WORKSHEET

U6.1 Two sources, one state

BugBotLab

State estimation · University · about 25 min

Name _____ Class _____ Date _____

What this lesson is about

A signal that drifts and a signal that is noisy, and why either alone is worse than both.

- The complementary filter
- Choosing a
- Wrapping
- Seeing all three

Questions

6 marks in all

1. A complementary filter uses a = 0.98 and dt = 0.1 s. What is its time constant in seconds? [1 mark]

2. Blending 359 degrees with 1 degree, first naively and then with the wrap. What does it print? [1 mark]

```
mine, fused = 359.0, 1.0
print((mine + fused) / 2)
f = fused
while f - mine > 180:
    f -= 360
while mine - f > 180:
    f += 360
print(f, ((mine + f) / 2) % 360)
```

3. Two ticks of the complementary filter. What does it print? [1 mark]

```
A, DT = 0.98, 0.1
mine = 90.0
for rate, fused in ((10.0, 95.0), (10.0, 96.0)):
    mine = A * (mine + rate * DT) + (1 - A) * fused
    print(round(mine, 3))
```

4. The filter is run with a = 0.7. What goes wrong? [1 mark]

- ☐ **A** The noise on the fused heading comes straight through
- ☐ **B** Gyro drift is never corrected
- ☐ **C** The heading wraps at 180
- ☐ **D** The filter becomes unstable and diverges

5. Which statements about the two heading sources are correct? [1 mark]

Tick every answer that is true.

- ☐ **A** The integrated gyro is smooth but drifts without limit
- ☐ **B** imu()[0] is noisy but does not run away
- ☐ **C** The integrated gyro is noisy but does not drift
- ☐ **D** imu()[0] is smooth but drifts without limit

6. In frequency terms, what does the complementary filter do to each source? [1 mark]

- ☐ **A** High pass on the gyro, low pass on the absolute heading, summing to unity gain
- ☐ **B** Low pass on the gyro, high pass on the absolute heading
- ☐ **C** Low pass on both
- ☐ **D** A band pass on the gyro only

The task: a complementary filter

Turn the robot about, running a complementary filter on the heading, plotting `gyro`, `fused` and `mine`, and print `my heading:` at the end. `heading()` is the truth and is not allowed, so plot the three headings themselves. They will lie almost on top of each other, which is expected: they differ by a few degrees on a chart that runs to 360.

```
from bugbot import *
connect()

DT = 0.1
A = 0.98
mine = imu()[0]
```

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

Do it on the robot

www.bugbotlab.com/learn/u6-1-two-sources/

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

Challenges

1. Run it at `a = 0.7` and `a = 0.999` and describe both failures.
2. Remove the wrapping and turn the robot through north. What happens?
3. Compare your estimate with `heading()` afterwards. Which is better, yours or `imu()[0]` alone?