Egypt University of Informatics

ARM Mega Project

Autonomous Car

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- GitHub:

  https://github.com/rawwaann/rawwaann-eme_ARM_autonomousCar.git

- Video:

  https://drive.google.com/drive/folders/14-qgyNWPFXvsnaBeTxFLRSuQbu9dF3dW?usp=drive_link

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I. Introduction

In this team project, we present the development of an autonomous car system. This system combines basic hardware components and software algorithms to develop a dependable and efficient autonomous vehicle.

Our autonomous car is equipped with four DC motors, enabling precise control over its movement. To enhance its navigation capabilities, we have integrated two Light Dependent Resistors (LDRs), allowing the car to autonomously follow paths with higher levels of illumination. Additionally, we've implemented an ultrasonic sensor that plays a critical role in detecting objects within a 10 cm range. When an obstacle is detected, the car executes a predefined sequence, including a brief backward movement and a 90-degree rotation, ensuring obstacle avoidance.

User interaction is facilitated through a tactile switch on the TIVA C board, allowing the car's activation and providing the means to halt its operation either through a designated TIVA button press or after a predefined 60-second duration. Furthermore, the project features a user-friendly Liquid Crystal Display (LCD) that displays real-time information, including elapsed time (0 to 60 seconds) and temperature readings obtained from an onboard sensor.

To streamline the project's functionality, we have organized the core tasks into three distinct components:

- LDR-Based Navigation (Task 1): Realizing intelligent path selection based on LDR inputs.
- Obstacle Avoidance (Task 2): Efficiently navigating around obstacles using data from the ultrasonic sensor.
- Data Display (Task 3): Presenting relevant information on the LCD screen.

To efficiently manage these tasks, we have implemented a simple scheduler that switches between them non preemptively based on predefined execution intervals (tasks' periodicity). This project exemplifies the integration of hardware and software in the realm of embedded systems, showcasing the potential for creating autonomous and intelligently controlled devices.

Components used:

- TI LaunchPad Tiva C TM4C123GH6PM.
- LDR (Light Dependent Resistor) sensor.
- Ultrasonic sensor (HC-SR04).
- Internal (Die) Temperature sensor.
- RC car chassis and wheels.
- DC motors.
- L298N Motor Driver Module.
- Breadboard and jumpers.
- External batteries.

II. Sensors Overview and circuit topology

1. Ultrasonic sensor (HC-SR04):

- Overview:

  The HC-SR04 is a widely used ultrasonic sensor module designed for measuring distances accurately. It operates on the principle of emitting ultrasonic pulses and calculating the time it takes for the sound waves to bounce back after hitting an object.

Figure 1: ultrasonic sensor

- Topology:
  - Ultrasonic Transducer Pair: ultrasonic transmitter and receiver pair, which work together for distance measurement.
  - Control Circuit: The module incorporates a control circuit, often including a microcontroller, to manage the timing and operation of the sensor.
  - Power Supply: The HC-SR04 module is powered by a 5V DC power supply.
  - Trigger Pin (Trig): This is the input pin where a short 10µs pulse is applied to trigger the ultrasonic transmitter.
  - Echo Pin (Echo): This is the output pin where the module sends an echo pulse back after receiving the reflected ultrasonic waves.

2. LDR (Light Dependent Resistor) Sensor:

- Overview:

  A Light-Dependent Resistor, commonly known as an LDR or a photoresistor, is a passive electronic component that exhibits a change in resistance in response to variations in incident light levels. LDRs are widely used in applications that require light sensing, such as automatic streetlights, camera exposure control, and daylight detection.

Figure 2: LDR

- Topology:
  - LDR (Photoresistor): The core component of the circuit is the LDR itself. It's a two-terminal device with a resistance that varies with light intensity. In darkness, its resistance is high, and it decreases as light intensity increases.
  - Voltage Divider Circuit: The LDR is often used in a voltage divider circuit configuration. It is connected in series with a fixed resistor (often called a pull-up resistor) between the power supply voltage (Vcc) and ground (GND).
  - Power Supply: The circuit requires a power supply voltage (Vcc) to operate, usually in the range of 3V to 5V.

- Analog-to-Digital Converter (ADC) or Comparator (Optional): Depending on the application, you may include an ADC or a comparator to convert the analog voltage produced by the voltage divider into a digital signal or to trigger specific actions based on light levels.

