APO-E technical documentation

Contents

1. Introduction

This project aimed to design and implement a mobile robotic platform that would be able to perform basic spatial mapping using an ultrasonic sensor. This sensor is placed on top of the mobile platform and top of a servo motor, serving as a rotating radar for detecting obstacles in the surrounding environment.

2. Components

ESP32-C6 DevKitC

The ESP32-C6 DevKitC is a development board based on the ESP32-C6 microcontroller manufactured by Espressif Systems. The microcontroller features a 32-bit RISC-V single-core CPU, integrated Wi-Fi 6, Bluetooth 5.0 Low Energy, and multiple general-purpose input/output (GPIO) interfaces. The board is supplied with standard headers and USB connectivity for programming and power. This microcontroller is used as the main processing unit of the robot.
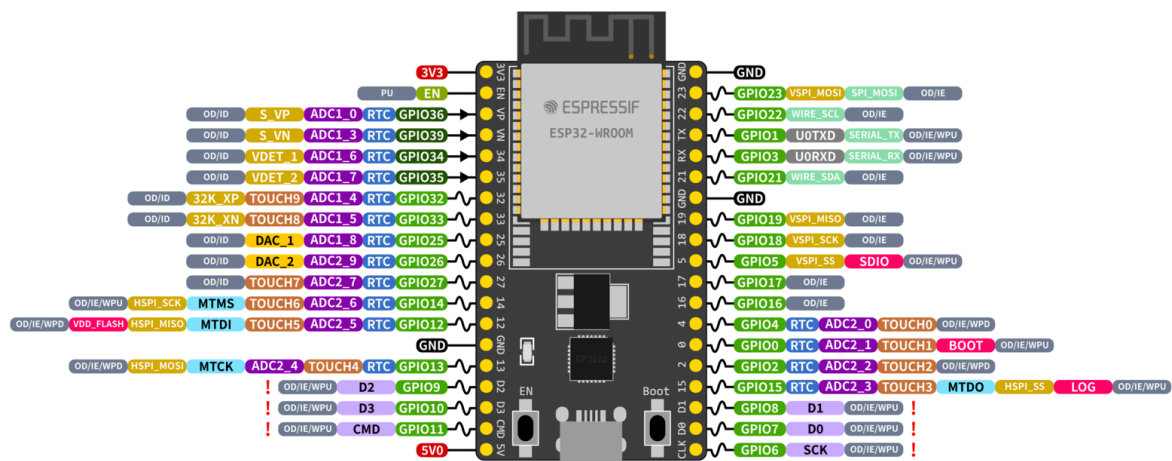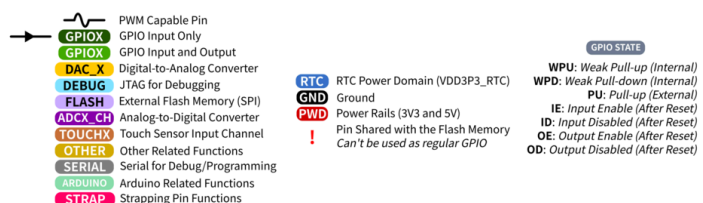
ESP32-DevKitC pins schematic (docs.espressif.com)

Motor driver TB6612FNG

The TB6612FNG is a dual H-bridge motor driver IC capable of independently controlling two DC motors. It supports bidirectional drive with speed control via pulse-width modulation (PWM).

DC motors

Two brushed DC motors are employed to provide locomotion to the platform. Each motor is connected to a wheel and independently driven via the TB6612FNG.

Ultrasonic distance sensor HC-SR04

The HC-SR04 is an ultrasonic ranging module used to measure distance to nearby obstacles. It emits a high-frequency pulse and measures the time until the echo is received, calculating the distance based on the speed of sound in the air.

Servo motor MG90S

The MG90S is a miniature servo motor capable of angular positioning. It is controlled via a PWM signal that sets the output shaft to a desired angle. The servo motor serves the purpose of rotating the ultrasonic sensor.

Power supply

The system is powered by a battery pack that utilizes 4 AA batteries, providing a 6V voltage. The voltage is controlled by a regulator to not damage other parts.

Custom 3D printed parts

To assemble the entire robot, custom-made 3D parts were used, the documentation of which can be found in the GitLab repository.
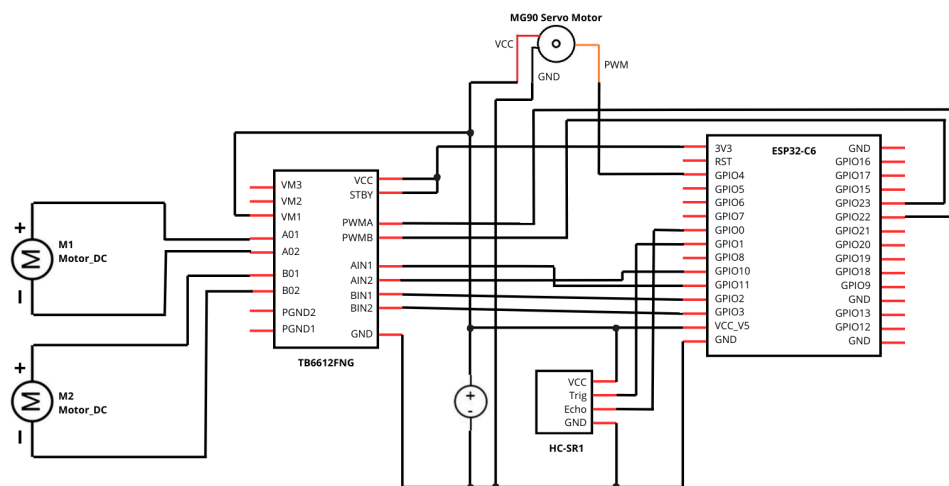
Circuit schematic of the robot wiring

3. System Architecture

The system is designed as a modular, real-time embedded platform composed of coordinated hardware and software subsystems. The primary objective is to enable a mobile unit to scan its surrounding environment, interpret distance measurements, and expose a simple interface for remote control and monitoring.

Module overview

The system architecture consists of the following core components:

apo_e_main.c
The main entry point that initializes subsystems and handles basic system execution flow.

Motor Control Module (motorcontrol.c/.h)
Interfaces with the TB6612FNG motor driver to control two DC motors. Provides functions for forward, backward, left, right, and stop operations. And a function for sending PWM signals.

Servo Control Module (servocontrol.c/.h)
Controls the SG90 servo motor to rotate the ultrasonic sensor. Provides precise angular movement necessary for scanning.

Ultrasonic Sensor Module (ultrasoniccontrol.c/.h)
Interacts with the HC-SR04 ultrasonic sensor. Measures distances using the echo time and outputs them for further processing.

Room Mapping Module (roommapping.c/.h)
Coordinates the servo and ultrasonic modules to perform a scan at multiple angles. Stores the results for mapping purposes. Can print out mapped distances and send data to the HTTP server. Has a function for conversion of the mapped data to Cartesian coordinates.

Web Server Module (webserver.c/.h)
Takes care of running the server, loads the HTML page from resources in the assets folder. Handles commands sent to the server and controls the platform movement accordingly. Can switch between auto and manual modes.