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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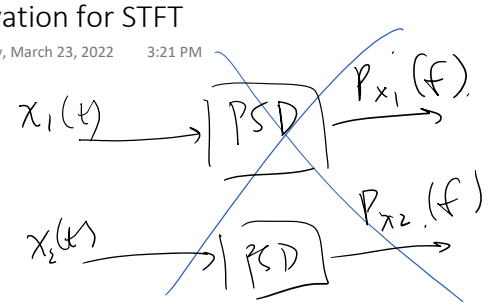
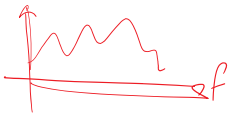
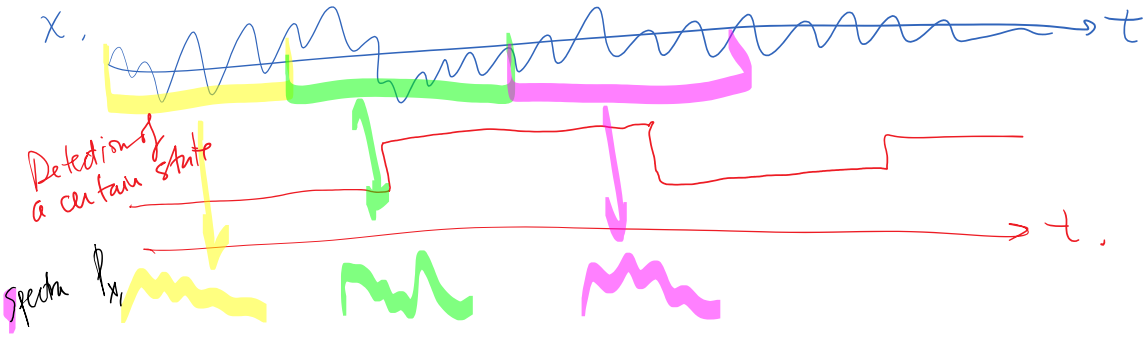
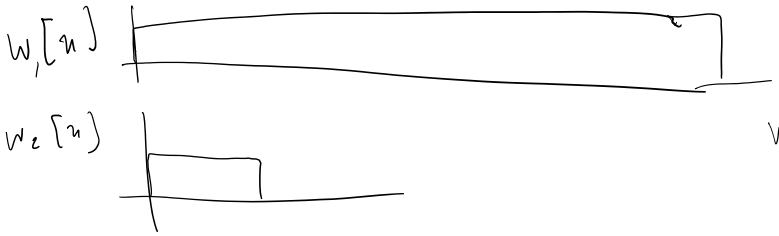


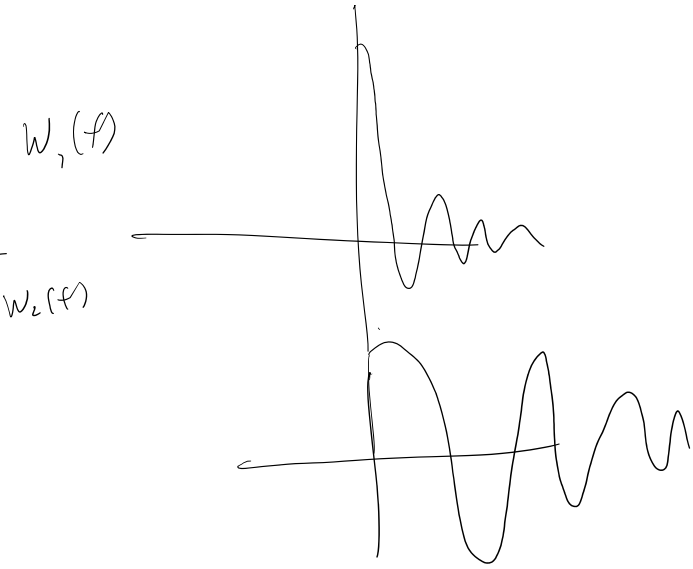
Doesn't allow us to analyze over time.





