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Line Follower Robot Using ESP32 Cam

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Abstract*— This project presents the development of an intelligent line following robot using the ESP32CAM module for real, time image processing and guidance. Thanks to machine learning algorithms, the robot will automatically follow the defined path and provide dynamic navigation services. Using computer vision, it can follow lines and adapt to changes in the environment, resulting in increased performance. The system integrates real time image analysis to provide accurate guidance and suitability for various situations. The robot increases its overall performance by achieving high performance and communication by using the features of ESP32CAM. This application increases the level of control management by demonstrating the integration of artificial intelligence, computer vision and robotics into intelligent operation. The program is dedicated to academic research and the use of robotics to meet the needs of hobbyists and professionals. Its modular design allows for scalability and customization, helping to adapt to specific requirements. Use of open source software and hardware increases usability and encourages collaboration in the robotics community. Through many trials and tests, the reliability and performance of the system has been proven in many places and situations. Future improvements will include additional sensor integration and algorithm optimization to further improve performance. Overall, this project demonstrates the potential of integrating these technologies to create versatile and adaptable robotic systems for real-world use.

***Index Terms*— Arduino UNO, L293D Driver, ESP32-Cam, IR Sensors, Li-Ion Batteries, DC Motor Driver**

I. INTRODUCTION

Autonomous robots that can monitor, detect and track the movement of the ball in real time are called ball tracking robots. The robot behaves like a human in sports such as basketball or football. The main role of the robot is to provide fun and entertainment, but analyzing how humans and robots interact and control the robot is also an important part of the research. Design: Both hardware and software elements were used to create the following robot package. Information and control of engines. The software includes algorithms for packet detection and tracking, engine control and decision making. The camera needs to analyze the video stream to determine the location and size of the ball. The algorithm needs to be powerful enough to find the ball even in poor and intense lighting conditions. . The robot's movement needs to work in conjunction with a tracking algorithm's ability to predict the ball's path. He also needs to deal with situations where the ball is moving or changing quickly. In order for the ball to remain in the field of view, the robot's speed, direction and turning radius must be able to change. I plan to do it. It must decide how fast the robot will move, stop and turn.

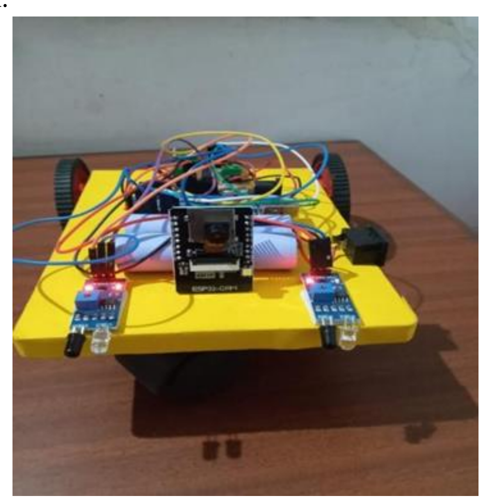

Figure 1. A Line following robot

Arduino UNO

Open source called Arduino for creating electronic projects. An integrated development environment (IDE) running on the system is used to generate the control code and send it to the physical panel. Arduino consists of a programmable circuit board (often called a microcontroller) and software. Using the prototype provided by Arduino, the functionality of the microcontroller is separated into more useful boxes. Uno is a great choice for beginners and is one of the most popular boards in the Arduino family.

Prebuilt Arduino boards contain microcontrollers and are programmed using the Arduino programming language from the Arduino Development Setup.

The main platform is to provide a way to design and manufacture electronic products. The "blueprint" of the Arduino uses basic programming techniques such as switches and functions and forms the basis of the basic structure of the C/C++ programming language. These are then converted into a C++ program. The Italian word UNO here means "one". It was called UNO to describe the first version of the Arduino software. This is also the first USB board released by Arduino. It is considered a strong board adopted by many projects. Arduino UNO board created by Arduino.cc. It is easier to use compared to other boards such as Arduino Mega board. The board contains shields, various circuits, and digital and analog input/output (I/O) pins. In addition to the 6pin analog input, the Arduino UNO has 14 digital pins, a USB port, a power jack, and an ICSP (InCircuit Serial Programming) header. It is programmed as an IDE (Integrated Development Environment). It works on both online and offline platforms.

L293D Motor Driver IC

Figure 2. L293D Motor Driver

L293D is a 16pin motor driver IC that can drive two DC motors simultaneously on both sides. The L293D provides a bidirectional drive current of up to 600 mA (per channel) over a voltage of 4.5 V to 36 V (at pin 8!). It can be used to control toy motors, which are small DC motors. It can get very hot sometimes. To drive the motor further, you need some type of transformer that can deliver a small current, amplify it and deliver a larger power current, because the motor is powerful and requires more current than the standard microcontroller pins can produce. The "driver" is the person who completes all the work. The L293D motor driver IC makes this task easier and supports many applications with great ease. With the L293D integrated circuit, the DC motor can be driven in both directions. A pair of two DC motors can be controlled simultaneously in each direction using the 16pin IC L293D. This means that one L293D IC can drive two DC motors. Because there are two H_bridge circuits. The L293D can also run large, quiet motors. H_bridge motor control circuits can be created in many ways, including the use of relays, transistors, and L293D/L298. Before discussing the details, let's define the H-bridge circuit.

