Task 5: Racecar Analysis

Ryan Babcock
CSCD 524: Advanced Software Engineering

Task 5 is referring a simulation that was built for a given Racecar and Racetrack model. The RacecarController holds all the tuning parameters that are used to influence the cars speed and direction variables. Along with containing tuning parameters, the RacecarController also predicts the event of an accident. This is done by actually creating clones of the racecar and controller, letting them run for a number of steps (or until a crash), and reacting accordingly.

There are different operations the controller performs based on the results from the prediction results. If it predicts a collision with a vehicle, it applies the brake. If a wall collision is near, then it brakes and turns in the direction opposite of the wall. If a wall collision is going to happen, but not suddenly, it decelerates and turns away from the wall. If there are no threats in a foreseeable future, then it accelerates and turns toward the inside wall. This method of using clones to predict the future seemed reasonable, but did not perform as well as expected.

The easiest part to solve was how to record and calculate the data. WaypointStatistics is a class that was added to the Waypoint class. The Racecar had a reference to the waypoints, and the controller had a reference to the Racecar, so recording the results could be applied easily with the then current setup.

The hardest part was figuring out what math was working and what was not. It turns out that the mathematical representations that were established were correct, and that a lot of the problems came from other places. But not having confidence in the math led to changing code that did not need to be changed. In addition, some of the math was sloppy and could be further optimized.

In version 2.0, things would be done much differently. The use of clones to predict collisions seemed like a good idea, but does not work well for this simulation. The idea was that drivers are constantly having to predict where they are going and what is going to happen further ahead with their current vehicle parameters. However, this becomes cumbersome to work with, and it is unclear for how this compares with probing methodology. Whether or not using clones is a good idea needs to be tested and refined.

The Results

The following results use the below tuning, and is an average taken over a hundred runs for 1, 5, and 10 racecars.

Parameters	Tuning Value
Delta Brake	30
Delta Speed	5
Delta Turn	6
Max Speed	60
Max Turn	8

```
========
THE RACE
========
Number of cars: 1
Total runs: 100
Total updates to finish track: 136
Average number of wrecks: 0.16


================
Entire racetrack
================
Total distance covered: 4634.279929264778
Number of wall collisions: 10
Number of car collisions: 0
Maximum speed: 60.0
Average speed: 17.352408040813618
Number of speed changes: 102
Number of braking events: 4
Number of minor steering changes: 39
Number of major steering changes: 3


============
Straightaway
============
Total distance covered: 1266.4255084795418
Number of wall collisions: 0
Number of car collisions: 0
Maximum speed: 55.0
Average speed: 14.580571478104343
Number of speed changes: 29
Number of braking events: 2
Number of minor steering changes: 12
Number of major steering changes: 0


================
Sharp narrow turn
================
Total distance covered: 1343.5080072572507
Number of wall collisions: 2
Number of car collisions: 0
Maximum speed: 35.0
Average speed: 12.9571589829513
Number of speed changes: 19
Number of braking events: 0
Number of minor steering changes: 7
Number of major steering changes: 1
```

```
==============
Narrow passage
==============
Total distance covered: 1244.6060568001112
Number of wall collisions: 6
Number of car collisions: 0
Maximum speed: 40.0
Average speed: 13.165094990237321
Number of speed changes: 30
Number of braking events: 1
Number of minor steering changes: 12
Number of major steering changes: 2


===========
Choke point
===========
Total distance covered: 528.2146633974394
Number of wall collisions: 1
Number of car collisions: 0
Maximum speed: 50.0
Average speed: 23.992088063295494
Number of speed changes: 9
Number of braking events: 0
Number of minor steering changes: 3
Number of major steering changes: 0


===============
Expansion point
===============
Total distance covered: 638.0697560483319
Number of wall collisions: 0
Number of car collisions: 0
Maximum speed: 60.0
Average speed: 47.02701830333409
Number of speed changes: 6
Number of braking events: 0
Number of minor steering changes: 1
Number of major steering changes: 0
```

```
========
THE RACE
========
Number of cars: 5
Total runs: 100
Total updates to finish track: 790
Average number of wrecks: 0.428


================
Entire racetrack
================
Total distance covered: 20600.00622799187
Number of wall collisions: 150
Number of car collisions: 83
Maximum speed: 60.0
Average speed: 17.63068043361397
Number of speed changes: 524
Number of braking events: 62
Number of minor steering changes: 182
Number of major steering changes: 31


============
Straightaway
============
Total distance covered: 6227.316789363391
Number of wall collisions: 39
Number of car collisions: 51
Maximum speed: 60.0
Average speed: 13.5891973051674
Number of speed changes: 163
Number of braking events: 25
Number of minor steering changes: 54
Number of major steering changes: 1


================
Sharp narrow turn
================
Total distance covered: 6314.575538971884
Number of wall collisions: 63
Number of car collisions: 25
Maximum speed: 35.0
Average speed: 11.572039568360827
Number of speed changes: 101
Number of braking events: 17
Number of minor steering changes: 34
Number of major steering changes: 12
```