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





STFT = short-time Fourier transform

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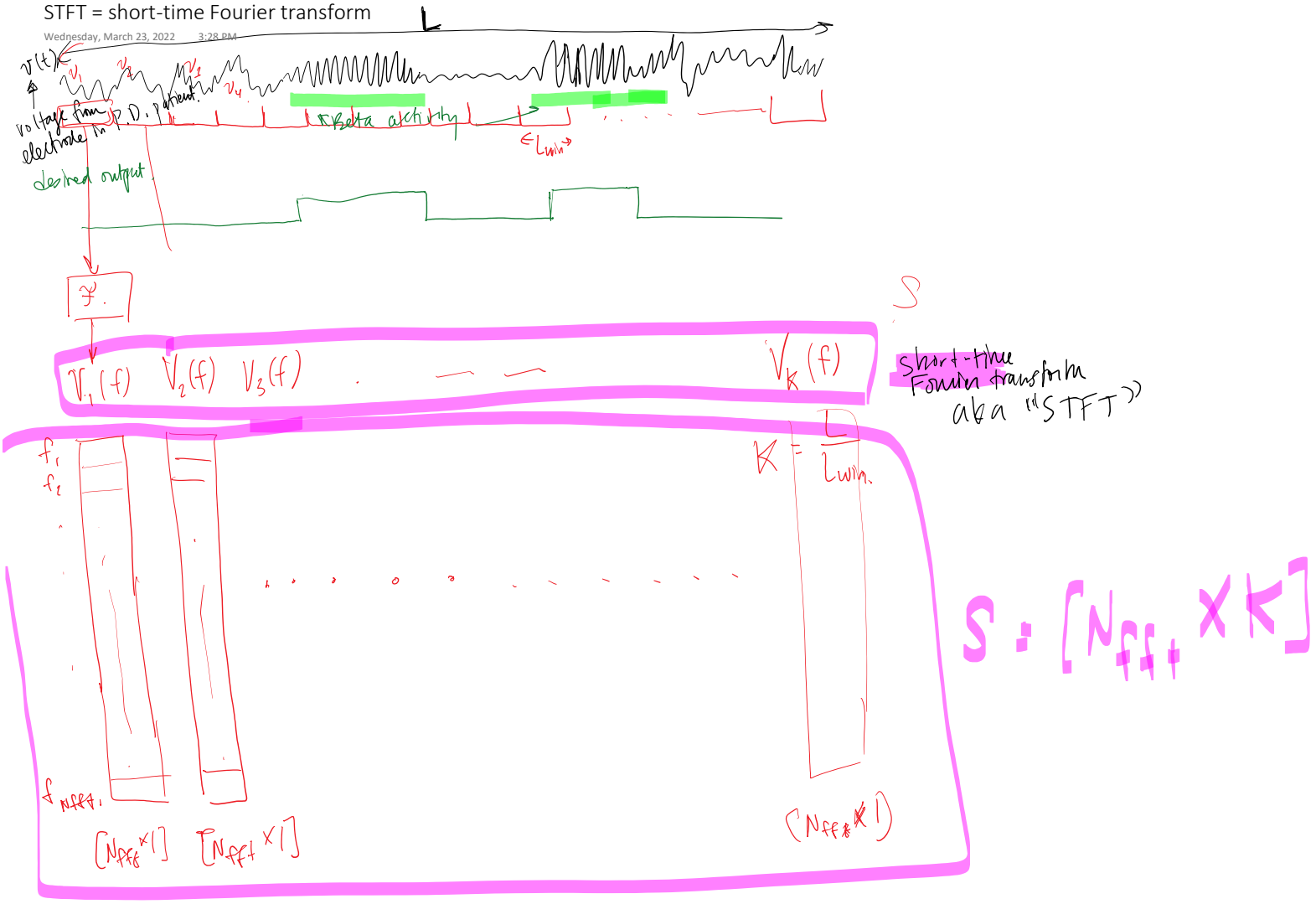

Class exercise - Guess the rhythms over time

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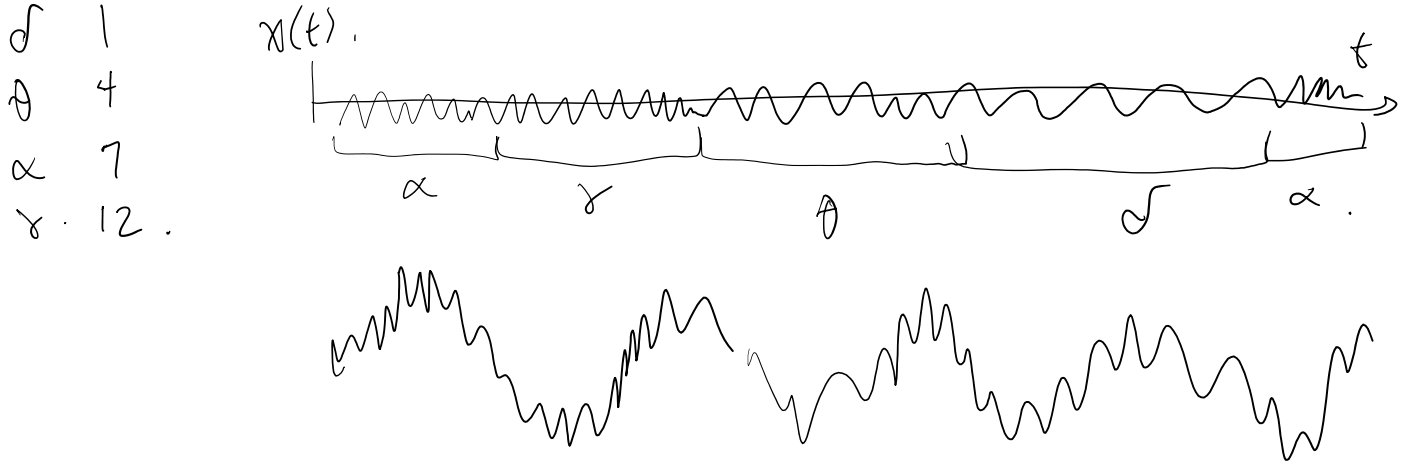

