Goals 4 Submission

–DriveSystem.py

- Motor Class
  - Class: Controls one motor using two PWM GPIO pins.
  - __init__(self, io, pinA, pinB)
    - Sets up pins and initializes PWM.
  - setLevel(self, level: float)
    - Sets motor speed and direction.
  - stop(self)
    - Stops motor movement.
- DriveSystem Class
  - Class: Controls both left and right motors for movement.
  - __init__(self, io, left_pins: tuple[int, int], right_pins: tuple[int, int])
    - Creates left and right Motor objects.
  - drive(self, mode: str)
    - Drives with a named movement mode.
  - stop(self)
    - Stops both motors.

–Sense.Py

- IR Class
  - Class: Reads a single IR sensor.
  - __init__(self, io, pin: int)
    - Sets up one GPIO pin for input.
  - read(self) → int
    - Returns 1 if tape detected, 0 otherwise.
- LineSensor Class
  - Class: Reads three IR sensors as a unit.
  - __init__(self, io, pin_L: int, pin_M: int, pin_R: int)
    - Assigns pins for left, middle, right sensors.
  - read(self) → tuple[int, int, int]
    - Returns a 3-tuple of IR values.

- AngleSensor.Py
  - AngleSensor Class
    - __init__(self, io)
      - Initializes the sensor interface (e.g., pigpio, I2C).
      - Sets up internal state for heading tracking and optional offset calibration.
    - readadc(self,address):

        - Reads an 8-bit integer (0–255) from the specified ADC channel (0 or 1)
    - read_angle(self) → float
        - Computes and returns the heading angle in degrees based on scaled ADC voltages (range: –180° to +180°).

–street_behaviors.py

- Behaviors Class
    - __init__(self, io, drive, sensor, AngleSensor)
        - Initializes motor, sensor, and angle tracking interfaces. Sets time constants and state filters.
    - follow_line(self) → str
        - Follows a black tape line using IR feedback.
        - Returns "intersection" if triple detection, "end" if all sensors lose tape, or continues tracking.
    - pull_forward(self)
        - Drives forward briefly to ensure the robot fully enters an intersection before stopping.
    - turning_behavior(self, direction: str) → int
        - Executes a left or right turn using angle feedback from AngleSensor.
        - Waits to leave and re-detect the tape before stopping.
        - Returns the net turn amount in 45° steps (±1, ±2, etc).

–MapBuilding.py

- STATUS (Enum)
    - Defines the five possible states for any street direction from an intersection:
    - UNKNOWN: no information yet
    - NONEXISTENT: confirmed no street in that direction
    - UNEXPLORED: street detected but not yet driven
    - DEADEND: street ends without connecting to another intersection
    - CONNECTED: street successfully traversed in both directions
- Class Intersection
    - __init__(self, x, y)
    - Initializes all 8 directional streets from this intersection as UNKNOWN.
- PoseTracker Class
    - heading_vectors = {
    - 0: (0.0, 0.5),
    - 1: (-0.5, 0.5),
    - 2: (-0.5, 0.0),

- 3: (-0.5, -0.5),
- 4: (0.0, -0.5),
- 5: (0.5, -0.5),
- 6: (0.5, 0.0),
- 7: (0.5, 0.5)
- }
- color_map = {
- STATUS.UNKNOWN: 'black',
- STATUS.NONEXISTENT: 'lightgray',
- STATUS.UNEXPLORED: 'blue',
- STATUS.DEADEND: 'red',
- STATUS.CONNECTED: 'green'
- }

- Tracks the robot’s current (x, y, heading) pose and manages a dictionary of Intersection objects.
- __init__(self)
  - Starts the pose at (0, 0) facing north (heading 0), with an empty intersection map.
- calcmove(self)
  - Moves the robot one unit forward based on its current heading.
- calcturn(self, turn_amount: int)
  - Updates the robot's heading using 45° increments (mod 8).
- calcuturn(self)
  - Rotates the robot 180° (adds 4 to the heading).
- pose(self) → tuple[int, int, int]
  - Returns the robot’s current position and heading as a tuple.
- getintersection(self, x, y) → Intersection
  - Returns the Intersection at (x, y); creates it if it doesn't exist yet.
- show(self)
  - Uses matplotlib to draw:
    - All intersections as gray dots on a grid
    - Streets extending from each intersection, color-coded by STATUS
    - The robot’s current heading as a magenta arrow

– brain.py

- Main Script: Coordinates the robot’s logic loop by connecting sensor readings, motor commands, navigation behaviors, and map building.
- Function:
  - Continuously prompts the user for a command ("straight", "left", or "right").

