

Biomedical applications of spectral analysis

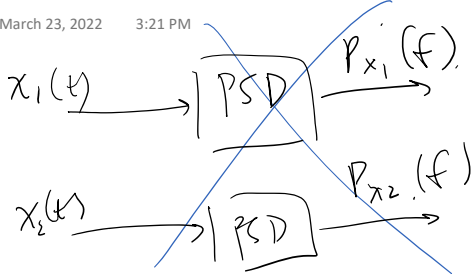
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- Heart rate - does it have arrhythmias, or what state are we in? e.g. stressed vs relaxed; meditative vs normal
- Neurological disorders - diagnosing ... epilepsy? Parkinson's disease
- Sleep studies -- analyze brain rhythms in eeg.
- Assessing consciousness - again looking for rhythms in brain activity

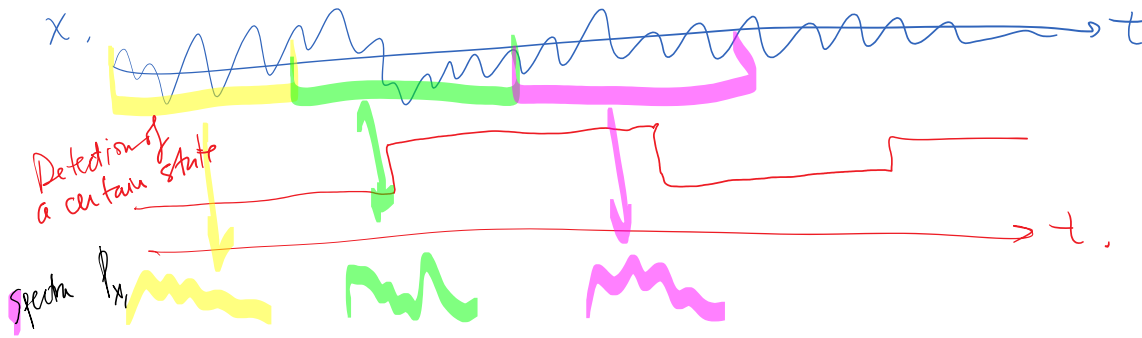
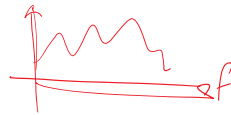
=> want to know how spectral activity is changing **_over time_**

Motivation for STFT

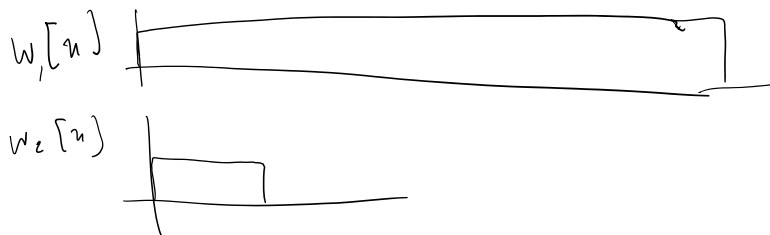
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Doesn't allow us to analyze over time.

