Detailed Description of the Autonomous Navigation System

1. Initialization and Boot

The system begins with an initialization phase where all hardware components are configured. The home button pin is first set with internal pull-up resistance, allowing it to detect when the user is ready to start. The program waits indefinitely until the button is pressed, displaying the message "Press the button to start" through the serial port.

Once the button press is detected, the system waits for it to release and then enters a 2-second pause before proceeding. During this time set up:

Motor pins (ENB, IN3, IN4) for speed and steering control.

The servo motor on pin 9, positioning it at its central angle (88°).

The three ultrasonic sensors with their respective trigger and echo pins.

2. Main Operating Cycle

The program enters a continuous loop that executes the following operations every 50 milliseconds:

2.1 Status Check

First, check if the variable CareerFinished is true. If it is, it stops the engine and stays in that state indefinitely.

2.2 Sensor Reading

If the race is not over, proceed to ALWAYS read the three ultrasonic sensors:

Right sensor: Measures the distance to the right wall.

Left sensor: Measures the distance to the left wall.

Front sensor: Measures forward distance.

Each sensor takes 3 consecutive readings and calculates the average for a more reliable measurement. Invalid readings (greater than 400cm or without echo) are discarded. The entire reading process takes approximately 180ms.

3. Navigation Logic

The control logic is divided into two distinct behaviors depending on whether the vehicle has made its first turn or not:

3.1 Before the First Spin (Spin Counter = 0)

In this initial phase, the vehicle has a "confident" and simplified behavior:

Opening detection: Checks if there is an opening (distance > 100cm) to the right or left.

If it detects opening on the right:

Rotates the servo to 133° and keeps the motor moving forward for 1800ms

Set turn direction = 0 to remember to keep turning right

Reduces motor speed from 122 to 120 (post-turn fine adjustment)

If it detects opening on the left:

Rotate the servo to 33° and keep the motor moving forward for 1800ms

Set turn direction = 1 to remember to keep turning left

If it detects no openings: Just go straight WITHOUT applying any correction, keeping the servo at 88°

After any turn, apply an additional delay of 2000ms to avoid multiple detections of the same aperture.

3.2 After the First Spin (Spins counter > 0)

Once the first turn has been made, the behavior changes according to the direction set:

If turn direction = 0 (right):

Just look for openings on the right

If there is no opening, apply the proportional correction system

If turn direction = 1 (left):

Just look for openings on the left-

If there is no opening, apply the proportional correction system-

4. Proportional Correction System

This system is only activated after the first turn and when both walls are present (distance < 100cm on both sides):

Behaviour:

If you need minor adjustments:

Calculation: difference = distanceLeft – distanceRight.

If it differs > 15cm: It is closer to the right wall.

Applies soft correction to the left (68° servo).

Holds for 325ms.

If it differs < -15cm: It is closer to the left wall

Applies gentle correction to the right (servo at 105°).

Holds for 325ms.

If -15cm ≤ difference ≤ 15cm: It is sufficiently centered

Continue straight without correction.

5. Turn Control and Completion

5.1 Spin Counter

Each time the vehicle detects and takes an opening:

Increments CounterSpin

Shows by serial the turn number and direction

After each turn, wait 2000ms before continuing

5.2 Completion of the Race

When the Spins counter reaches 12 (equivalent to 3 full spins):

Displays "Last Spin Completed!"

Center the servo and move straight forward for an additional 2000ms

Completely stops the engine

Set CareerFinished = true

The program remains in a stopped state

6. Security Features

Average Readings: Reduces measurement errors

Continuous check during corrections: You can cancel a correction if you detect an opening

Post-turn delays: Avoid detecting the same opening multiple times.

Front Sensor: Adds an extra layer of safety against frontal collisions.

Timeouts on sensors: Prevents the program from freezing if a sensor fails.

7. Debug Information

The system sends continuously by serial port (115200 baud):

The three distances measured in each cycle

Opening detection

Type of correction applied (AGGRESSIVE/SOFT)

Number of turns made

Special states (start, end)