WORKSHEET

U12.2 Fitting a model to data

Learning, and the capstone · University · about 35 min

Name _____ Class _____ Date _____

What this lesson is about

Least squares in plain Python, and a robot that drives by the model it fitted to itself.

- The problem
- Collecting data on a robot that moves
- The dead band, and what a model is for
- Using the fit

Questions

7 marks in all

1. What does this least squares fit of speed against command print? [1 mark]

```
data = [(20, 3.1), (40, 7.4), (60, 11.2), (80, 15.3), (100, 19.0)]
n = len(data)
sx = sum(c for c, v in data)
sv = sum(v for c, v in data)
sxx = sum(c * c for c, v in data)
sxv = sum(c * v for c, v in data)
slope = (n * sxv - sx * sv) / (n * sxx - sx * sx)
intercept = (sv - slope * sx) / n
print(round(slope, 4), round(intercept, 3))
```

2. A fit gives v = 0.2 c - 0.8. How many seconds should the robot drive at command 60 to cover 80 cm open loop? Give 2 decimal places. [1 mark]

3. Speeds are read 0.2 s after each command change. Why is that worse than random noise? [1 mark]

- ☐ **A** Every reading is taken on the ramp and is low by the same fraction, so the slope comes out quietly wrong
- ☐ **B** The readings become too noisy to average
- ☐ **C** The intercept becomes exactly zero
- ☐ **D** The fit fails to converge

4. What does taking (forward - backward) / 2 at each command achieve? [1 mark]

- ☐ **A** It cancels any fixed offset in the sensor and reduces the noise, and the robot ends where it began
- ☐ **B** It doubles the speed range of the sweep
- ☐ **C** It removes the drive's dead band
- ☐ **D** It corrects the flow sensor's scale factor

5. A straight line is fitted to commands from 5 to 100, including the region below 15 where the drive does not move. What is the sensible response? [1 mark]

- ☐ **A** Restrict the fit to where the model applies and state that domain, or use a model with a dead band in it
- ☐ **B** Keep all the points, because more data always gives a better fit
- ☐ **C** Force the intercept to zero
- ☐ **D** Fit a degree 5 polynomial to follow the bend

6. A proportional heading correction asks for 8 percent turn during the sweep, and the robot slowly turns anyway. Why? [1 mark]

- ☐ **A** 8 percent is below the 15 percent dead band, so the correction does nothing; it needs a minimum magnitude above it
- ☐ **B** The gyro is not being read
- ☐ **C** The correction has the wrong sign
- ☐ **D** Heading has no effect on flow readings

7. Driving for D / v open loop lands close to D despite the 0.25 s lag. Why? [1 mark]

- ☐ **A** The robot loses about v tau of travel while speeding up and gains about the same coasting after the stop
- ☐ **B** The lag only affects turning
- ☐ **C** The flow sensor corrects the distance during the run
- ☐ **D** The fit's intercept absorbs the lag

The task: fit the drive

Sweep the command, fit speed against command by least squares, print `slope:` and `intercept:`, then use the fit to drive 80 cm open loop and stop there.

```
from bugbot import *
connect()

DT = 0.1
COMMANDS = [20, 30, 40, 50, 60, 70, 80, 90, 100]
TARGET = 80.0
```

Plan your program here, then type it in and press Run.

Do it on the robot

www.bugbotlab.com/learn/u12-2-fitting-a-model/

The simulator checks it and tells you when it passes. Nothing to install, no account.

Challenges

1. Fit the lateral axis as well. Is the slope the same as forward, and should it be?
2. Fit with the command 20 point included and excluded. How much does the intercept move?
3. Work out, from the residuals, how far off your 80 cm drive should be expected to land, and compare with where it landed.