ESP32-Cam

ESP32CAM is a fullfeatured microcontroller that also has an integrated camera and microSD card slot. Because it is cheap and easy to use, it is ideal for IoT devices that need a camera with advanced features such as image tracking and recognition.

Figure 3. ESP32-Cam

It has the following features:

- 802.11b/g/n Wi-Fi
- Bluetooth 4.2 with BLE
- UART, SPI, I2C and PWM interfaces
- Clock speed up to 160 MHz
- Computing power up to 600 DMIPS
- 520 KB SRAM plus 4 MB PSRAM
- Supports WiFi Image Upload
- Multiple Sleep modes
- Firmware Over the Air (FOTA) upgrades possible
- 9 GPIO ports
- Built-in Flash LED

Using the ESP32CAM is similar to using the ESP32 module we reviewed previously, with one important exception. You cannot connect the ESP32CAM boar d to your computer and start installing the program be cause it does not have a USB connector. Since you wi ll be using this adapter to program the Arduino Pro M ini, you most likely have a Pro Mini if you have used one.

IR Sensor

Figure 4. Infrared sensor

An electronic device called an infrared sensor emits li ght to detect nearby objects. Infrared sensors can mon itor the temperature of objects and detect motion. Ge nerally all objects emit some form of radiation in the infrared range. Although the radiation is invisible to t he human eye, infrared sensors can detect them. Phot odiodes detect infrared light of the same wavelength emitted by IR LEDs. When infrared light hits the pho todiode, the resistance and output voltage will change according to the intensity of the infrared light receive d. Success is the five key elements of the infrared ins pection process. Infrared source includes infrared lase rs and LEDs of specific wavelengths. We offer a vari ety of chassis with tank crawlers or fourwheel drive (4WD). They are ideal when you don't have the time o r resources to build your own robot chassis. Sensor or lidar. In robots, they are connected to DC motors po wered by lithium-ion batteries.

Simplifications

Some of the simplifications we made throughout the text are not mentioned. First, we are only looking at left to right movement, not back and forth movements. Even if the ball and the robot are a distance L apart, we still consider the motion to be linear because the ball must move in a circle with the rotation of the robot. We can assume that the difference at distance L is negligible. The model robot then assumes pure coordination, responding immediately to the signal. This is incorrect because the inertial mass m of the robot causes a delayed response. Additionally, contrary to what we believe, the movement of a real robot does not depend linearly on input from the motors. Additionally, due to the limited power of the engine, we cannot exceed certain limits. Again, we can ignore this problem for small changes in the fixed position near zero. The modeling camera is the main difference between the model and the real robot. It is not easy to think that the button definition process will take more time when there are so many elements in the picture. Each time the image is processed, the time delay must be changed according to the TD model. We can solve this problem by determining the maximum value of TD. You won't see the oscillations in a real robot, but they all have slightly different times. This can be avoided by using as similar an environment as possible.

CONCLUSION

We have reviewed products for 15 years and talked about many robots. Although the AI process is seen as "smarter" than the traditional process, in our example the traditional process provides more information than the description of the system. We can also determine the correct values of system parameters and predict the behavior of the system. Packagebased robots can be used for many different purposes and come in many forms or upgrades. We then touch on the research gaps and issues, how it can be a guide for future research, and how we can develop the package that will follow the robot, from creating good algorithms and simulations. It is possible to correct the following lines:

1. Advanced Line Detection:
Investigate learning techniques such as neural networks to train robots to follow complex lines, colored lines, and patterns on various surfaces. An adaptive algorithm takes lighting changes into account and improves line spacing.

Power line tracking:
Integration of multiple line sensors (infrared, ultrasonic or line cameras) to ensure repeatability and increase performance in harsh environments. Integralderivative control for smoother line tracking, especially around curves and intersections.

Multi-Line Navigation:
Program the robot to follow lines of different colors or patterns for difficult route selection or obstacle avoidance. Comment out code or real-time measurement data. Product information and interaction:

1. Object detection and avoidance:
Use object recognition models (such as YOLO, SSD) to train the ESP32CAM torecognize and track problems or specific objects.) for almost multiple problems to be found and collisions to be avoided.

Delivery or handling:
Provide a robot with an arm or attachment to pick up, carry, or interact with a specific item as per requirement. It is possible to perform arm movement using inverse kinematics.

Human-computer interaction:
Recognizing faces or objects to personalize interactions or perform specific actionswhen identifying people or objects. Robot control. Advanced Communication and Control:

1. Wi-Fi or Bluetooth connection:
Remote monitoring and control via WiFi or Bluetooth for realtime monitoringFollow or change route during operation. The web interface is used to interact with the robot and view camera data.