        - "straight": calls follow_line() until intersection or dead end, then optionally calls pull_forward().
        - "straight" → Calls follow_line() to drive forward until it detects an "intersection" or "end".
            - If an intersection is found, it calls pull_forward() to fully enter it.
            - If an end is detected (no tape), the robot:
            - Marks the street as a DEADEND on the map.
            - Automatically performs a U-turn (left spin),
            - Drives back to the previous intersection, and
            - Updates the map to mark the return path as CONNECTED.
    - "left" or "right": calls turning_behavior() to rotate the robot by a tracked angle, then updates map heading.
    - Also Handles:
        - Map updates using PoseTracker and Intersection status logic (e.g., CONNECTED, DEADEND, UNEXPLORED, NONEXISTENT).
    - Visualization of the map at every step using PoseTracker.show().

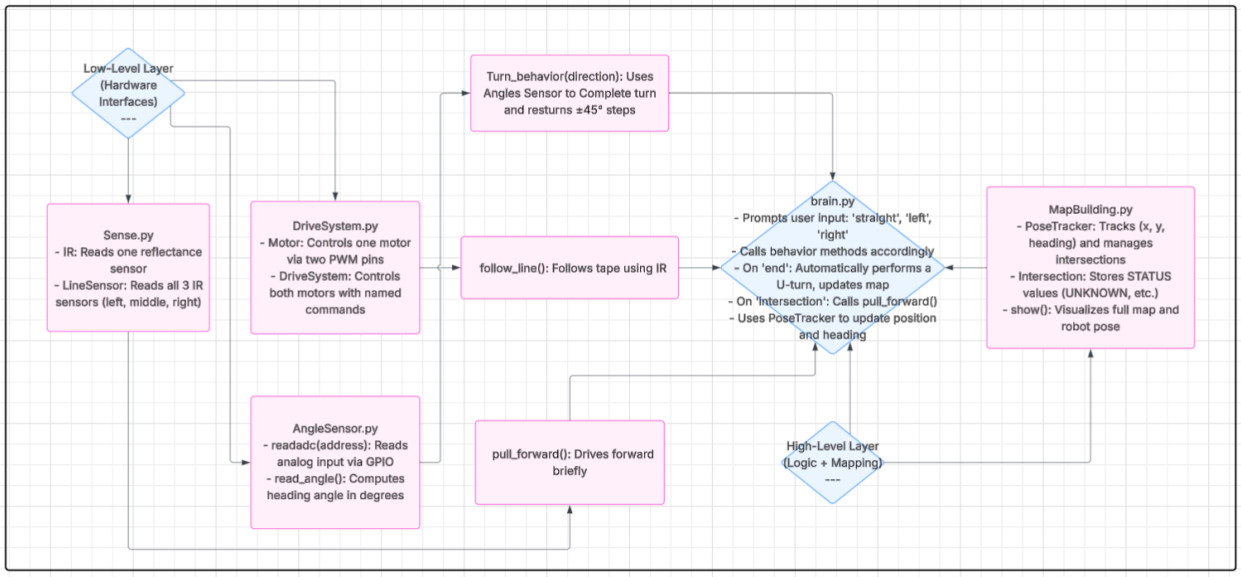
Changes made from Goals3 Content

- Made one Behaviors class instead of having separate classes for Turning_behaviors, pull_forward and line_following.
- Reset all of our filters by creating a reset filters function so that we do not face any problems when reaching a dead end and making a u turn back.
- Fine tuned turning by having the robot turn in the opposite direction after completing a turn till the IR sensors read (0,1,0)