3. Internal Temperature Sensor (Die Temperature Sensor):

- Overview:

The TM4C123GH6PM microcontroller includes an on-chip temperature sensor that allows you to measure the die temperature of the microcontroller itself. This temperature sensor is valuable for applications where monitoring the operating temperature is critical for ensuring proper functionality and reliability.

- Topology:
  - Microcontroller Pins: Identify the specific ADC pins on the TM4C123GH6PM microcontroller dedicated to the internal temperature sensor. Consult the microcontroller's datasheet for the pin information.
  - Power Supply: Connect the microcontroller to a suitable power supply, typically within the recommended voltage range (e.g., 3.3V).
  - Ground Connection: Connect the microcontroller's ground (GND) pin to the ground of the power supply.
  - Temperature Sensor Interface: Set up your software code to configure the ADC module to read the internal temperature sensor. You'll need to specify the correct ADC channel associated with the temperature sensor.
  - Data Processing: the microcontroller code can process the temperature data read from the sensor to calculate the actual temperature in degrees Celsius or Fahrenheit. This typically involves converting the ADC reading to a temperature value using calibration data provided in the microcontroller's documentation.
  - Output: Depending on the application, you can display the temperature data on an LCD, transmit it via communication interfaces, or use it for real-time decisions based on temperature readings. In our autonomous car we have displayed its reading on an LCD.

