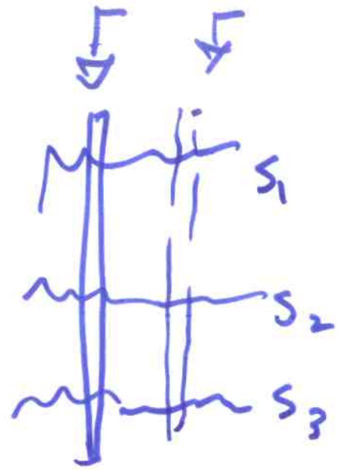
Speech Analyses for:

"short-time"

Energy

Voicing

Pitch



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Autocorrelation function:

$$ACF(k) = r(k) = \mathcal{E}\{x[m] \cdot x[m+k]\} \quad \leftarrow$$

$$\Rightarrow \quad r(k) = \lim_{M \to \infty} \frac{1}{2M+1} \sum_{m=-M}^{M} x[m] \cdot x[m+k] \quad \leftarrow (1)$$

Properties:

a) $r(k) = r(-k)$

b) It's value is maximum at $k=0$

$$\Rightarrow \left| \sum_{m=-\infty}^{\infty} x[m]\, x[m+l] \right| \leq \sum_{m=-\infty}^{\infty} x^2[m]$$

To prove this :

$$\sum_{m=-\infty}^{\infty} \left(x[m] + \varepsilon\, x[m+k]\right)^2 \geq 0$$

take $\varepsilon = 1$
& $\varepsilon = -1$

c) For periodic signals,

$r[k] = r[k+P]$, P = period in samples

i.e. $r[k]$ attains maximum value at $k = 0, \pm P, \pm 2P, \ldots$

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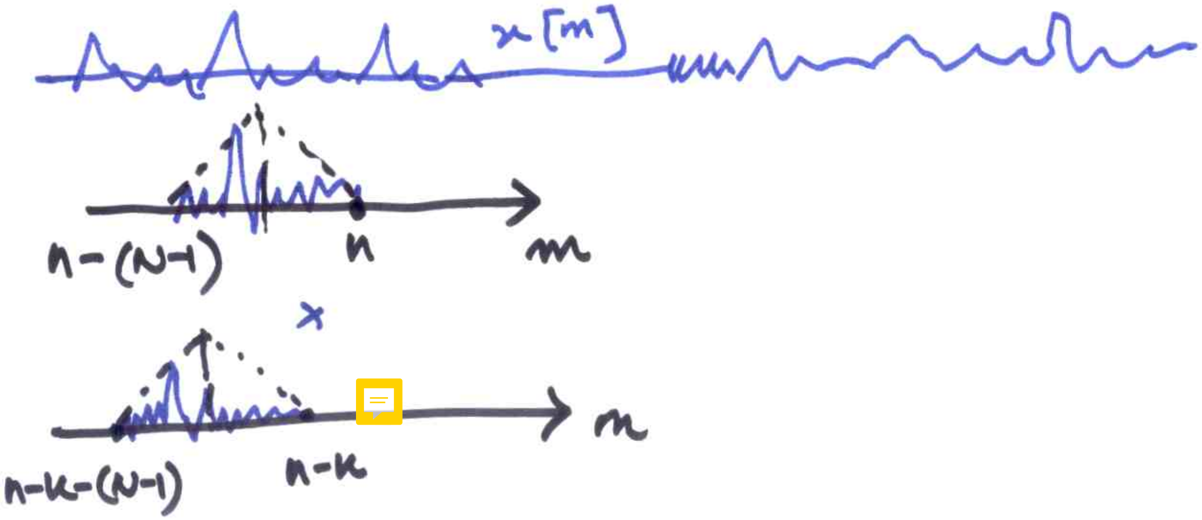
quasi-stationary

Short-time ACF :

