

Problem 4 Let a be a real-valued vector that contains the real-valued vector b , i.e., a has the form a_1, b, a_2 for some vectors a_1 and a_2 . Suppose that the maximum of the correlation between a_1 and b and that between a_2 and b is small compared to the squared norm of b .

1. Draw a qualitative plot of the result of `xcorr(a,b)`. Note: the help for `xcorr` is available.
2. Describe the length of a_1 as a function of the result of the MATLAB operation `[t,u]=max(xcorr(a,b))`. Note: the help for `max` is available.
3. Draw a qualitative plot of the result of `xcorr(b,a)`.
4. Describe the length of a_1 as a function of the result of the MATLAB operation `[v,w]=max(xcorr(b,a))`.

Solution Let l_a, l_{a1}, l_{a2} , and l_b , be the lengths of the vectors a, a_1, a_2 , and b , respectively, where $l_a = l_{a1} + l_{a2} + l_b$.

1. The function `c1 = xcorr(a,b)` returns a vector named c_1 of length $2l_a - 1$. As $l_a > l_b$, b is zero-padded to match the length of a . The starting position of the correlation between a and padded b is shown in Figure 1. The first $(l_a - l_b)$ elements of c_1 are zeros. The peak of the correlation occurs when the two sub-vectors b are aligned and they sum coherently. This happens at position $(l_a + l_{a1})$. The output of `xcorr(a,b)` is plotted in Figure 2.
2. We can write $u = l_a + l_{a1}$, hence $l_{a1} = u - l_a$.

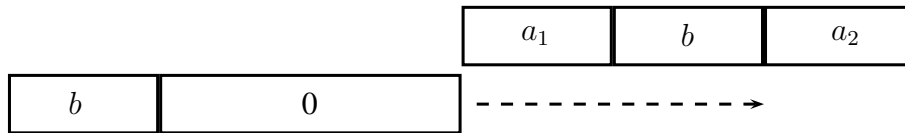


Figure 1: Initial position of the correlation between a and b .

3. Similarly, the function `c2 = xcorr(b,a)` returns a vector named c_2 of the length $2l_a - 1$. Here, the last $(l_a - l_b)$ elements of c_2 are zeros, and peak of the correlation occurs at position $(l_a - l_{a1})$. The output of `xcorr(b,a)` is plotted in Figure 3.
4. In the case we write $w = l_a - l_{a1}$, hence $l_{a1} = l_a - w$.

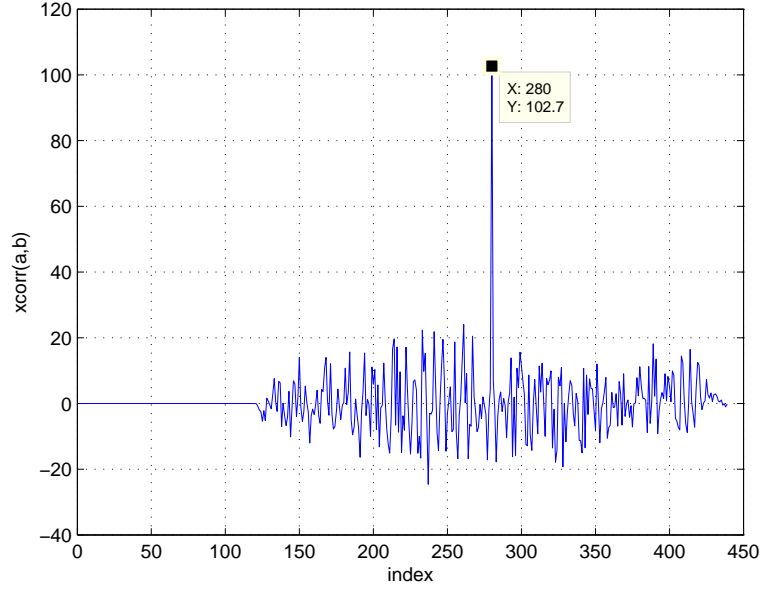


Figure 2: Output of the correlation between a and padded b , where $l_{a1} = l_{a2} = 60$ and $l_b = 100$.

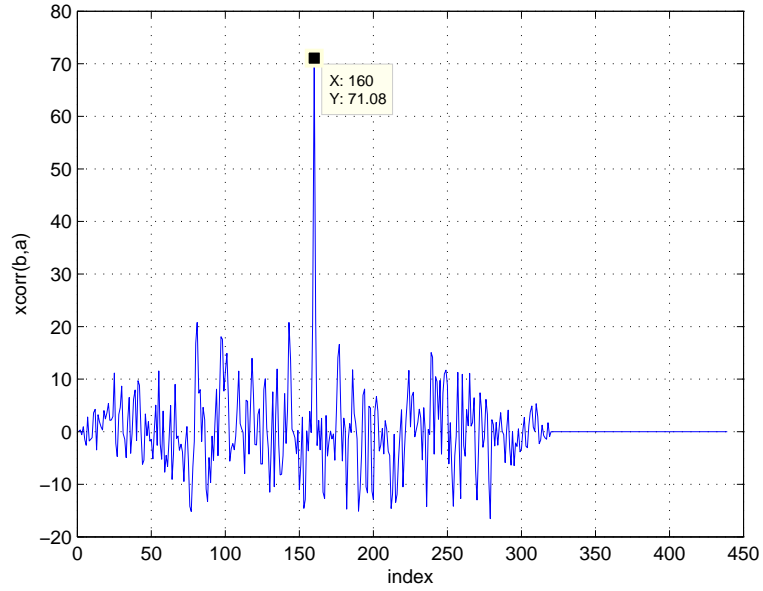


Figure 3: Output of the correlation between padded b and a , where $l_{a1} = l_{a2} = 60$ and $l_b = 100$.