Autonomous Path-Following Vehicle

Project Report: ECE 3 - Introduction to Electrical Engineering

Group "Good Enough"

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1 Development Plan

Before we proceeded with our development plan, we had to verify that all of the components of the car themselves worked (especially the sensors) before proceeding with any testing of the car. Subsequently, the development plan consisted of the following steps:

1. We first decided to adjust two assumed values of K_p and K_d at a very low constant base speed between each trial depending on which point the car deviated from the track. We knew to move onto the next step in the development process when the car was able to follow the track to the end for the given K_p and K_d values at that particular base speed.
2. Next, we wanted to program the vehicle to turn around at the end of the track at a certain speed (not necessarily base speed) for a set amount of time. We knew that we could move onto the next step in the development process when the car consistently turned around fully at the end of the track and proceeded on the center of the track with little oscillation.
3. Afterwards, we planned to make slight modifications to the K_p and K_d values so the car would be able to follow the track in the reverse direction with little to no deviations. We knew that we could move onto the next step in the development process when the car was able to successfully follow the track to the end and return to the starting position.
4. We then planned to further adjust the values of K_p and K_d while increasing the car's base speed. We knew we had successfully finished the project when the car was able to follow the track to its end and back to its starting position in under 15 seconds.

2 Testing

The parameters that we controlled were the base speed of the wheels, the proportional (K_p) and derivative (K_d) gain constants of the vehicle, and the time the vehicle rotated at the end of the track. The variables that we measured but did not control were the starting position of the vehicle and the voltage of the six AA batteries, which served as its power source. The test for each step in the development process consisted of the following:

1. Starting at a low speed, we ran the car along the track and independently adjusted K_p and K_d whenever any deviations occurred so the vehicle would be able to run from one end of the track to the other with minimal oscillations on straight sections and minimal overcorrecting on turns.
2. Starting just before the turning point on the track, we concurrently adjusted the turning speed and time to ensure the vehicle fully turned around, and then ran it from the beginning of the track to check for a seamless transition from following the track to turning around.
3. Starting just before the turning point on the track we ran the vehicle until it reached the starting point on the track, slightly adjusting K_p and K_d as well as the turning time so that the return route would start with as few oscillation as possible, before running the vehicle completely down and back the track.
4. After completing a successful run, we iteratively increased the base speed of the vehicle and repeated steps 1-3 until the car could complete the track to the end in successively faster times.

3 Analysis

Link to Graphs for Data From Calibration:

https://docs.google.com/document/d/1q7xDOycTKr71xpf8w13VtP7Fg1CvWML30VOqY6Vh5Tc/edit?usp=sharing

Link to Handwritten Project Car Data:

https://docs.google.com/document/d/1dfycG63OHy2nqg4XFxTxne9rBt3_GmCxhaVH_FhJCnY/edit?usp=sharing

Link to Digital Project Car Data:

https://docs.google.com/document/d/1t8sLT3KDc0T9gWQ0vCI3IauZvMigI6QzwVxAJw9Ifig/edit?usp=sharing

- **For distance rating:**
    - 0 = car passes first straight
    - 1 = car passes first turn
    - 2 = car passes middle straight
    - 3 = car passes second turn
    - 4 = car passes last straight
    - 5 = car passes u-turn
    - 6 = car passes second turn again
    - 7 = car passes middle straight again
    - 8 = car passes first turn again
    - 9 = car passes first straight again
    - 10 = car successfully finishes running the track

Graphs for Running Car Data:

