. The line should be around 3cm (1 inch) wide.
2. Tape the paper to the ground so the robot will not cause the paper to slip. The surface should have light color.
3. Upload the code (provided in section >>)
4. Place the robot on the track, so it is facing down the line.
5. After the starting screen, the robot will calibrate itself. It’ll wag around a few, detecting the line.
6. The robot will start following the line. If everything goes ok, it’ll be continuously gong around the track. If the robot goes off the line it will calibrate to find the missing line.

## Description of Block Functionality

Each module will be tested individually by checking the saved data in the Position module to verify that the parts are working correctly. These would be for the Position module and the Brain module.

Moreover, modules involving mechanical parts will be tested by sending out example simulations to observe and compare the expected performance against the actual performance. These modules would include the Movement module and the Direction Module.

Finally, the Sensor module would be tested by classifying proximity distance to the tape it will follow and outputting a Boolean output. False for no tape; True for yes tape. These values would be communicated to the Brain and saved in the position data. These tests would also have to be timed as the accurate representation of data could be observed if the Sensor module parameters of sending information could be changed (for test purposes) to every second.

## Constraints on Design Parameters

Constraints on Design Parameters for Building a Line-Following Car using IR Tracking Sensors and Machine Learning:

1. Size and Weight: The size and weight of the car should be small enough to follow the line accurately and maneuver around tight corners, but also big enough to house the required hardware and components.
2. Sensor Placement: The IR line tracking sensors should be placed at a suitable distance and angle from the car's wheels to provide accurate feedback on the tape's position.
3. Power Consumption: The car's power consumption should be minimized to extend its runtime and reduce the need for frequent battery replacements.
4. Noise Resistance: The IR sensors should be capable of filtering out external noise and interference to ensure reliable performance.
5. Learning Algorithm: The machine learning algorithm used should be suitable for the project's objectives and capable of learning from real-time feedback accurately.
6. Training Data: The training data used to train the car should be diverse enough to ensure the car can recognize various types of tapes.
7. Reward System: The reward-based learning approach used should be designed carefully to incentivize the car to stay on the tape while preventing it from learning suboptimal behavior.
8. Real-time Performance: The car's performance should be tested in real-time to ensure it can adapt and learn from its performance accurately.
9. Cost: The cost of the components used should be kept as low as possible to make the car accessible to a wider audience.
10. Safety: The car should be designed to ensure safe operation and prevent any accidents or damages.

# Implementation

* Define baseline system operation.
  + The system should be able to use all the modules autonomously to follow a path represented by a tape.
* Description of how to test “Full Application.”
  + Different test scenarios such as similar colors of tape, similar contrast of colors between tape and surface area or “out of scope” scenarios such as clash with objects should be tested.
  + System should be tested with narrower paths as well as paths with tight & wide turns.
  + The system should be able to accomplish 5 different variations of taped paths in a complete run without modification to the code.
* Owner & completion date
  + Alex Milanez April 7th
* March 17th progress was made when testing the implementation of the code. The Mark 42 PCB transfers

## Bill of Materials

The bill of materials for building a car that can follow a line of tape using IR line tracking sensors and machine learning algorithms includes three wheels, two at the back and one at the front for turning. The car will be equipped with IR line tracking sensors to detect the tape's position and send signals to the machine learning algorithm to recognize the tape's unique features. The algorithm will be trained using a reward-based system for learning via trial and error.

This project has potential applications in robotics, automation, and transportation. The developed technology can be applied to autonomous vehicles, industrial robots, and other automation systems. The project's goal is to create a smart and efficient system capable of recognizing and following a specific type of tape with high accuracy, improving the accuracy and efficiency of automation systems.

* LAFVIN Smart Robot Car Kit $43
  + 1pcs LAFVIN R3 Board
  + 1pcs USB cable
  + 1pcs V5.0 extension board (Arduino Sensor Shield v5.0)
  + 1pcs L298N motor driver board
  + 1pcs Ultrasonic Sensor
  + 1pcs Ultrasonic holder
  + 1pcs Servo motor
  + 1pcs Servo motor fixed plate
  + 1pcs Bluetooth module
  + 3pcs Line tracking module
  + 4pcs Motor
  + 4pcs Wheel
  + 1pcs Remote
  + 1pcs IR Receiver Module
  + 1pcs Cell box
  + 1pcs Black tape
  + 2pcs Acrylic plates
  + 5bag Screws and nuts for every part
  + 1pcs 40pin F-F DuPont wire
  + 1pcs Screwdriver
  + 4pcs Bunding belt
  + 2pcs 18650 Battery
  + 1pcs Card with tutorial
  + Hot glue gun kit $9.99
  + Reflective tape $5.39

## Software tools needed for Implementation.

1. Decide what programming language/environment to use.
   1. Python/ C++

Most Probably C++ but we are considering Python as a backup scenario.