$$r(n,k) = \sum_{m=-\infty}^{\infty} x[m]\, w[n-m]\, x[m+k].$$

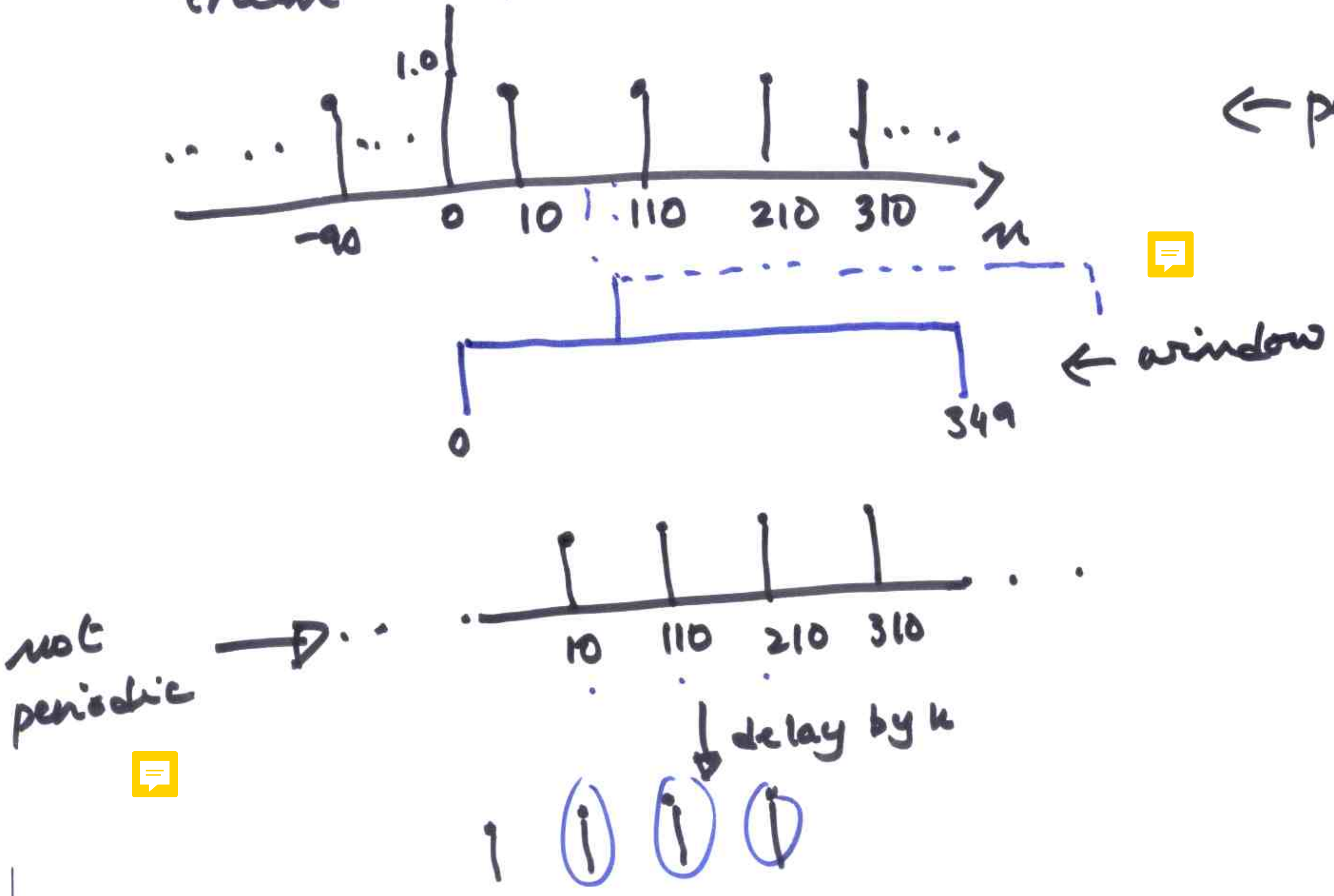
$$w[n-(m+k)]$$

$w[n] \rightarrow$ window of dur^n = N



Examples :

(i) Compute the s-t ACF, using a rect. window of $N = 350$ samples, of a periodic impulse train of period = 100



$k = 0 \Rightarrow r[k=0] = 4$

$r[k=1] = 0$

$r[k=2] = 0$

$\vdots$

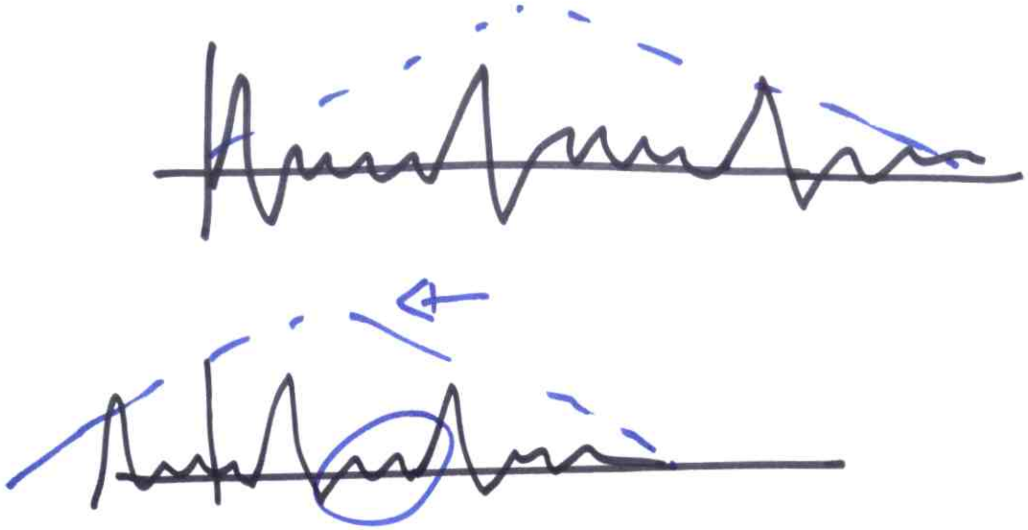
$r[k=100] = 3$

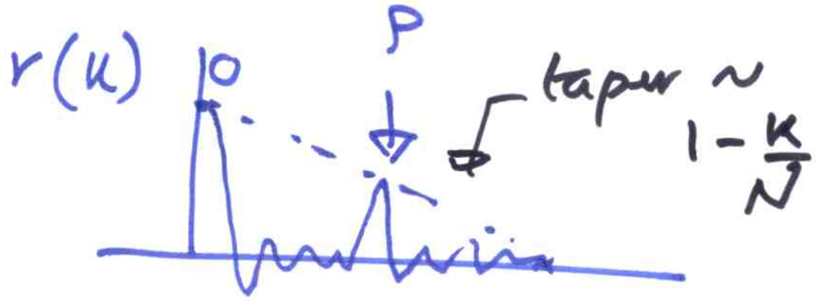
$r[k=200] = 2$

$r[k=300] = 1$

$\vdots$

(ii) Voiced speech segment (vowel)





(iii) white noise segment

$\sum x[n]\, x[n+k] \Rightarrow r[k] = \delta[k]$

(iv) unvoiced speech
"coloured noise"

ACF & power spectrum :

$$r(k) \sim |X(\omega)|^2$$