Food-Carrying Juggernaut: A Line-Following and Remote-Controlled Robot Inspired by Star Wars

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Idea:

Create and develop a working prototype of a vehicle incorporating design elements from the A6 Juggernaut from Star Wars, featuring a specialized container for food transportation.

Problem Statement:

Design and develop a line-following and remote-controlled robot, inspired by the A6 Juggernaut from Star Wars, with a built-in compartment to securely hold and transport food items. The robot should exhibit autonomous line-following capabilities while also allowing remote control operation for enhanced user interaction. The primary objective is to create an entertaining and functional robot that combines the joy of Star Wars aesthetics with practicality by providing a reliable and secure compartment for transporting food items.

Constraints:

- The robot must be able to follow a line that is drawn on the floor.
- The robot must be able to deliver food to a specific location.
- The robot must be modeled after the A6 Juggernaut from Star Wars.
- Weight capacity should be defined for the food compartment.
- Size limitations should accommodate common food containers.
- Design should prioritize easy cleaning and food safety.
- Power efficiency must be maximized for extended operation.
- Maneuverability on different surfaces and stability are crucial.
- Remote control range should allow operation from a distance.
- Safety sensors for collision detection and emergency stop.
- Adherence to a specific budget or cost constraints.
- Intuitive and user-friendly interface for easy operation.

Solution:

- Implement a robust and reliable power management system to efficiently utilize and monitor the battery life.

- Integrate a microcontroller, such as the ESP32, to serve as the central control unit, managing sensor inputs, motor control, and communication.
- Develop a PID algorithm to provide precise and smooth line-following capabilities for improved accuracy and stability.
- Install an ultrasonic sensor for obstacle detection and avoidance, allowing the robot to navigate around objects in its path.
- Utilize an onboard camera and servo motor to enable a pan-tilt functionality, providing a wider field of view for remote monitoring or surveillance purposes.
- Design a user-friendly web interface accessible through the robot's web server to control and monitor its functions remotely.
- Implement safety mechanisms such as emergency stop buttons or collision detection sensors to ensure the well-being of users and prevent accidents.
- Use sturdy and durable materials for the robot's construction to withstand the rigors of transportation and handling of food items.
- Incorporate noise reduction and vibration damping techniques to minimize disturbances and ensure smooth and quiet operation.
- Develop a secure locking mechanism for the food compartment to prevent accidental opening or spillage during transportation.

Benefits:

- Efficient Food Transportation: The built-in compartment in the robot enables efficient transportation of food items, making it convenient to deliver snacks, drinks, or small meals without the need for human intervention. This can be particularly useful in settings such as parties, events, or even at home.
- Novelty and Entertainment: The robot's resemblance to the A6 Juggernaut from Star Wars adds a fun and entertaining element to the project. It can attract attention and spark conversations, providing a unique and enjoyable experience for users and spectators alike.
- Versatility: While primarily designed for food transportation, the robot can be modified or expanded for other purposes. It can be adapted to carry different items such as small packages, toys, or even personal belongings, offering flexibility in its usage.
- Technological Showcase: The project serves as a technological showcase, demonstrating the integration of line-following and remote-controlled capabilities. It highlights the practical application of robotics in everyday scenarios, showcasing the potential for advancements in autonomous systems.

Technical Objectives:

- Utilize 2 IR sensors for accurate and fast line-following capabilities, incorporating a PID algorithm.

- Drive 6 BO gear motors using 1 L298N motor drivers for efficient and controlled movement.
- Incorporate an ultrasonic sensor to provide object detection and implement basic obstacle avoidance functionality.
- Use the ESP32 microcontroller as the main control unit for processing and managing the robot's operations.
- Mount a basic camera on a servo motor to enable a panoramic view of the robot's surroundings, accessible via a web server.
- Set up a web server to allow users to control the robot remotely through a web-based interface.
- Implement an override mechanism to switch from line following to remote control mode, providing manual control of the robot's movements.
- Power the entire system using a series connection of 2 3.7V 2500mAh batteries, ensuring sufficient energy for prolonged operation.

Solutions Brainstorming:

We set out on the task of scaling down the remarkable A6 juggernaut model, aiming to strike the perfect balance between size and functionality to accommodate a portion of food. Initially, we considered 3D printing the entire model, but soon realized that crafting compartments and casings for the electronics posed a significant challenge. As a result, we opted for laser-cut wood parts, which allowed us to work with precision and creativity. Creating the scaled-down version presented some unique challenges, especially because there were no readily available dimensions online. With ingenuity and resourcefulness, we relied on a series of practical experiments and careful adjustments to achieve the desired outcome. Each step involved thoughtful trial and error, refining our design until it met our high standards. Another crucial decision we had to make was determining the number of powered wheels. Considering factors such as motor weight and battery capacity, we carefully weighed our options to ensure optimal performance and balance. Throughout this captivating journey, we encountered obstacles that tested our problem-solving skills and determination. Yet, with unwavering dedication and a collaborative spirit, we successfully crafted a scaled-down A6 juggernaut that is as functional as it is visually impressive.

Materials Used:

6 x BO Gear Motors, 10 x Wheels, 1x L298N Motor Driver, 2 x 3.7V 2500mAh Lithium Ion Batteries, 1 x Battery Holder, 2 x IR sensors, 1 x ESP32-S, Jumper Wires, White LEDs, Spray Paint

Tools/Machines Used:

ToHacksaw, Dremel, Jigsaw, Laser Cutter, 3D Printer

Skills Used:

Paper prototype, Power tools, Hand tools, Programming, Electronics, IoT, Robotics, 3D Modeling

Process:

We started by drawing some very rough diagrams on a piece of paper, taking approximate measurements. We also worked on the circuit diagram for the prototype.

Next, we designed the components in LightBurn and Fusion 360. We used MakerCase to make the finger joints for the straight pieces of wood. The diagonal pieces were a challenge, so we had to make the finger joints manually. This involved a lot of trial and error until we perfected the fit.

Meanwhile, we also put together the electronics just to test how they would function when placed inside the case.

Prototype 1

We took cardboard and roughly put together a paper prototype with tape and glue to visualize how the final product would look.

Prototype 2

We then laser cut some cardboard pieces for more accuracy. We put these pieces together while testing the finger joints. We kept replacing pieces until the joints fit correctly and the model looked to scale.

Prototype 3

We moved on to laser cutting on wood. However, we quickly realized that the manually made finger joints were too tight due to the difference in material. After adjusting this, we put together the case for the electronics. However, we then realized that the axle housing for the wheels wasn't placed properly.

Prototype 4

With all the new fixes in place, we laser cut the final pieces of wood and put together the model along with the electronics inside it.

Relevant Links:

Motor Driver Connections - ESP32 with DC Motor - Control Speed and DirectionRandom Nerd Tutorialshttps://randomnerdtutorials.com › esp32-dc-motor-l29…

3D model for reference - https://www.thingiverse.com/thing:2703964

Finger Joints from MakerCase - MakerCase - Easy Laser Cut Case DesignMakerCasehttps://en.makercase.com

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