To access class files

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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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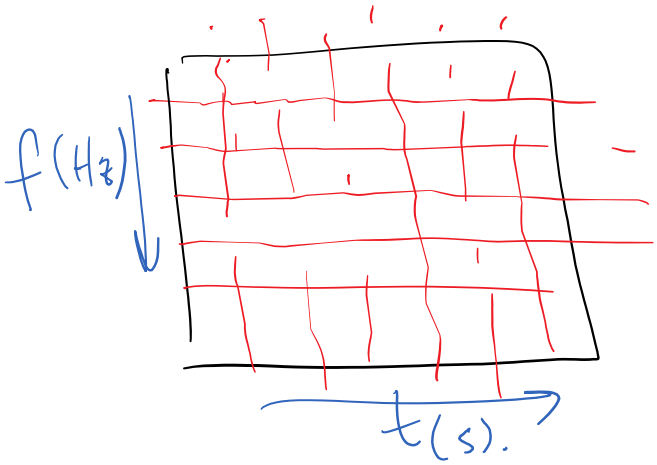


plot(t, x)
plot(f, Xf)

imagesc(t, f, abs(Sf))

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
```

imagesc.

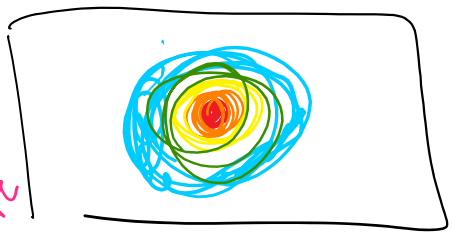
Value represented by: color intensity.

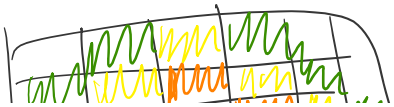
Values are constant within a pixel.

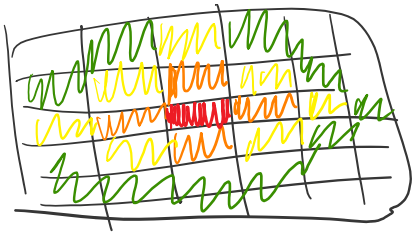
contour

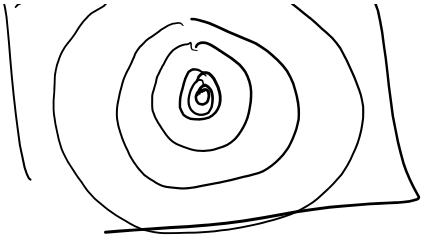
density of lines.

values are constant along the contour line.









STFT vs Spectrogram

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FFT vs PSD

