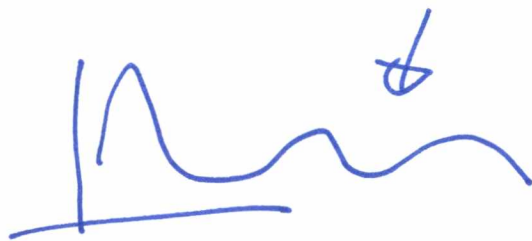


Visible speech



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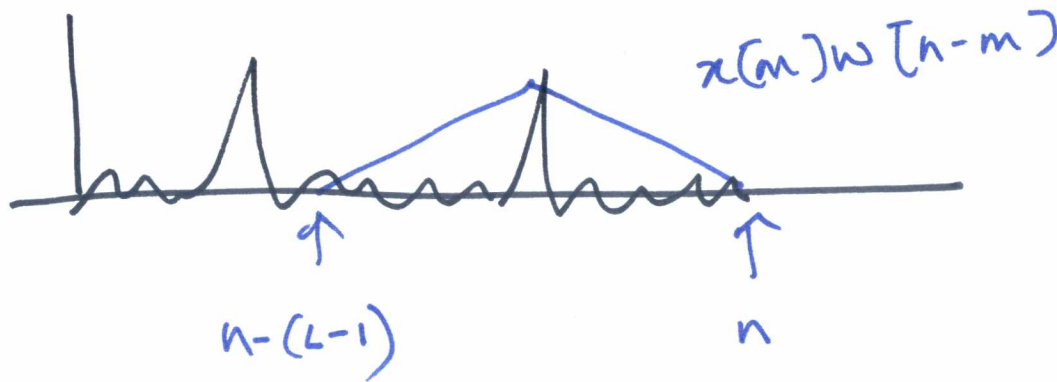
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$$\{x[m]\}, -\infty < m < \infty$$

$$\text{DTFT: } X(e^{j\omega}) = X(\omega) = \sum_{m=-\infty}^{\infty} x[m] e^{-j\omega m}$$

STFT :

$$X(n, \omega) = \sum_{m=-\infty}^{\infty} x[m] w[n-m] e^{-j\omega m}$$



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Can we recover $x[n]$?

$$\frac{1}{2\pi} \int_{-\pi}^{\pi} X(n, \omega) e^{j\omega m} d\omega = x[m] w[n-m]$$

Let $m=n$

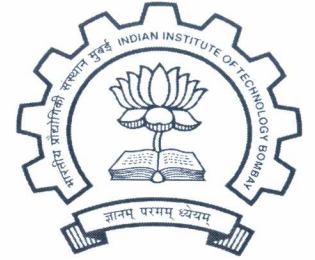
$$\Rightarrow x[n] w[0] = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(n, \omega) e^{j\omega n} d\omega$$

$$\Rightarrow x[n] = \frac{1}{w[0]} \cdot \frac{1}{2\pi} \int_{-\pi}^{\pi} \dots d\omega$$



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Now,

$$\sum_{n=-\infty}^{\infty} X(n, k) = \sum_{n=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} x[m] w[n-m] e^{-j \frac{2\pi}{N} km}$$

$$= \underbrace{\sum_{m=-\infty}^{\infty} x[m] \cdot e^{-j \frac{2\pi}{N} km}}_X[k] \underbrace{\sum_n w[n-m]}_{\text{const}}$$

we get back $X[k]$, or $x[n]$ ($N \geq L$)

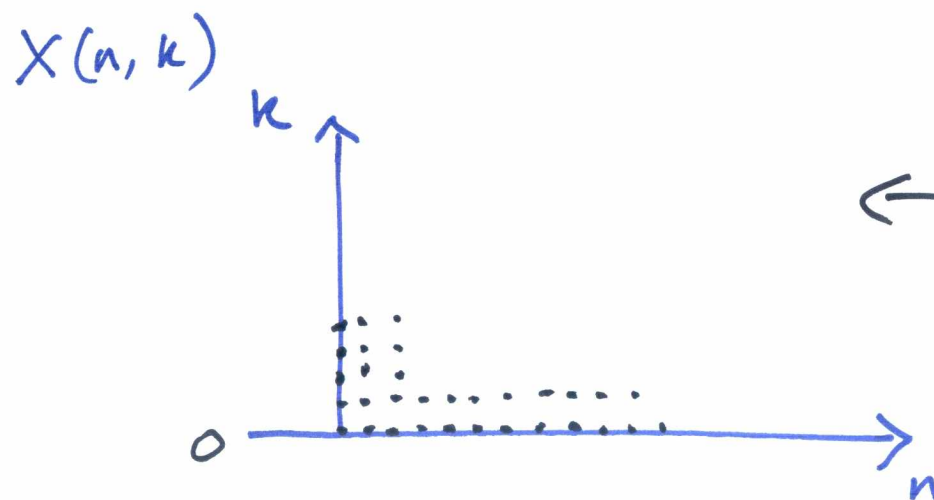


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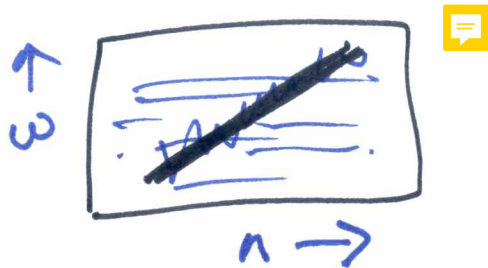
$$X(n, k) = X(n, \omega) \Big|_{\omega = \frac{2\pi}{N}k}$$

$$= \sum_m x[m] w[n-m] e^{-j\frac{2\pi}{N} \cdot km}$$

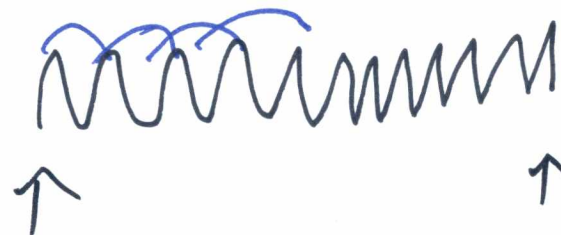


$$\leftarrow 10 \log_{10} |X(n, k)|^2$$

"Spectrogram"



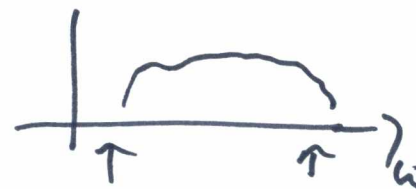
Chirp 



$$\sin \omega(t) t$$

\sim

$$\alpha t$$



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