III. Components Layout

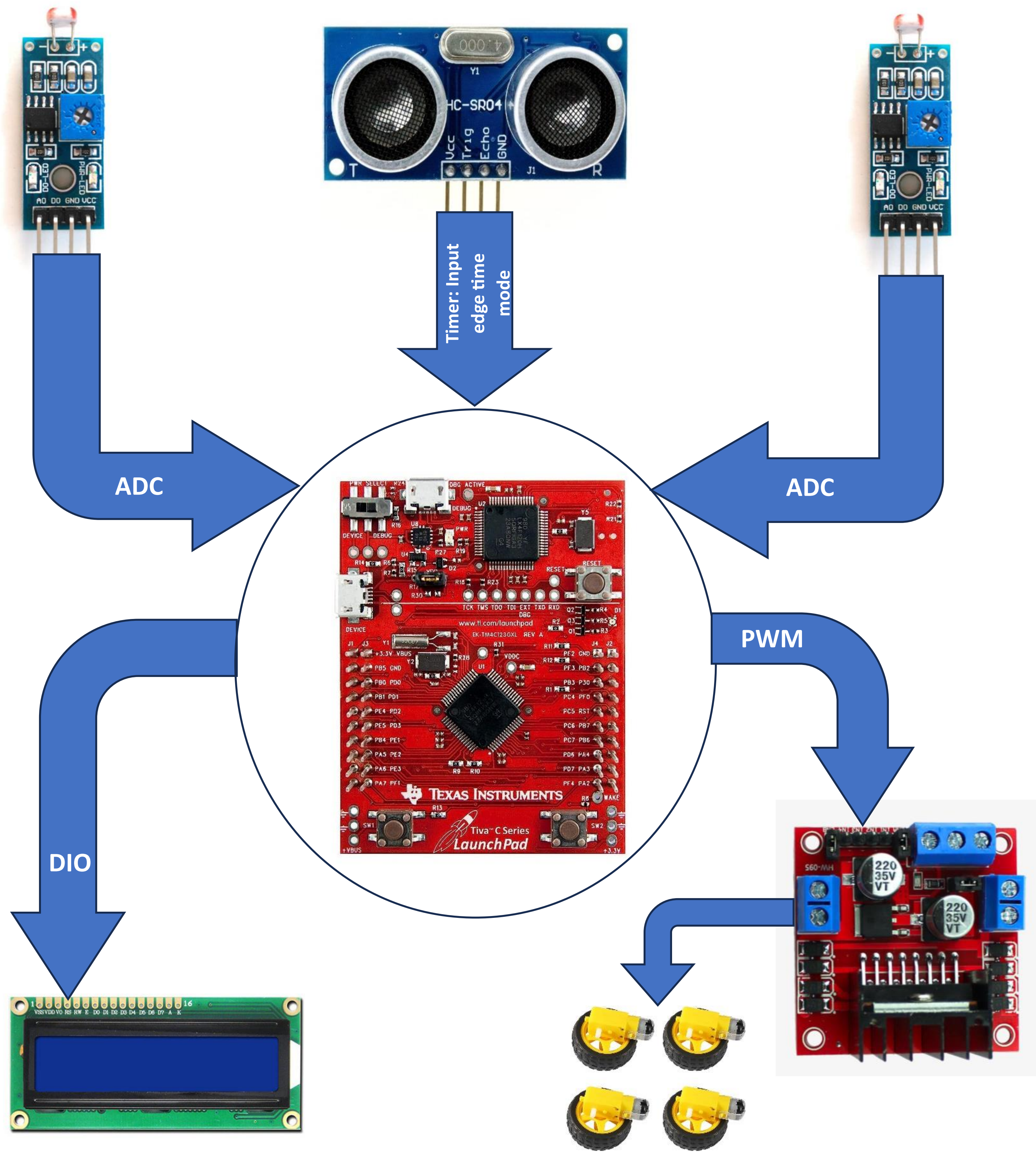

Figure 3: components layout

In our autonomous car system, meticulous attention has been given to interconnecting components for seamless functionality. Below, we present a comprehensive overview of these connections:

- DC Motors: Positioned strategically on the car chassis, four DC motors drive the vehicle's wheels, providing precise control over its movement. These motors are thoughtfully linked to the L298N Motor Driver Module, enabling sophisticated power control.

- Light Dependent Resistors (LDRs): Strategically placed to detect variations in illumination, our two LDRs interface with analog input pins on the microcontroller. Utilizing analog-to-digital conversion (ADC), they provide real-time data on light intensity.

- Ultrasonic Sensor: Mounted on the car's chassis, the ultrasonic sensor offers real-time distance measurements. It interfaces with specific GPIO pins on the microcontroller, with one pin serving as an echo input, while another generates trigger signals. The microcontroller's timer is configured in input edge time mode to detect echo rising and falling edges, facilitating precise distance calculations.

- TIVA C Microcontroller: As the central hub of our system, the TIVA C board orchestrates the seamless coordination of all components. The initiation and cessation of the car's operation are controlled via a dedicated switch on the TIVA C board. Furthermore, this microcontroller efficiently manages task scheduling, ensuring timely execution.

- Liquid Crystal Display (LCD): Connected to the microcontroller, the LCD module serves as a vital output interface. It visually displays essential information, including elapsed time and temperature readings. Data collected from various sensors is meticulously processed and presented on the screen.

- Temperature Sensor: Integrated seamlessly into the system, the temperature sensor interfaces with the microcontroller to provide accurate temperature data.

A purpose-built simple scheduler resides within the microcontroller, orchestrating the execution of three core tasks: ldr_swing_car, avoid_obstacles, and lcd_display. These tasks operate within predefined intervals, promoting efficient multitasking and enhancing overall system performance.

These well-planned connections enable our autonomous car system to effectively achieve autonomous navigation and obstacle avoidance, exemplifying the successful integration of hardware and software in our project.

IV. Features and delimitations

1. Features:

- Light-sensitive Behavior: The autonomous car exhibits adaptive behavior by dynamically adjusting its speed and direction in response to changes in ambient light conditions.
- Obstacle Avoidance: Equipped with an ultrasonic sensor, the car effectively detects obstacles in its path, allowing it to make autonomous decisions such as changing direction or stopping to prevent collisions.
- Temperature Monitoring: Real-time temperature data is captured and can be conveniently displayed on the LCD or transmitted to a remote controller for monitoring.
- User-Friendly Operation: The car's operation is initiated and halted through simple button presses on the TIVA C board, ensuring user-friendliness.
- Intelligent Scheduler: The project incorporates a straightforward simple scheduler, allowing efficient task switching based on predefined intervals (tasks' periodicity), showcasing intelligent multitasking capabilities.
- Customizable Operation: The project's codebase is open for customization, allowing for the integration of additional features or sensors as per future specific requirements.

2. Delimitations:

- Limited Processing Power: The Tiva C Series TM4C123G microcontroller, while powerful, does have finite computational capabilities. As a result, the complexity of algorithms and response times may be constrained.
- Range Limitations: The ultrasonic sensor has a defined range for obstacle detection, and the sensitivity of the LDRs is limited to variations in ambient light conditions. These limitations define the operational boundaries of the system.
- Simplicity of Design: While effective, the project maintains a simplified design to serve as a foundational platform for learning and experimentation, potentially limiting its scalability for more complex tasks.
- Single Sensor Redundancy: The project relies on a single ultrasonic sensor for obstacle detection, lacking redundancy. Sensor failure or interference may affect the car's obstacle avoidance capabilities.

