FOUNDATIONS OF SIGNALS AND SYSTEMS
11.2 Solved exercises
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Exercises 11.2

Solve the following MatLab problems:

1. Consider the signals

$$x(n) = \begin{cases} -1 & n = -1 \\ 3 & n = 0 \\ -5 & n = 1 \\ 2 & n = 2 \\ 0 & \text{otherwise} \end{cases} \qquad g(n) = \begin{cases} 1 & n = 0 \\ 2 & n = 1 \\ -1 & n = 2 \\ 0 & \text{otherwise} \end{cases}$$

   Plot the signals as well as their convolution $y(n) = x * g(n)$ in different subplots.

2. Evaluate numerically the convolution between the signals $x(t) = g(t) = \text{rect}(t-1)$ and check that the result is $y(t) = x * g(t) = \text{triang}(t-2)$. Choose a very small sampling spacing T to get an accurate result.

Solutions.

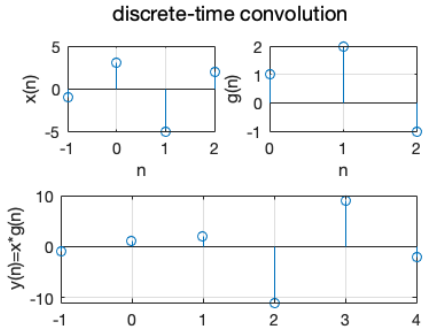
1. In the code we first define samples of x and g together with their sample time, then y is obtained by convolution and its sample times are built using the extension of convolution by using the starting elements $nx(0) + ng(0)$ and the ending elements $nx(end) + ng(end)$ of the arrays (here end is a keyword indicating the last element).

```
x = [-1,3,-5,2];
nx = -1:2;
g = [1,2,-1];
ng = 0:2;
y = conv(x,g);
ny = nx(1)+ng(1):nx(end)+ng(end);

figure
subplot(2,2,1)
stem(nx,x)
grid
xlabel('n')
ylabel('x(n)')
subplot(2,2,2)
stem(ng,g)
grid
xlabel('n')
```

```
ylabel('g(n)')
subplot(2,1,2)
stem(ny,y)
grid
xlabel('n')
ylabel('y(n)=x*g(n)')
sgtitle('discrete-time convolution')
```

We also note how sgtitle draws a title for the entire figure.



2. We set $T = 0.01$ and the range for both x and g (which are equal) to $[-1, 3]$. The numerical convolution conv is multiplied by T to obtain a correct approximation of the continuous-time convolution, and the extension of signals is set by the rule on the extension of convolution, as in the previous exercise. The true convolution, here named y_2, is calculated via a triang function defined at the end of the script, in a way similar to the rect function. Note the perfect accordance in the lower plot. You can try to modify the value of T, e.g., to $T = 0.1$, to see how some errors arise.

```
T = 0.01;
tx = -1:T:3;
x = rect(tx-1);
tg = -1:T:3;
g = rect(tg-1);
y = T*conv(x,g);
ty = tx(1)+tg(1):T:tx(end)+tg(end);
y2 = triang(ty-2);

figure
subplot(2,2,1)
plot(tx,x)
grid
xlabel('t')
ylabel('x(t)')
subplot(2,2,2)
plot(tg,g)
```

```
grid
xlabel('t')
ylabel('g(t)')
subplot(2,1,2)
plot(ty,y,ty,y2)
grid
xlabel('t')
ylabel('y(t)=x*g(t)')
legend('via MatLab','true signal')
sgtitle('continuous-time convolution')

function s = triang(t)
s = (abs(t)<1).*(1-abs(t));
end

function s = rect(t)
s = (abs(t)<.5)+.5*(abs(t)==.5);
end
```