EE110B Lab 7

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1) Choose a large N that is an integer power of 2, i.e., $N = 2^p$ with p being an integer. For example, $N = 1024$. And generate two random sequences $h(n)$ and $g(n)$ meeting the above "zero tail" properties.

```
N = 2^(11);
rng(0)
h_n = [rand(1, N/2) zeros(1, N/2)];
g_n = [rand(1, N/2) zeros(1, N/2)];
```

2) Compute the convolution $x(n) = h(n) * g(n)$ for $n = 0, 1, \ldots, N-1$ using the conventional method, i.e., $h(n) * g(n) = \sum_{l=0}^{N-1} h(l)g(n-l)$, and record the execution CPU tie T_1.

```
t1 = tic;
x_n = conv(h_n,g_n);
x_n = x_n(1:N);
T1 = toc(t1)
```

```
T1 = 0.0172
```

3) Then compute $H(k) = \mathrm{FFT}[h(n)]$ and $G(k) = \mathrm{FFT}[g(n)]$ (for all $k = 0, 1, \ldots, N-1$) and $y(n) = \mathrm{IFFT}[h(k)G(k)]$ (for all $n = 0, 1, \ldots, N-1$), and record the total execution time T_2

```
t2 = tic;
H_k = fft(h_n);
G_k = fft(g_n);
y_n = ifft(H_k.*G_k);
T2 = toc(t2)
```

```
T2 = 0.0292
```

4) is T_2 much smaller than T_1?

Yes, T_2 is about ten times smaller than T_1

5) Is $x(n)$ identical to $y(n)$ for $n = 0, 1, \ldots N-1$? (Hint: compute the mean squared error $\mathrm{MSE} = \frac{1}{N}\sum_{n=0}^{N-1} |x(n) - y(n)|^2$.)

```
MSE = immse(x_n, y_n)
```

```
MSE = 1.3747e-26
```

Yes, $x(n)$ is identical $y(n)$ because the mean squared error is extremely small. That means that the error betwen the actul squared difference of the values and the expected values is neglible.

6) Try an even larger N and repeat the above

```
N = 2^(21);
rng(0)
h_n = [rand(1, N/2) zeros(1, N/2)];
g_n = [rand(1, N/2) zeros(1, N/2)];

t3 = tic;
x_n = conv(h_n,g_n);
x_n = x_n(1:N);
T3 = toc(t3)
```

```
T3 = 173.5444
```

```
t4 = tic;
H_k = fft(h_n);
G_k = fft(g_n);
y_n = ifft(H_k.*G_k);
T4 = toc(t4)
```

```
T4 = 0.2764
```

Again, it appears that T_4 is much smaller than T_3. T_3 tends to ballon, whereas T_4 grew by a magnitude of 10 when N was doubled.

```
MSE2 = immse(x_n, y_n)
```

```
MSE2 = 1.2713e-17
```

As we can see once more, the $x(n)$ and $y(n)$ are identical.