V. Pseudo-code

```
if(switch0 is pressed )
{
	/*start the system*/
	g_currentTime_ms = 0
	systick_initialization();
	switch0_flag = 0
}
if(switch1 is pressed  ||  g_currentTime_ms >= 60000 )
{
	/*stop the system*/
	g_currentTime_ms = 0;
	systick_stop();
	Motor_brakes();
}
if(g_systick_newTick_flag==1)
{
	/*start the scheduler*/

	//Checking all the tasks periodicity
	if((g_currentTime_ms % tasks[i].task_periodicity)==0)
	{
		//Calling the tasks in order here
	}
	g_systick_newTick_flag =0
}
```

VI. Flowcharts

1. Scheduler:

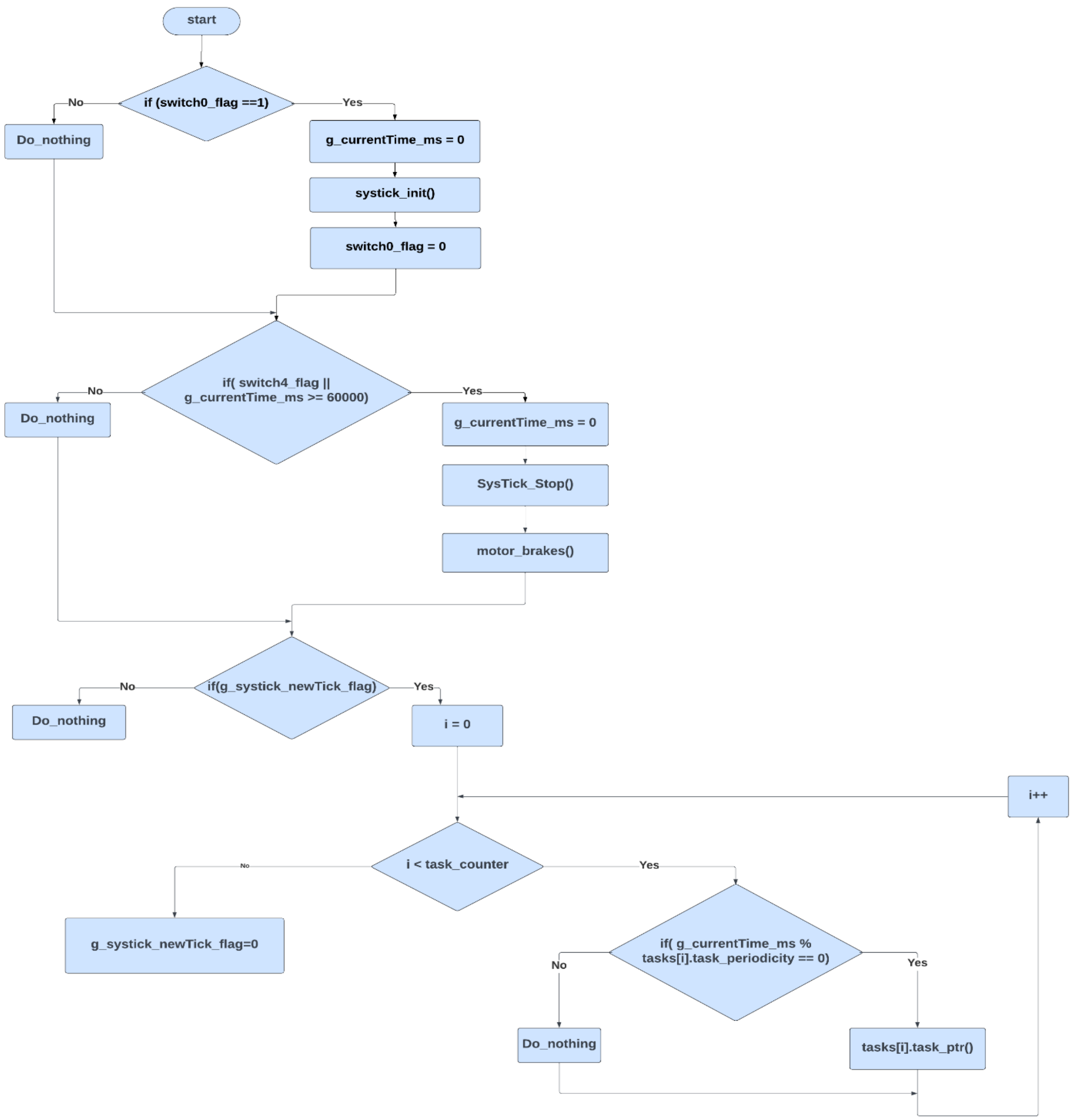

Figure 4: scheduler flowchart

2. LDR:

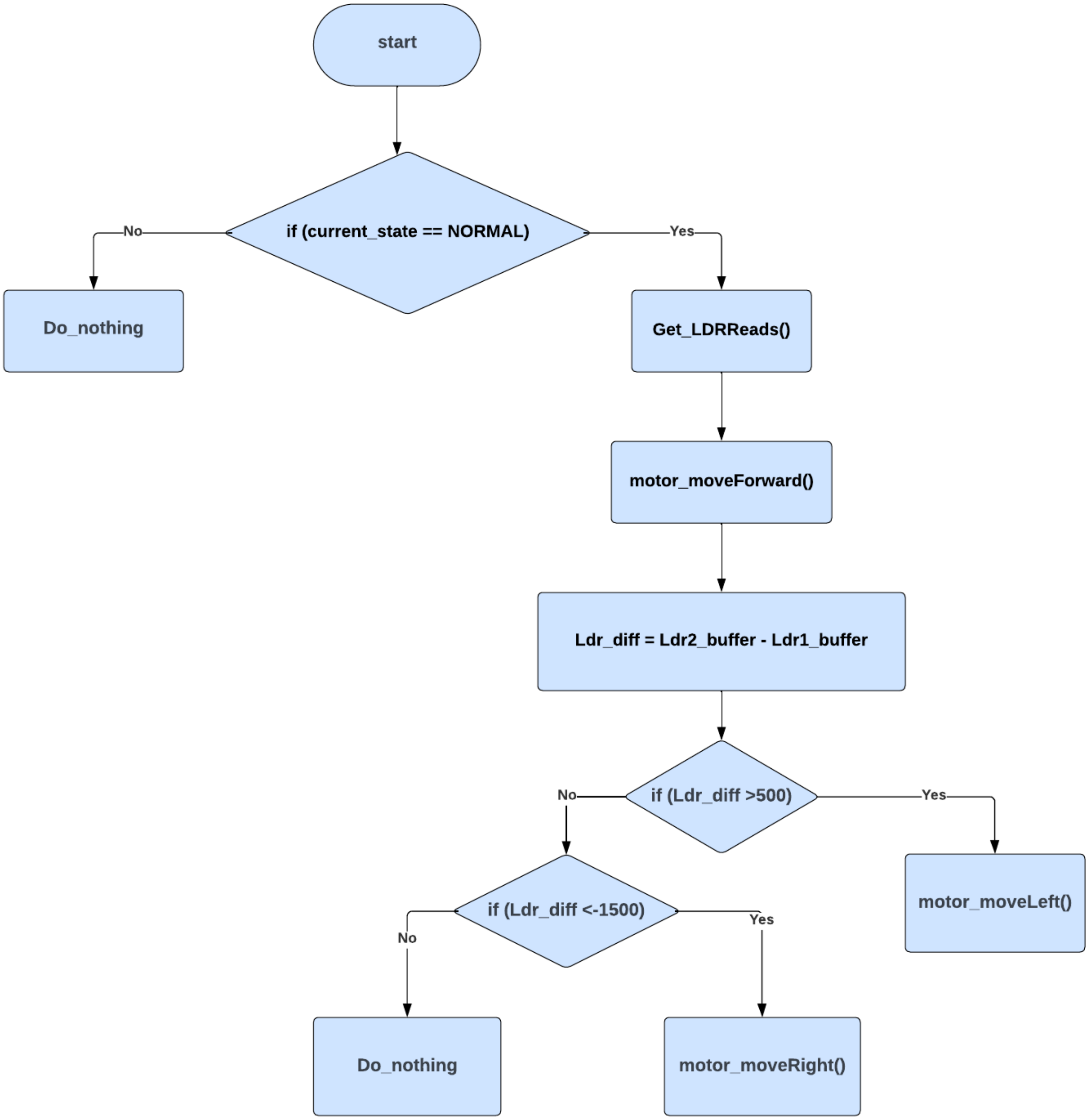

Figure 5: LDR flowchart

3. ULTRASONIC:

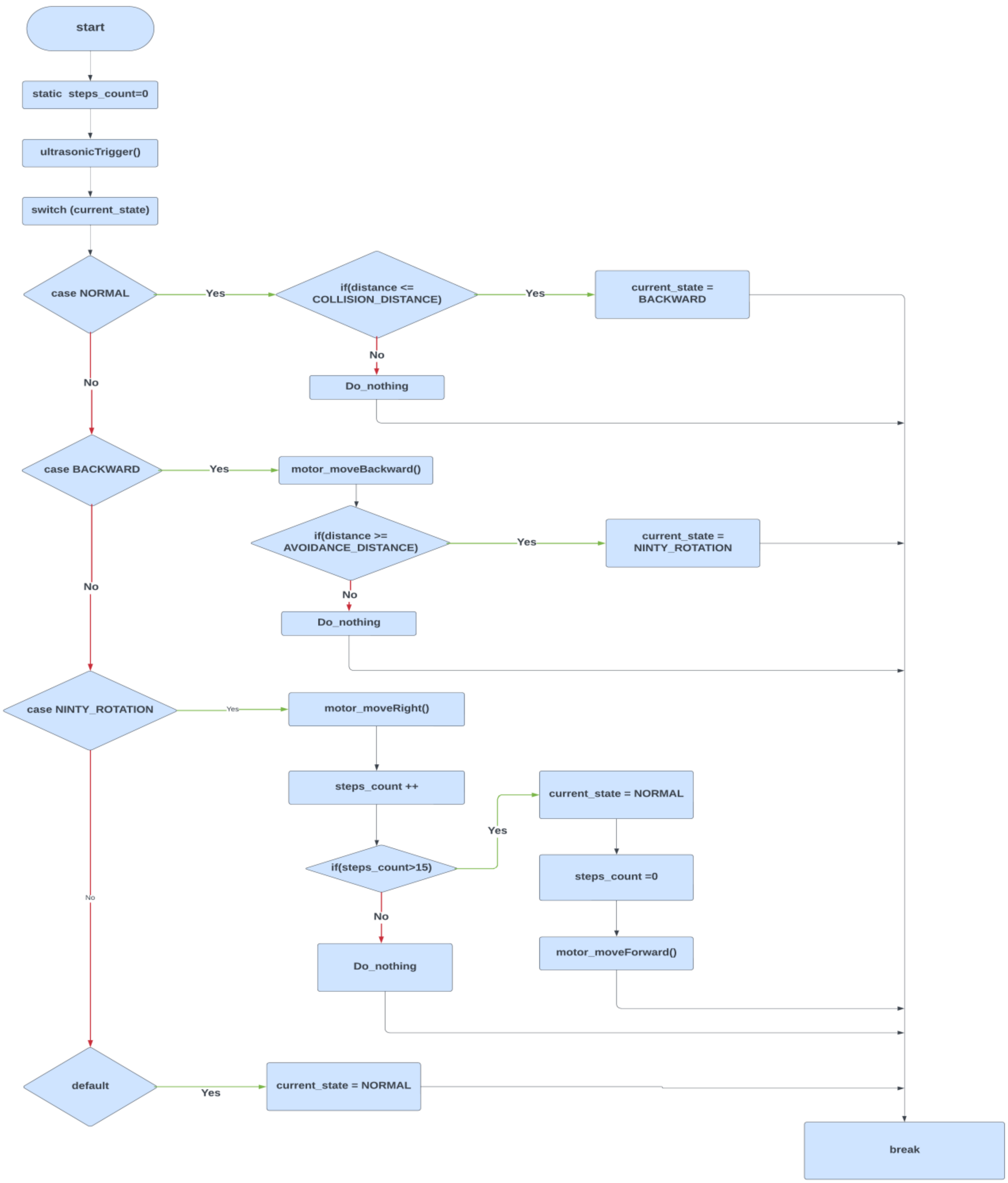

Figure 6: ultrasonic flowchart