Line-Following Robot: Strategy, Assumptions, and Statechart Description

Stately link

YouTube demo video link

Strategy Used

The line-following robot operates by continuously reading sensor inputs to determine its position relative to the track. Based on the sensor readings, the robot transitions between different movement states to follow the black line. The core strategy includes:

1. **Sensor-Based Navigation**: Five sensors detect the presence of the black line and intersections.
2. **State-Based Control**: The robot transitions through predefined states based on sensor readings.
3. **Directional Movement**: The robot moves straight, left, or right depending on the detected line position.
4. **Handling Intersections**: Special states exist to handle intersections and deviations.
5. **Stopping at the End**: The robot stops when it detects the end of the track.
6. **Recovery Mechanism**: If the robot moves out of the track area, it performs a 180-degree turn to reattempt following the line.

Assumptions Made

- The robot operates on a black line on a white background.
- The five sensors provide a binary representation of the line's position.
- The motor speeds and movement durations for precise turns are predetermined based on real-world testing.
- Movement execution relies on a time-based approach for turning angles:
  - **90-degree turn**: The robot moves for a specific duration at a controlled speed to achieve a precise right-angle turn.
  - **180-degree turn**: The robot rotates for a longer duration to execute a full turnaround.
- The specific values for speed and movement duration depend on the physical characteristics of the motors and the robot's mechanical setup.
- The track doesn't have any counter-clock wise (left turning) loop.

Description of the Statechart

The robot follows a hierarchical statechart with the following main components:

1. **Idle State**

- The robot starts in the `idle` state.
- On receiving the `Start` event, it transitions to `sensorDetection`.

2. **Sensor Detection State**

- The robot reads the five sensor values.

- Based on the readings, it determines the next movement:
    - Move straight when the center sensor detects the line.
    - Turn left or right when side sensors detect deviation.
    - Special cases for intersections.
    - Stop if all sensors detect the end of the track.

3. **Movement States**

- `MoveStraight`, `MoveLeft`, `MoveRight` and `Rotate180` states correspond to respective motor actions.
- Each movement state is executed for a predefined duration before returning to sensor detection.
- Turns (90-degree and 180-degree) are performed by running the motors for a specific time at a controlled speed.

4. **Handling Out-of-Track Situations**

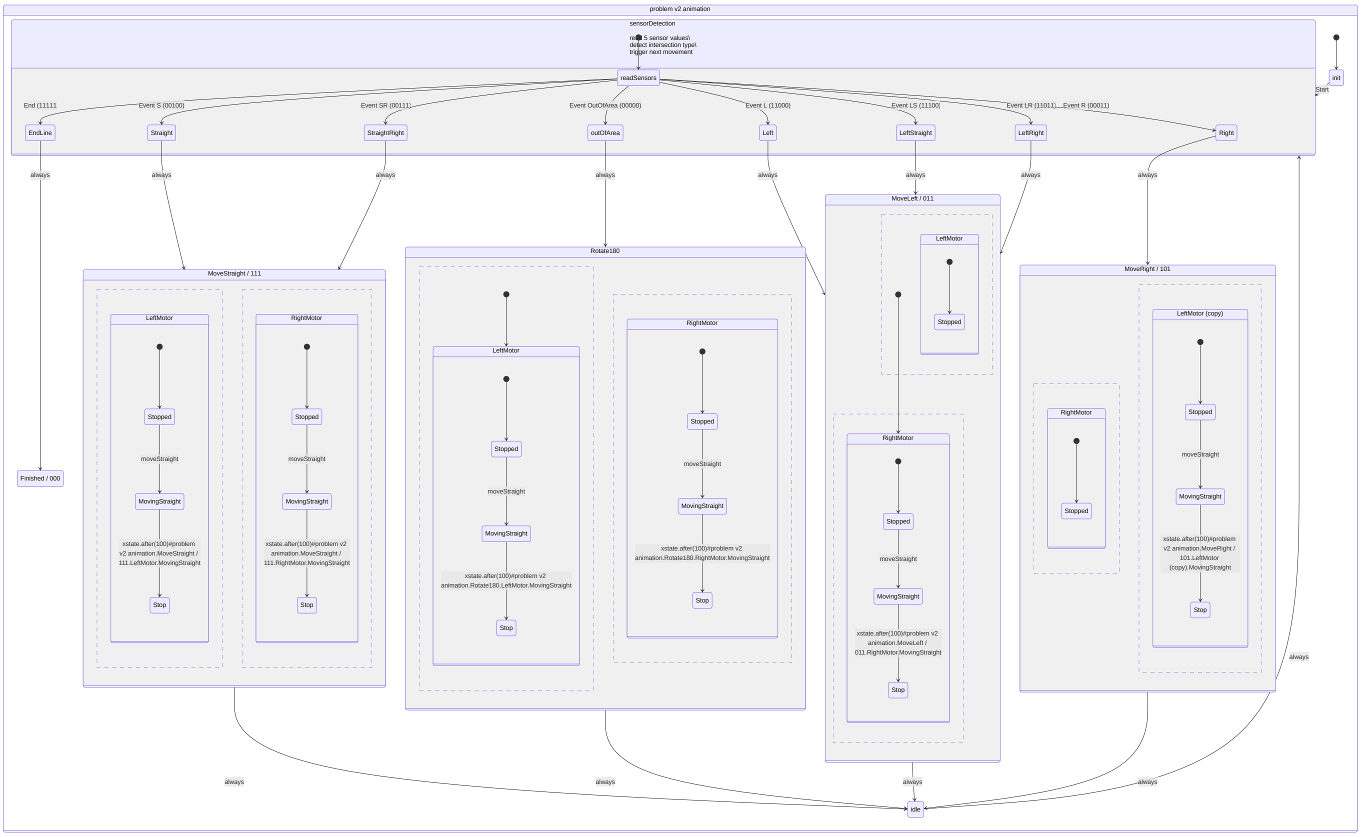
- If all sensors detect white (`00000`), the robot assumes it has left the track.
- It executes a 180-degree turn by rotating in place for a fixed duration before reattempting line following.

