

Today, we will:

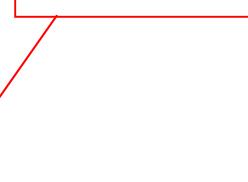
- Do example problems – hypothesis test with two independent samples
- Review the pdf module: **Digital Data Acquisition**, and do some example problems

Example: Hypothesis testing

Given: [Continuation of previous example] We buy a gadget that is supposed to increase the gas mileage of our car. We take 6 trips *without* the gadget and 8 trips *with* the gadget. We do not attempt to pair up the tests. The results:

x_A (mpg without gadget)	x_B (mpg with gadget)
25.6	26.2
27.3	27.1
24.2	24.1
28.7	29.2
23.6	24.5
25.1	24.9
	26.5
	25.8

We ran 2 more tests with the gadget installed



To do: Determine if there is a statistically significant improvement (increase) in gas mileage.

Solution:

We did this problem “by hand” in the previous lecture. Today I will show you how to do it in Excel, using the built-in macro.

Summary of the “by hand” procedure— see previous lecture notes for details:

1. Calculate the critical t statistic using equation in notes. Get $t = -0.2941$.
2. Calculate df from Welch’s equation. Get $df = 10$.
3. For these values of t and df, one tail, calculate or look up the p -value. Get $p = 0.3873$.
4. The final conclusion is that we are 61.3% confident that the gadget increases our gas mileage.
5. Since $61.3\% < 95\%$, we cannot accept the claim (to standard engineering confidence level) that this gadget increases our gas mileage.

In practice, since these kinds of problems are very common, there is an Excel macro to do all the calculations for us. Click on: Data-Data Analysis-t-Test: Two-Sample Assuming Unequal Variances.

See Excel spreadsheet on website: [Two_samples_t_test_different_n.xls](#)

[I also do this problem in Matlab – see website for Matlab file.]

See another example Excel file, posted on course website (compare final scores in a course).

Example: Digital data acquisition

Given: The integer 18 (base 10).

To do: Write this integer in 8-bit binary format.

Solution:

$$\begin{array}{rcl} \text{VALUE / 2} & = & \text{INTEGER} + \text{REMAINDER} \\ 18 / 2 = 9 + 0/2 \rightarrow 9 & & \\ 9 / 2 = 4 + 1/2 \rightarrow 4 & & \\ 4 / 2 = 2 + 0/2 \rightarrow 2 & & \\ 2 / 2 = 1 + 0/2 \rightarrow 1 & & \\ 1 / 2 = 0 + 1/2 \rightarrow 0 & & \\ & & \text{Stop @ } 0 \end{array}$$

Read up from bottom
ANSWER:
1 0 0 1 0,
but in 8-bit,
add leading
zeros:

128	64	32	16	8	4	2	1
0	0	0	1	0	0	1	0

ANSWER

Verify: $16 + 2 = 18 \checkmark$

Example: Digital data acquisition

Given: The integer 0010 0110 (8-bit binary).

To do: Write this integer in base 10 format.

Solution:

128	64	32	16	8	4	2	1
0	0	1	0	0	1	1	0

Add: $\rightarrow 32 + 4 + 2 = 38$

38

Example: Digital data acquisition

Given: Two integers in 8-bit binary format: $A = 0010 0110$ and $B = 1000 0100$.

To do: Add $A + B$ and write the result in base 10 format and in binary format.

Solution:

You can convert first, then add in base 10:

$$A = 38, \quad B = 132 \rightarrow A + B = 170 \quad \rightarrow \text{convert to binary using above procedure.}$$

OR, stay in binary; add directly:

$$\begin{array}{r}
 0010\ 0110 \\
 +1000\ 0100 \\
 \hline
 1010\ 1010
 \end{array}$$

Verify: $128 + 32 + 8 + 2 = 170 \checkmark$

Get 1010 1010

1010 1010 ✓

Example: Digital data acquisition

Given: A voltage signal ranges from -1.2 to 1.4 volts. A digital data acquisition system is to be chosen – four choices are available:

- (a) 12-bit A/D range = -10 to 10 V
- (b) 8-bit A/D range = -2 to 2 V
- (c) 10-bit A/D range = -5 to 5 V
- (d) ~~X~~ 14-bit A/D range = -1 to 1 V

To/Do: Determine which system is the best choice for this application, assuming that cost is irrelevant (all four are available in the lab).

Solution:

• Throw out (d) right off the bat – will clip!

(-1 to 1 V is too limited of a range, since signal ranges from -1.2 to 1.4 volt → will clip)

• Calculate quantizing (quantization) error for the other 3:

$$(a) \text{ quantization error} = \pm 0.5 \frac{V_{\max} - V_{\min}}{2^N} = \pm 0.5 \frac{10 - (-10)}{2^{12}} = \underline{\pm 0.00244 \text{ V}}$$

$$(b) \quad " \quad " = \pm 0.5 \frac{2 - (-2)}{2^8} = \underline{\pm 0.00781 \text{ V}}$$

$$(c) \quad " \quad " = \pm 0.5 \frac{5 - (-5)}{2^{10}} = \underline{\pm 0.00488 \text{ V}}$$

Smallest quantizing error is best, provided there is no clipping. So,

here, DAQ system (a) is the best choice.

Best resolution w/o clipping

[DAQ (a) has the best resolution, but it would clip]