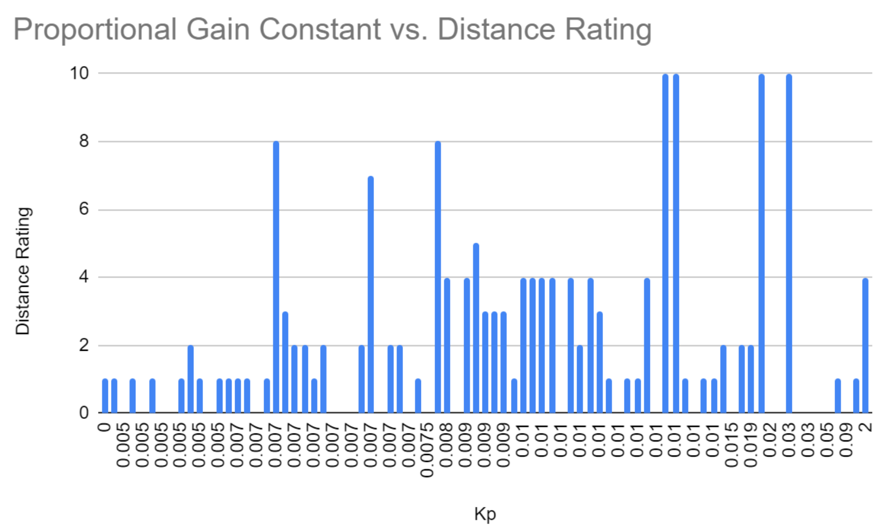

Figure 3.1: Car’s Coded K_d Value vs. its Distance Rating

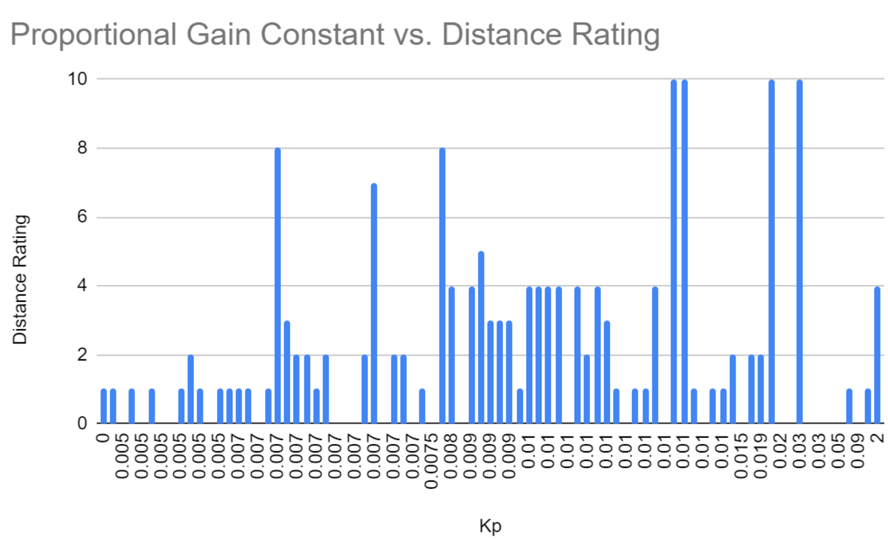

Figure 3.2: Car’s Coded K_p Value vs. its Distance Rating

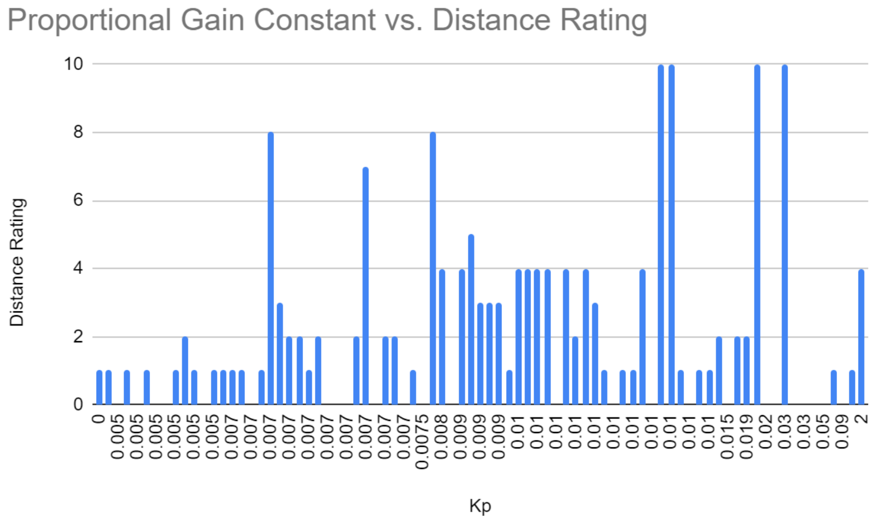

Figure 3.3: Car’s Speed vs. its Distance Rating

4 Interpretation of Data

After the calibration of the car, it appears that its derivative controller constant (K_d) is 0.18 and its proportional gain constant to be between 0.01 and 0.03 at a speed of 60 due to the testing points containing those values having the highest frequency of 10's for the distance rating (Figure 3.1). The car ran the most successfully when its voltage ranged from around 8.041 to around 8.759. However, the voltage of the car naturally decreased from 9.360 volts over time as we approached the K_d and K_p values, meaning that there is a possibility that the voltage affected the K_d and K_p values that made the car successfully complete the path (Figure 3.2). The car ran most successfully when its speed was 60 as it had more time to make error corrections (Figure 3.3). However, it should be noted that if we have adjusted the weighting of the car's sensors earlier and experimented more with the K_p values once the K_d value of 0.018 was discovered to be successful, we may have been able to find the correct K_p value that would allow us to get the car to a faster speed (Figure 3.3).

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