5. **Final State**

- When the robot detects the end of the track (`11111`), it enters the `Finished` state and stops all movement.

Input-Output Table

Sensor Input	Event Name	Intersection/Straight Type	Robot Action	Motor Output
`00100`	Event S	Straight Path	Move Straight	Both motors forward
`11000`	Event L	Only Left turn	Turn Left	Right motor forward, left motor stopped
`00011`	Event R	Only Right turn	Turn Right	Left motor forward, right motor stopped
`11011`	Event LR	Left turn or Right turn	Prioritize Left Turn	Right motor forward, left motor stopped
`11100`	Event LS	Left or straight at an intersection	Left or Straight	Depends on further detection
`00111`	Event SR	Straight or right at an intersection	Straight or Right	Depends on further detection
`11111`	End	Stop at the end of the path	Stop	Both motors stop
`00000`	OutOfArea	Rotate 180 degrees when out of area	Rotate 180 degrees	Both motors in opposite directions


problem v2 animation
sensorDetection
read 5 sensor values\
detect intersection type\
trigger next movement
readSensors
init
Start
End (11111
Event S (00100)
Event SR (00111)
Event OutOfArea (00000)
Event L (11000)
Event LS (11100)
Event LR (11011)
Event R (00011)
EndLine
Straight
StraightRight
outOfArea
Left
LeftStraight
LeftRight
Right
always
Finished / 000
MoveStraight / 111
LeftMotor
RightMotor
Stopped
moveStraight
MovingStraight
xstate.after(100)#problem v2 animation.MoveStraight / 111.LeftMotor.MovingStraight
xstate.after(100)#problem v2 animation.MoveStraight / 111.RightMotor.MovingStraight
Stop
Rotate180
xstate.after(100)#problem v2 animation.Rotate180.LeftMotor.MovingStraight
xstate.after(100)#problem v2 animation.Rotate180.RightMotor.MovingStraight
MoveLeft / 011
xstate.after(100)#problem v2 animation.MoveLeft / 011.RightMotor.MovingStraight
MoveRight / 101
LeftMotor (copy)
xstate.after(100)#problem v2 animation.MoveRight / 101.LeftMotor (copy).MovingStraight
idle

Conclusion

This report outlines the strategy, assumptions, and implementation details of the statechart used in the line-following robot. Key considerations such as sensor interpretation, movement execution, and turn timing are determined by real-world motor specifications. Future refinements could include dynamic speed adjustments for smoother navigation.