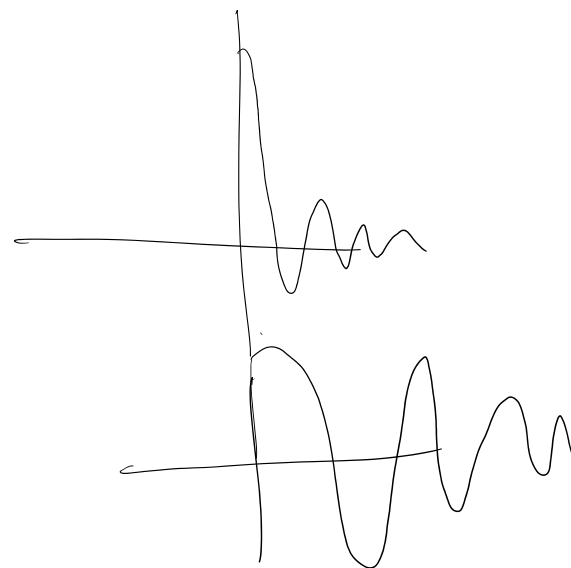


$$X_1(f) * W(f)$$



$$W_1(f)$$

$$W_2(f)$$



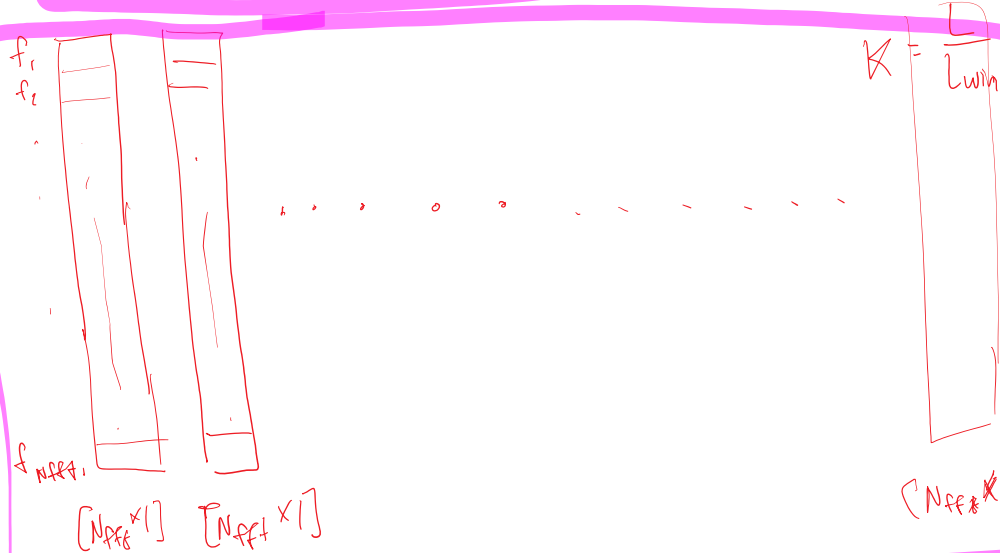
STFT = short-time Fourier transform

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$V_1(f)$ $V_2(f)$ $V_3(f)$... $V_K(f)$

Short-time Fourier transform aka "STFT"



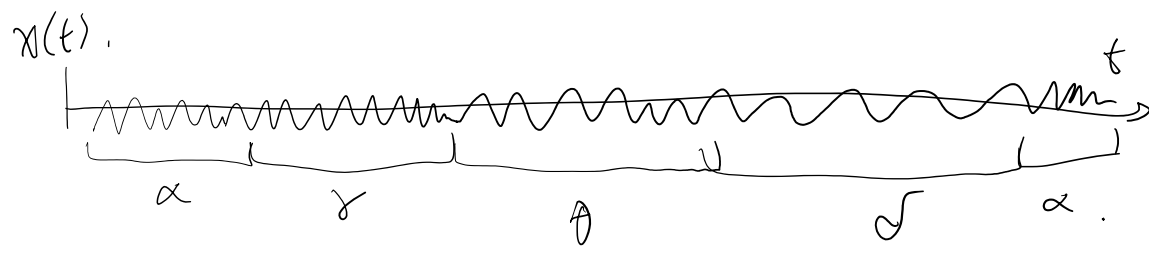
$$S = [N_{fft} \times K]$$

Class exercise - Guess the rhythms over time

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δ 1
 θ 4
 α 7
 γ 12



To access class files

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To save your mystery file for others to see:

In Matlab, use the "save" command:

save filename.mat variable_name_of_mystery_signal

In Canvas:

- Go to People (on left panel)
- Groups tab
- Media Share -> visit
- On left there should be a new link called "Files"

STFT in MATLAB

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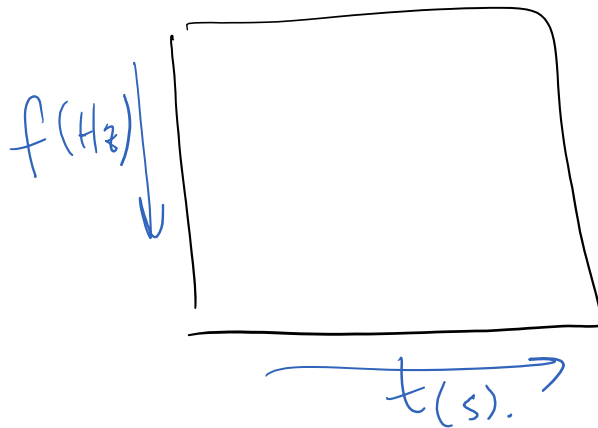
What do we have control over? (ie. What are the input parameters to the STFT?)

1. # of segments
2. Overlap of segments (percentage or number of samples to overlap by)
3. Window - type
4. Window -length
5. # of frequencies to evaluate- i.e., Nfft

```
S = stft(x, 'Window', win, 'OverlapLength', Noverlap, 'FFTlength', Nfft);
```

Contour plots and imagesc

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$\text{plot}(t, x)$
 $\text{plot}(f, X_f)$

$\text{imagesc}(t, f, \text{abs}(Sf))$
 \uparrow

Just to play around with the imagesc command and know how it works

```
x = repmat([1:10], 5, 1);  
imagesc(x)  
colorbar
```

```
Figure;  
M = rand(5,10)*100;  
imagesc(M)  
colorbar
```

STFT vs Spectrogram

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$$\overset{\text{FFT}}{|X(f)|} \text{ vs. } \overset{\text{PSD}}{|X(f)|^2}$$

$$\overset{\text{STFT}}{|X(f)|} \text{ vs. time} \quad \text{vs.} \quad \text{Spectrogram} \quad |X(f)|^2 \text{ vs. time}$$