WORKSHEET

U4.1 A reading is a distribution

BugBotLab

Noise and filtering · University · about 25 min

Name _____ Class _____ Date _____

What this lesson is about

Mean, standard deviation, and what one number from a sensor is actually telling you.

- Two numbers describe it
- Measuring it
- Bias against noise, again
- A new reading only arrives so often

Questions

6 marks in all

1. A still robot's depth readings have mean 57.0 cm and standard deviation 2.0 cm, and are Gaussian. About what fraction of readings land between 55 and 59 cm? [1 mark]

- ☐ **A** About 68 percent
- ☐ **B** About 95 percent
- ☐ **C** About 50 percent
- ☐ **D** About 99.7 percent

2. Same sensor: mean 57.0 cm, sigma 2.0 cm. About what percentage of readings fall outside 51 to 63 cm? Give a percentage to one decimal place. [1 mark]

3. This computes the mean and sigma exactly as the lesson does. What does it print? [1 mark]

```
readings = [56, 58, 60, 62, 64]
mean = sum(readings) / len(readings)
var = sum((r - mean) ** 2 for r in readings) / len(readings)
sigma = var ** 0.5
print(mean, var, round(sigma, 2))
```

4. A sensor gives readings with sigma 0.3 cm, but their mean is 4 cm short of a tape-measured distance. What will fix it? [1 mark]

- ☐ **A** Calibrate against the tape measure
- ☐ **B** Average more readings
- ☐ **C** Use a stronger low pass filter
- ☐ **D** Take the readings further apart in time

5. A student reads the depth sensor 100 times in a tight loop with no wait and gets sigma = 0.4 cm, much smaller than with a 0.1 s wait. Why is that number a lie? [1 mark]

- ☐ **A** The sensor only produces a new measurement about every 0.1 s, so most reads repeat the same sample
- ☐ **B** Reading quickly lets the sensor warm up and become more precise
- ☐ **C** The variance should have been divided by 99, not 100
- ☐ **D** Sigma is the square of the variance, so it was computed wrongly

6. A reading's spread is described by its standard deviation. What is the name of its square, measured in squared units? [1 mark]

The task: measure the noise

Standing still, print `mean:` and `sigma:` for this sensor, in centimetres.

```
from bugbot import *
connect()

readings = []
```

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

Do it on the robot

www.bugbotlab.com/learn/u4-1-a-reading-is-a-distribution/

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

Challenges

1. Print how many readings fall within one, two and three sigma. Is it 68, 95, 99.7?
2. Change the robot's distance from the wall and measure sigma again. Does the noise grow with range?
3. Read the sensor a hundred times with no wait at all. What is sigma now, and why is it a lie?