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SIGNAL & DATA ANALYSIS IN NEUROSCIENCE 2017

THE WAVELET TRANSFORM

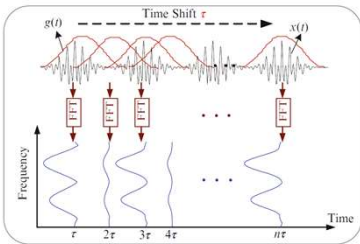
Ayala Matzner

biu.sigproc@gmail.com

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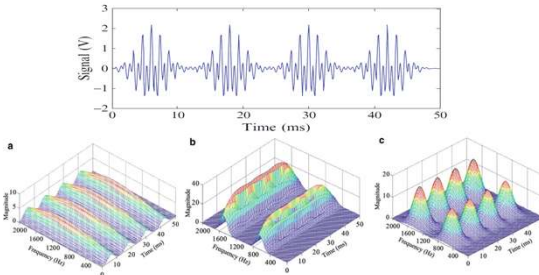
Time-frequency analysis

Short-time Fourier transform



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STFT



1.6 ms window 25.6 ms window 6.4 ms window

- How to select the appropriate window length?
- Time-frequency trade-off

Wavelet transform

- A wavelet is a waveform of effectively limited duration that has an average value of zero.

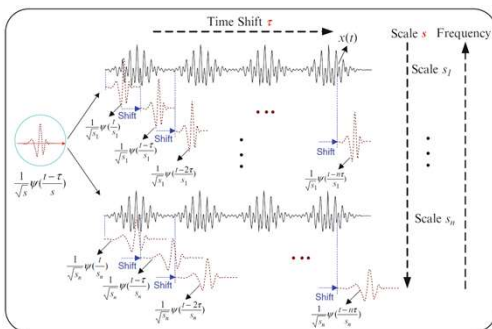


- Uses a variable length window, e.g.:
 - Narrower windows are more appropriate at high frequencies
 - Wider windows are more appropriate at low frequencies

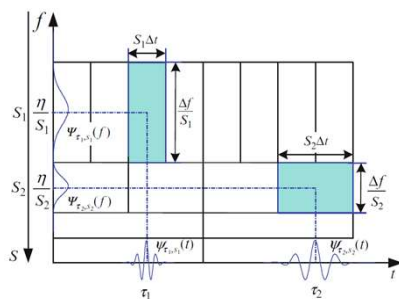
- τ – shift in time
- s – change in scale
- ψ – mother wavelet

$$\psi_{(\tau,s)} = \frac{1}{\sqrt{s}} \psi\left(\frac{t-\tau}{s}\right)$$

Wavelet transform



Time and frequency resolutions of the wavelet transform

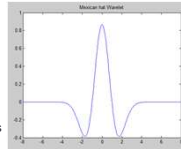


Matlab example

```
fs = 1000;
t = 0:1/fs:10;
t1 = 3*fs; t2 = 6*fs;
x = [sin(2*pi*10*t(1:t1)), sin(2*pi*15*t(t1+1:t2)), sin(2*pi*20*t(t2+1:end))];
waveletName = 'mexh';
[psi,xval] = wavefun(waveletName);
figure; plot(xval,psi);
title('Mexican hat Wavelet');

freqRange = [5 25];
scalRange = centfrq(waveletName)/(freqRange*(1/fs));
scales = scalRange(end):scalRange(1);
freqs = scal2frq(scales,waveletName,1/fs); %for the y-axis

coeffs = cwt(x,scales,waveletName);
figure;
wscalogram('image',coeffs,'scales',freqs,'ydata',x,'xdata',t);
xlabel('Time [s]');
ylabel('Freq [Hz]');
```



Example cont.