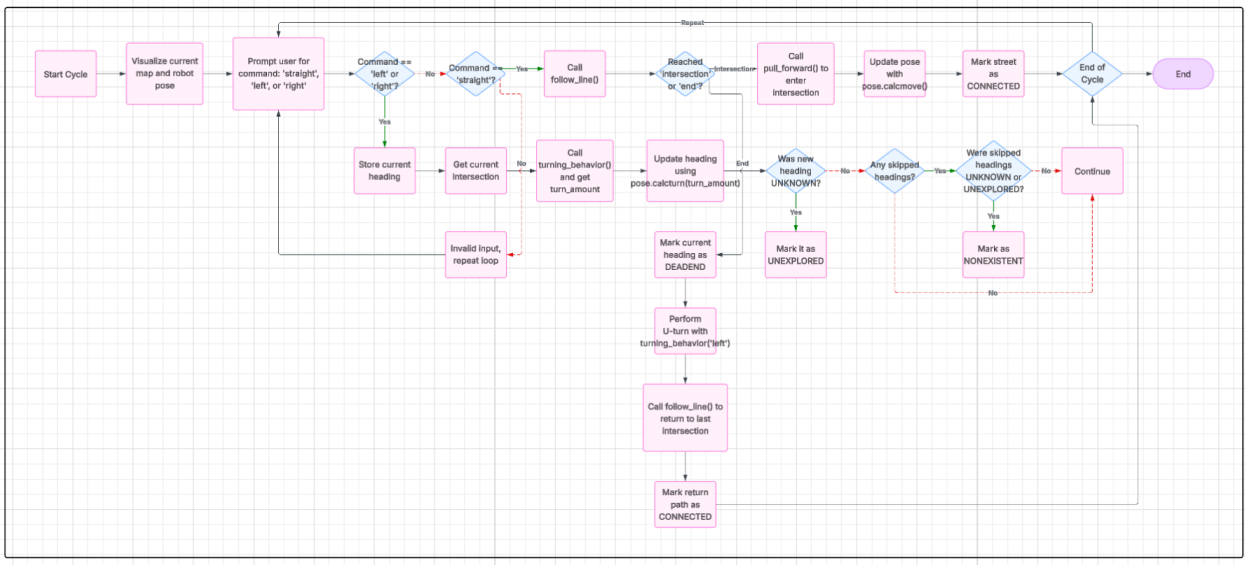
Magnetometer Testing

- Channel 0: Max = 2019, Min = 95
- Channel 1: Max = 218, Min = 85
- Bringing an Iphone 16 close to the sensor, caused the sensor readings of both channels to jump by around 50-75. When i slightly shifted the position of the iphone the magnetometers readings were extremely sensitive

Flow Chart for Code Behavior



Flow Chart for Brain Logic



(3) For the three outcomes A/B/C, how did you update the robot's (x,y,heading)? (Sect. 4.1)

Outcome A – In-Place Turn

The robot turned left or right at the intersection without translating.

- Called turning_behavior() to get the turn amount (+/- 1)
- Updated the robot's heading using pose.calcturn(turn_amount).

- The position (x, y) stays the same.

Outcome B – Straight Movement to Next Intersection
The robot followed the line and reached a new intersection.

- After reaching an intersection via follow_line(), called pose.calcmove() to update (x, y) based on current heading.
- The heading remains unchanged.

Outcome C - The robot found a dead-end, made a U-turn, and returned to the same intersection but in the opposite heading

- Marked the current heading as DEADEND.
- Called pose.calcturn(turn_amount) to perform a 180° turn.
    - where turn_amount = behaviors.turning_behavior("left")
- Waited until the robot re-crossed an intersection before calling calcmove() to update (x, y) again.

(4) how you updated the map (intersections) for the outcomes A/B/C in Sect. 5.
Outcome A – Turned in Place
The robot remained at the same intersection but changed heading.

- The robot remains at the same intersection (x, y) but changes its heading.
- No new intersection is added.
- The robot marks the new facing direction as STATUS.UNEXPLORED if not previously explored.
- Other directions that were not seen can be marked as STATUS.UNKNOWN
- No edge is added to the map since there was no movement.

Outcome B – Drove to a New Intersection
The robot moved one unit forward and reached a new intersection.

- The robot moves one unit in the direction of its current heading, arriving at a new intersection (x', y').
- A new Intersection object is created at the new position
- The previous intersection's street in the heading direction is set to STATUS.CONNECTED.
- The new intersection's street in the reverse direction is also marked STATUS.CONNECTED.
- adds an edge between the two intersections.

Outcome C – U-Turned at Dead-End
The robot reached a dead-end, U-turned, and returned to the previous intersection.

- The robot reaches a dead-end, then performs a U-turn and returns to the same intersection.
- The street it attempted to drive into is marked as STATUS.DEADEND.
- The robot's heading is reversed.
- No new intersection is added, but the map now reflects that direction as a dead end.