Smart Sensors for IoT

Exercise 2 (27.09.2023)

Christian Enz

Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland

Problem 1 Error comparison

A given sensor has a specified linearity error ε_1 of 1% of the reading plus 0.1% ($\varepsilon_{\text{FSO},1}$) of the full-scale output (FSO), which represents a systematic error. A second sensor having the same measurement range has a specified error ε_2 of 0.5% of the reading plus $\varepsilon_{\text{FSO},2}$ = 0.2% FSO (systematic error).

- For what range of values is the first sensor more accurate than the second one?
- If the second sensor had a measurement range twice that of the first one, for what range of values would it be the more accurate?

Problem 2 Systematic errors

In order to measure the drop in voltage across a resistor, we consider two alternative methods: (1) Use a voltmeter, whose accuracy is about 0.1% of the reading. (2) Use an ammeter, whose accuracy is also about 0.1% of the reading and apply Ohm's law.

- If the resistor has 0.1% tolerance, which method is more accurate?

Recall about accuracy and precision

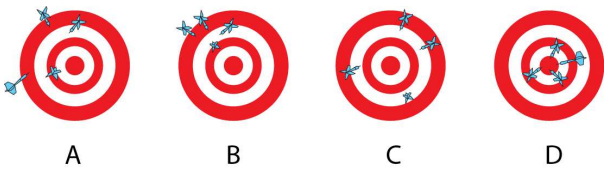

Figure 1: Dartboards showing different accuracy and precision scenarios.

A classic way of demonstrating the difference between precision and accuracy is with a dartboard. Think of the bulls-eye (center) of a dartboard as the true value. The closer darts land to the bulls-eye, the more accurate they are.

- If the darts are neither close to the bulls-eye, nor close to each other, there is neither accuracy, nor precision (Fig. 1A).

- If all of the darts land very close together, but far from the bulls-eye, there is precision, but not accuracy (Fig. 1B).
- If the darts are all about an equal distance from and spaced equally around the bulls-eye there is mathematical accuracy because the average of the darts is in the bulls-eye. This represents data that is accurate, but not precise (Fig. 1C). However, if you were actually playing darts this would not count as a bulls-eye!
- If the darts land close to the bulls-eye and close together, there is both accuracy and precision (Fig. 1D).

Multiple Choice Questions

Select **one** answer for each of the questions below.

1. A student is asked to count the number of sensors in several arrays. On the specifications, it says that each array has 100 sensors. The student counts 100 of them on the first array; the other arrays either have too many or too few.

   How would you describe the array of sensors with 100 sensors inside?

   (a) Neither accurate nor precise.

   (b) Both accurate and precise.

   (c) Accurate, but the precision cannot be determined.

   (d) Precise, but not accurate.

   (e) Accurate, but not precise.

2. A student's scale measures the mass of objects as consistently 2 kg less than their actual mass. How would you describe the scale?

   (a) It is precise, but not accurate.

   (b) It is accurate, but not precise.

   (c) It is neither accurate nor precise.

   (d) Accuracy and precision are synonyms.

   (e) It is both accurate and precise.

3. An brand of thin copper wires claims that each wire has a mass of 25.5 g. After weighing three wires, a student observes the masses to be 25.5 g, 25.6 g, and 26.1 g.

   How can the student describe the accuracy and precision of the first wire he measured?

   (a) Accurate, but not precise.

   (b) Neither accurate nor precise.

   (c) There are insufficient data points to draw a conclusion.

   (d) Accurate and precise.

   (e) Precise, but not accurate.

4. Which of these is an example of high precision?

   (a) An archer hits the bulls-eye.

   (b) A student correctly calculates the acceleration due to gravity to be 9.8 m/s^2

   (c) An archer hits the same spot on the target three times in a row.

   (d) A student tries to throw a pencil into the garbage can and makes it in.

   (e) A student correctly calculates the mass of an object to be 54 kg.