==============
Narrow passage
==============
Total distance covered: 5189.704374836285
Number of wall collisions: 47
Number of car collisions: 13
Maximum speed: 40.0
Average speed: 12.562709028408682
Number of speed changes: 147
Number of braking events: 15
Number of minor steering changes: 55
Number of major steering changes: 16

===========
Choke point
===========
Total distance covered: 2142.0506834930247
Number of wall collisions: 6
Number of car collisions: 2
Maximum speed: 55.0
Average speed: 25.174046125766928
Number of speed changes: 41
Number of braking events: 2
Number of minor steering changes: 11
Number of major steering changes: 0

===============
Expansion point
===============
Total distance covered: 2483.943644521557
Number of wall collisions: 5
Number of car collisions: 2
Maximum speed: 60.0
Average speed: 57.79979502507514
Number of speed changes: 28
Number of braking events: 2
Number of minor steering changes: 4
Number of major steering changes: 0

```
========
THE RACE
========
Number of cars: 10
Total runs: 100
Total updates to finish track: 1759
Average number of wrecks: 0.514


================
Entire racetrack
================
Total distance covered: 38556.506780185475
Number of wall collisions: 429
Number of car collisions: 343
Maximum speed: 60.0
Average speed: 16.93512307093019
Number of speed changes: 1040
Number of braking events: 162
Number of minor steering changes: 348
Number of major steering changes: 64


============
Straightaway
============
Total distance covered: 12208.56521005727
Number of wall collisions: 143
Number of car collisions: 202
Maximum speed: 60.0
Average speed: 13.01049988114572
Number of speed changes: 347
Number of braking events: 69
Number of minor steering changes: 99
Number of major steering changes: 4


================
Sharp narrow turn
================
Total distance covered: 11966.69303401398
Number of wall collisions: 186
Number of car collisions: 94
Maximum speed: 35.0
Average speed: 10.52455773739012
Number of speed changes: 200
Number of braking events: 41
Number of minor steering changes: 68
Number of major steering changes: 23
```

==============
Narrow passage
==============
Total distance covered: 9496.61975045665
Number of wall collisions: 93
Number of car collisions: 49
Maximum speed: 45.0
Average speed: 12.161176548580007
Number of speed changes: 278
Number of braking events: 37
Number of minor steering changes: 106
Number of major steering changes: 31

===========
Choke point
===========
Total distance covered: 3901.3530011322746
Number of wall collisions: 13
Number of car collisions: 12
Maximum speed: 55.0
Average speed: 24.16845830664534
Number of speed changes: 79
Number of braking events: 7
Number of minor steering changes: 24
Number of major steering changes: 0

===============
Expansion point
===============
Total distance covered: 4496.1444344037955
Number of wall collisions: 20
Number of car collisions: 12
Maximum speed: 60.0
Average speed: 57.02755040393903
Number of speed changes: 54
Number of braking events: 5
Number of minor steering changes: 10
Number of major steering changes: 0

Metaanalysis

0 is weakest and 5 is strongest.

1. How to understand a real-world problem domain (i.e., autonomous racecar).

      4

2. How to abstract the problem into the CS solution domain.

      4

3. How to design an appropriate model.

      3

4. How to build the model.

      3

5. How to demonstrate that the model is correct (i.e., does the right thing).

      4

6. How to demonstrate that the model is safe (i.e., continues to do the right thing).

      4

7. How to demonstrate that the model is efficient (i.e., does the right thing at the most appropriate cost).

      3

8. How to reduce the search space of possible tests to a manageable number (i.e., mitigate dimensionality).

      3

9. How to present the results convincingly.

      3

10. How to make sense of the results.

      4