$|X(f)|$ vs. $|X(f)|^2$.

STFT vs. Spectrogram

$X(f)$ vs. time $|X(f)|^2$ vs. time

theoretical difference.

*in MATLAB, only real difference is range of frequencies.

very similar in MATLAB

but ...

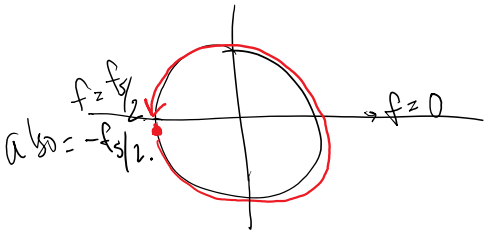
stft(x, fs, 'parameter1 name', param1 value, 'parameter2 name', par2 val, ...)

vs.

spectrogram(X,WINDOW,NOVERLAP,NFFT,Fs)

each param. is in a certain order in input argument list.

stft ⇒ $f = [-f_s/2 \quad f_s/2]$ spectrogram → $[0 \quad f_s/2]$.



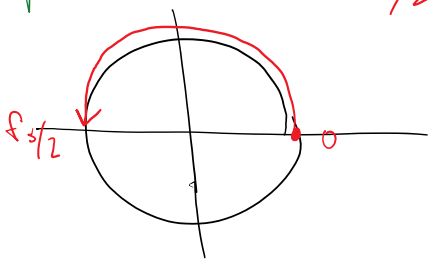


Figure out time vector and frequency vector

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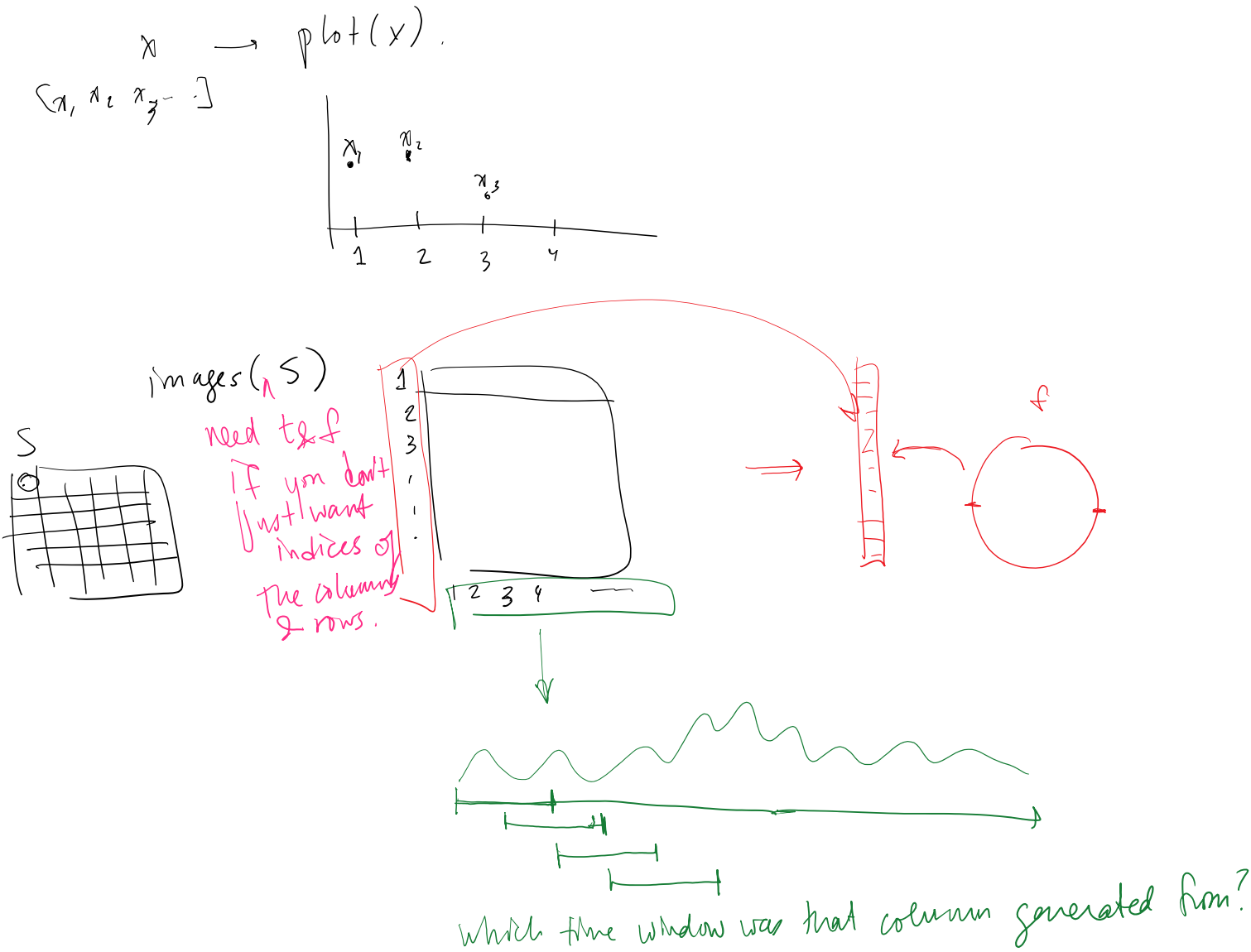

Spectrogram for Greg'sMystery signal

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