Correlation

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Similarity between two signals :

Cross correlation

Pattern Matching

Delay Measurements (Radar)

Digital Communication

Correlation with signal itself :

Autocorrelation

To identify hidden periodicities in signal i.e. signal buried under noise Detection of return signals (Radar)

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For two sequences x(n) & y(n) having finite energy, Cross correlation is given by,

$$r_{xy}(l) = \sum_{n=-\infty}^{+\infty} x(n)\,y(n-l)$$

OR

l is called lag parameter

l = 0, +/-1, +/-2, ……

$$r_{yx}(l) = \sum_{n=-\infty}^{+\infty} y(n)\,x(n-l)$$

Properties of Cross-correlation

- r_{xy}(l) is folded version of r_{yx}(l)

  $r_{xy}(l) = r_{yx}(-l)$

- provides same information w. r. t. similarity of x(n) & y(n)

Autocorrelation is given by,

$$r_{xx}(l) = \sum_{n=-\infty}^{+\infty} x(n)x(n-l)$$

Properties of Autocorrelation

- Attains maximum value at zero lag $r_{xx}(0)$

  $r_{xx}(0) > r_{xx}(l)$
- Even function $r_{xx}(l) = r_{xx}(-l)$
- $r_{xx}(0)$ is the energy of $x(n)$

  $r_{xx}(0) = E_x$

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Normalized form of Correlation

$$\rho_{xx}(l) = \frac{r_{xx}(l)}{r_{xx}(0)}$$

$$\rho_{xy}(l) = \frac{r_{xy}(l)}{\sqrt{r_{xx}(0)\, r_{yy}(0)}}$$

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Correlation of periodic and power signals

$$r_{xx}(l) = \frac{1}{N}\sum_{n=0}^{N-1} x(n)x(n-l)$$

$$r_{xy}(l) = \frac{1}{N}\sum_{n=0}^{N-1} x(n)y(n-l)$$

where N is the period of the signal

$r_{xy}(l)$ & $r_{xx}(l)$ are periodic sequences with period N

1/N can be viewed as ***normalization*** factor

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To identify periodicities in noise corrupted signal

$$r_{x1x1}(l) = \sum_{n=-\infty}^{+\infty} x1(n)x1(n-l)$$

$$r_{x1x1}(l) = \sum_{n=-\infty}^{+\infty} [x(n) + d(n)][x(n-l) + d(n-l)]$$

$$r_{x1x1}(l) = r_{xx}(l) + r_{dd}(l) + r_{xd}(l) + r_{dx}(l)$$

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