**MATLAB exercise**

Estimation of a random process with an FIR filter.

**Part 1:** Pencil and paper. Consider the following system:

d[n]

s[n] r[n] s\_hat[n]

c[n]

h[n]

⊕

We wish to design a filter h[n] to estimate s[n] from r[n] such that s\_hat[n] is an MMSE estimate.

Assume that s[n] is an i.i.d processes which takes value +/-1 with equal probability for each sample. d[n] is a white, Gaussian noise process with variance σ2 . c[n] is an FIR filter with impulse response of [1, 0.5, 0.3 ];

Find an expression for Rsr[n] and Rrr[n]. Rsr[n] is the cross-correlation of the observations R[n] an Rrr[n] is the auto-correlation of the observations.

Set up and solve the normal equations (9.55 or 11.11 from the MIT notes) for N = 4. (Note that N is the length of the FIR filter h[n], not c[n]

**Part 2:** MATLAB

MMSE estimation: Simulate the system for filters of length N = 1, 2 and 4. Note these systems should be simulated with the theoretically calculated correlations (not empirically found). You may use MATLAB to compute the necessary correlations and filter coefficients, but you should not use the XCORR function. Report the MSE of your results in a table. The MSE should go down as N increases. If it does not, you did something wrong. Start with a variance of .01, feel free to experiment with other values. Also produce a scatter plot of your data points before the channel, after the channel + noise, and then after applying the equalization filter you designed.

**Stretch goal #1, 1 point:** Compute the theoretical MSE for the 3 systems and compare against your results.

**Stretch goal # 2, 1 point:** Use empirically estimated correlations from the XCORR function, and compare them to your results.