AV332: Digital Communication Lab

Lab 10
Signal space, Signal constellation, and ML decoding — Date: 26th and 27th October 2016

Please note that this experiment has to be done in MATLAB.

1 Message source model

Prelab assignment

1. Review the message source model in Chapter 5 of "Communication Systems".

In lab tasks

1. In this task, you have to implement an IID random process model for a general message source. For the IID model, each symbol in the sequence is a realization of a random variable X_n taking values in a set $\mathcal{S}$ with pmf p_s such that $P(X_n = s) = p_s$. Successive symbols from the source are assumed to be independent. Implement a function "MessageSequence" to generate a sequence of symbols using the above model for the message source. The function takes three inputs - N the length of the sequence of symbols generated, $syms$ an array of symbols which the source generates, and pmf which is the probability mass function on $syms$. For example, if $syms = [2, 4, 6, 10]$ and $pmf = [0.2, 0.1, 0.4, 0.3]$ then $P(X_n = 2) = 0.2$.

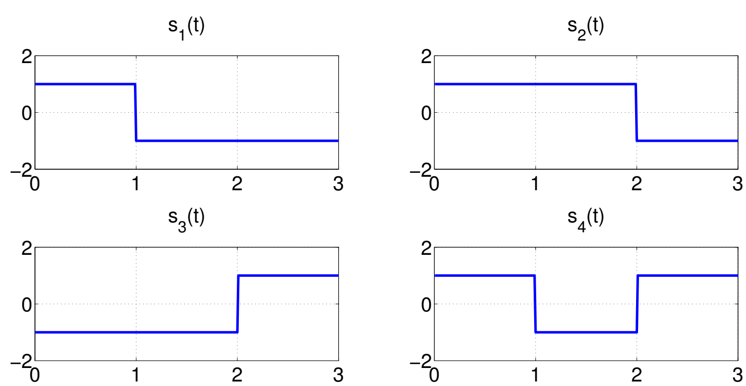
2 Signal space and constellation

Prelab assignment

1. Review the Gram Schmidt procedure for signals and vectors
2. Review what a signal space is from Chapter 5 of "Communication Systems".

In lab tasks

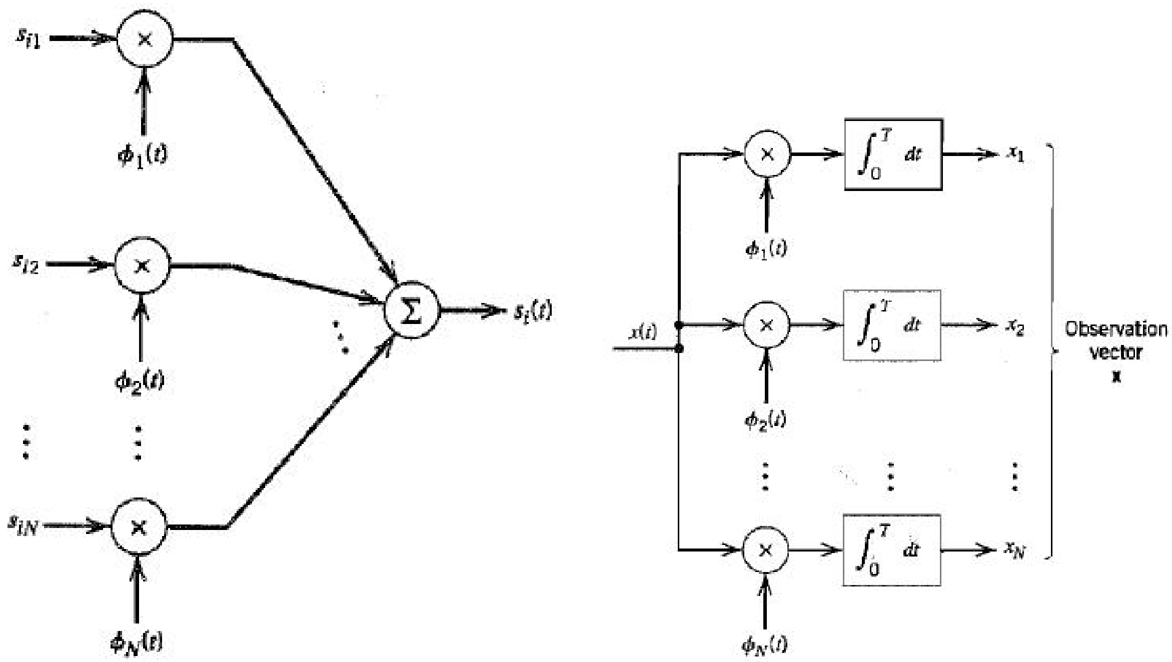
1. Assume that the set of symbols is $[1, 2, 3, 4]$ and the pmf is $[0.25, 0.25, 0.25, 0.25]$ for the message source model. For the i^{th} message symbol the source uses a signal $s_i(t), t \in [0, T]$. Assume that $T = 3$ and the signals are as shown. Using an appropriate discrete time representation obtain a set of orthonormal basis functions $\{\phi_j(t)\}$ (more precisely - discrete time orthonormal basis functions) for this set of signals in Matlab using the Gram Schmidt procedure. Also find out analytically what the set of basis functions is. In Matlab, obtain a visualization (plot - 2D or 3D) of the signal space with the signals being represented as vectors.



3 Transmitter and Correlation receiver

Prelab assignment

1. Review the transmitter and correlation receiver architecture from Chapter 5 of "Communication Systems" corresponding to the block diagrams shown below



In lab tasks

1. Implement the transmitter and correlation receiver that you have reviewed in your pre-lab assignment. To implement a transmitter write a function with inputs being the message sequence generated from the function "MessageSequence" with $N = 5$, $syms = [1, 2, 3, 4]$ and $pmf = [0.25, 0.25, 0.25, 0.25]$. The set of signals that the transmitter uses is as given in Section 2.
2. Note that for the i^{th} symbol the signal used is $s_i(t)$. Simulate the addition of mean zero IID Gaussian noise to the signal $s_i(t)$ for each of the 10 symbols that are transmitted. Obtain a received signal which is the sum of $s_i(t)$ and $N(t)$, where $N(t) \sim \mathcal{N}(0, \sigma^2)$. Assume that $\sigma^2 = 2$.
3. Visualize the received observation vector x obtained from sampling the correlator outputs in the (received) signal space for all the transmitted symbols.

4 Maximum likelihood decoding

Prelab assignment

1. Review maximum aposteriori and maximum likelihood decoding from Chapter 5 of "Communication Systems"

In lab tasks

1. At this point you have set up a correlation receiver from which you obtain the observation vector x. Note that this observation vector is obtained for every symbol that is transmitted (which is decided by the sequence from the message source). We now need to convert or map this observation vector x to an estimate $\hat{m}$ about which message was transmitted. Implement the following decision rule for this map.

   $$\text{Choose } \hat{m} = m_i \text{ for which } ||x - s_i|| \text{ is minimum.}$$

   Here s_i is the vector corresponding to the i^{th} signal $s_i(t)$.