

## CSP lab Assignment 1

### Convolution:

Convolution is a process of sliding one signal over the folded and shifted version of the other signal. In other terms it relates the input  $x[n]$ , output  $y[n]$  and the impulse response  $h[n]$  of an LTI system as

$$y[n]=x[n]*h[n], \text{ where } * \text{ denotes convolution}$$

If  $x[n]$  has a sequence length of  $l_x$ ,  $h[n]$  has a sequence length of  $l_h$ , then the length of the output sequence  $y[n]$  would be  $l_y=l_x+l_h-1$ .

### Correlation:

Correlation of two signals tells the similarity between those signals. It is a process of sliding one signal over the shifted version of the other signal. In other terms it is same as convolution without folding one of the two signals.

Correlation is of two types:

#### 1.Auto correlation:

It measures the similarity between a signal and its delayed version.

By definition Auto correlation of  $x[n]$  can be defined as

$$R_{xx}[n]=x[n]*x[-n] \text{ where } * \text{ denotes convolution}$$

#### 2.Cross correlation

It measures the similarity between two different signals .

By definition cross correlation of  $x[n]$  and  $y[n]$  signals can be defined as

$$R_{xy}[n]=x[n]*y[-n] \text{ where } * \text{ denotes convolution}$$

### Down sampling:

Down sampling is the process of reducing the sampling rate, i.e. reducing the length of the signal. This process is also called as decimation.

By definition if down sampling factor is  $M$ , then the output of the down sampled signal is

$$y[n]=x[Mn] \text{ where } M>1;$$

if the length of the input signal  $x[n]$  is  $l_x$ , then the length of the down sampled signal  $y[n]$  can be given as  $l_d=l_x/M$ .

### Up sampling:

Up sampling is the process of increasing the sampling rate, i.e. increasing the length of the signal. This process is also called as interpolation.

Interpolation can be done by

- 1) Padding (L-1) zeros between the samples which is called as zero interpolation
- 2) Padding the previous sample (L-1)times between the samples which is called as step interpolation
- 3) Padding the average of the adjacent samples (L-1)times between the samples which is called as Linear interpolation

We can say that, the inverse of interpolation is decimation but the converse statement need not necessarily be true always.

By definition: If up sampling factor is L, then the output of the up sampled signal using zero interpolation is

$$y[n] = x[n/L] \text{ if } n \text{ is a multiple of } L, L > 1$$
$$\text{else } y[n] = 0$$

if the length of the input signal  $x[n]$  is  $l_x$ , then the length of the up sampled signal can be given as  $l_u = (L-1)*(l_x-1) + l_x$  since (L-1) zeros are padded between the samples of the input signal.

I