CSE276C-HW2-2024

Due October 31 end of day

1 Question 1

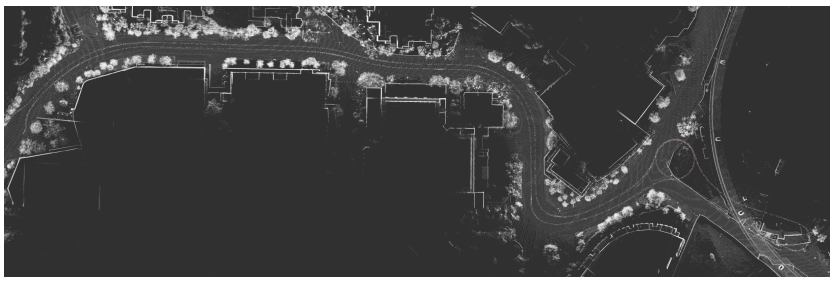

Figure 1: Waypoints recorded on Voigt Drive, The track consists of FAH → SME roundabout → trolley stop → FAH.

Robots can use interpolation to approximate intermediate datapoints they were unable to measure directly. This enables us to emulate perceiving at higher sample rates than our hardware can deliver. In this problem, you will investigate the performance of three interpolation methods in reconstructing the high-temporal-resolution trajectory of a self-driving car from waypoints gathered at increasingly lower sample rates.

The provided file `waypoints.csv` contains our ground-truth trajectory tracing out the route shown in Figure 1. The waypoints were gathered at a sample rate of 30Hz. The spatial density varies; it's as little as ≈0.1m but tends to vary a bit when the cart is driving faster.

1. Plot the ground truth trajectory.
2. Consider scenarios in which vehicle's sensors instead recorded at only 10Hz, 1Hz, and 0.2Hz. Downsample `waypoints.csv` to each sample rate to simulate the observed waypoints in each case. For each test sample rate:
   (a) Use **linear interpolation** to approximate the additional waypoints recorded at 30Hz. Plot the interpolated trajectory and report cumulative error.

(b) Use **quadratic polynomial interpolation** to approximate the additional waypoints recorded at 30Hz. Plot the interpolated trajectory and report cumulative error.

(c) Use **cubic spline interpolation** to approximate a 30Hz sample rate. Plot the interpolated trajectory and report cumulative error.

3. (1-3 sentences) Comment on the quality of your interpolated paths at each test sample rate. Under what conditions is a low sample rate most detrimental?

4. (1-3 sentences) Comment on the difference between the interpolation methods and the conditions under which each performs best. Under what conditions does their performance differ the most dramatically?

2 Question 2

We decided to build a cheap robot with no floating point unit. Suppose you need to build an interpolation table with entries of the form $(x, f(x))$ for the function $f(x) = \cos x$ over the interval $[0, \pi]$. Please use uniform spacing between points.

a. What table spacing is required to ensure 6 decimal digit accuracy, assuming that you will use linear interpolation between adjacent points in the table?

b. How fine must the spacing be if you use quadratic interpolation?

c. In each case, how many entries do you need in the table?