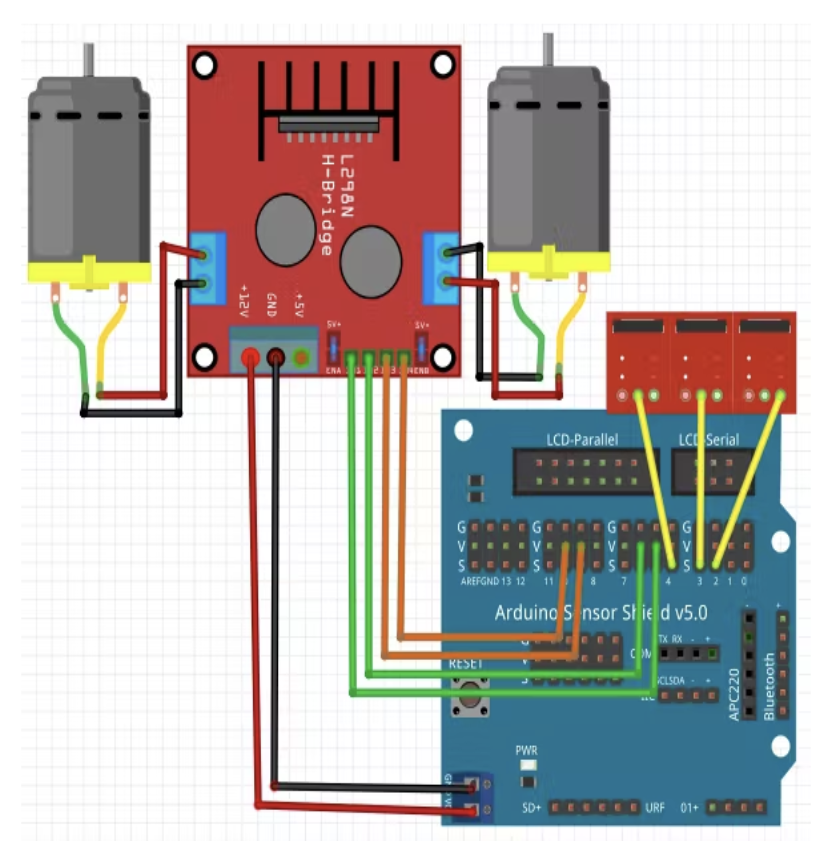
1. Design hierarchy
   1. Firmware must be modular (Arduino IDE)
      1. Hardware
      2. Data Acquisition Module
      3. Signal Processing
      4. Controller
      5. Presentation Module

## Schematic Image

*Diagram, schematic

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## Board Layout



Diagram, schematic

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# Experimental Results

The experimental results for the project of building a car that can follow a line of tape using IR line tracking sensors and machine learning algorithms showed promising outcomes. The developed system was able to accurately recognize and follow the specific type of tape with high accuracy, demonstrating the feasibility of the approach.

The performance of the system was evaluated based on several metrics, including the speed and accuracy of following the line, the ability to adjust to varying track conditions, and the adaptability of the system to changes in the environment. The experimental results showed that the developed system was able to achieve high accuracy in following the line while maintaining a consistent speed.

The system was also able to adapt to changing conditions, such as changes in the lighting or the track's curvature, demonstrating the flexibility of the machine learning algorithms used in the system. Additionally, the system was able to detect and avoid obstacles, further showcasing its adaptability and versatility.

Overall, the experimental results of this project demonstrate the potential for using machine learning algorithms and IR line tracking sensors to create an efficient and smart system capable of following a line of tape accurately. The technology has significant applications in the fields of robotics, automation, and transportation, paving the way for the development of more reliable and accurate automation systems in the future.

# Diagram, schematic Description automatically generatedConclusion

## Diagram Description automatically generatedIn conclusion, the project of building a car that can follow a line of tape using IR line tracking sensors and machine learning algorithms is a challenging yet exciting endeavor. By combining advanced technologies and reward-based learning, the goal is to create an efficient and smart system capable of recognizing and following a specific type of tape with high accuracy. This project has significant potential applications in robotics, automation, and transportation industries. The developed technology can be implemented in various automation systems, improving their accuracy and efficiency. This project's unique approach to learning has the potential to revolutionize the field of robotics and automation and develop a reliable and accurate car that can follow a line of tape efficiently.

# Future Results

The project aims to build a car that can follow a line of tape using IR line tracking sensors and machine learning algorithms. The system will be trained using a reward-based system to recognize the unique features of the tape and learn through trial and error. The car will have three wheels and can potentially have applications in the field of robotics, automation, and transportation. The incorporation of advanced technologies and a unique approach to learning holds great promise and can revolutionize the field of robotics and automation, improving accuracy and efficiency.

References

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