EECS 16A   Designing Information Devices and Systems I
Fall 2022   Discussion 14B

1. Polynomial Fitting

Let's try an example. Say we know that the output, y, is a quartic polynomial in x. This means that we know that y and x are related as follows:

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4$$

We're also given the following observations:

x	y
0.0	24.0
0.5	6.61
1.0	0.0
1.5	−0.95
2.0	0.07
2.5	0.73
3.0	−0.12
3.5	−0.83
4.0	−0.04
4.5	6.42

(a) What are the unknowns in this question?

(b) Can you write an equation corresponding to the first observation (x_0, y_0), in terms of a_0, a_1, a_2, a_3, and a_4? What does this equation look like? Is it linear in the unknowns?

(c) Now, write a system of equations in terms of a_0, a_1, a_2, a_3, and a_4 using *all of the observations*.

(d) Finally, solve for a_0, a_1, a_2, a_3, and a_4 using IPython or any method you like. You have now found the quartic polynomial that best fits the data!

(e) What if we didn't know the degree of the polynomial? Use the IPython Notebook to explore what happens when we choose a polynomial degree other 4 and explain what you see.

(f) OPTIONAL: Play around with what happens when you add more noise to the data or if you decide to drop data points on the IPython Notebook. Additionally, explore what you see when you change the degree of the polynomial alongside these factors.

2. Identifying satellites and their delays

We are given the following two signals, $\vec{s_1}$ and $\vec{s_2}$ respectively, that are signatures for two satellites. Your cell phone recieves signals from these two satellites and given a recieved signal $r[n]$ you can identify which, if any, satellite sent the message based on their personal codes.
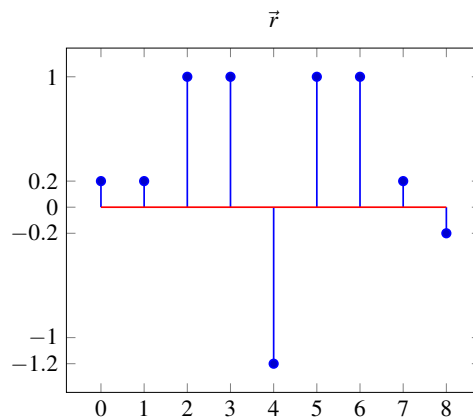
(a) Your cellphone antenna receives the following signal $r[n]$. You know that there may be some noise present in $r[n]$ in addition to the transmission from the satellite.

By computing the cross-correlations, can you identify which satellite(s) most likely sent the signal, and by what shift the code is identified relative to our received signal? You can use iPython to compute the cross-correlation. When using iPython to plot, think about the range of shifts k that we are interested in plotting based on the lengths of the signals.

(b) Now your cellphone receives a new signal $r[n]$ as below. Can you identify which satellite(s) most likely sent the signal, and by what shift the code is identified relative to our received signal?