E9 205 Machine Learning for Signal Processing

Introduction to Machine Learning of Sensory Signals

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http://leap.ee.iisc.ac.in/sriram/teaching/MLSP_19/

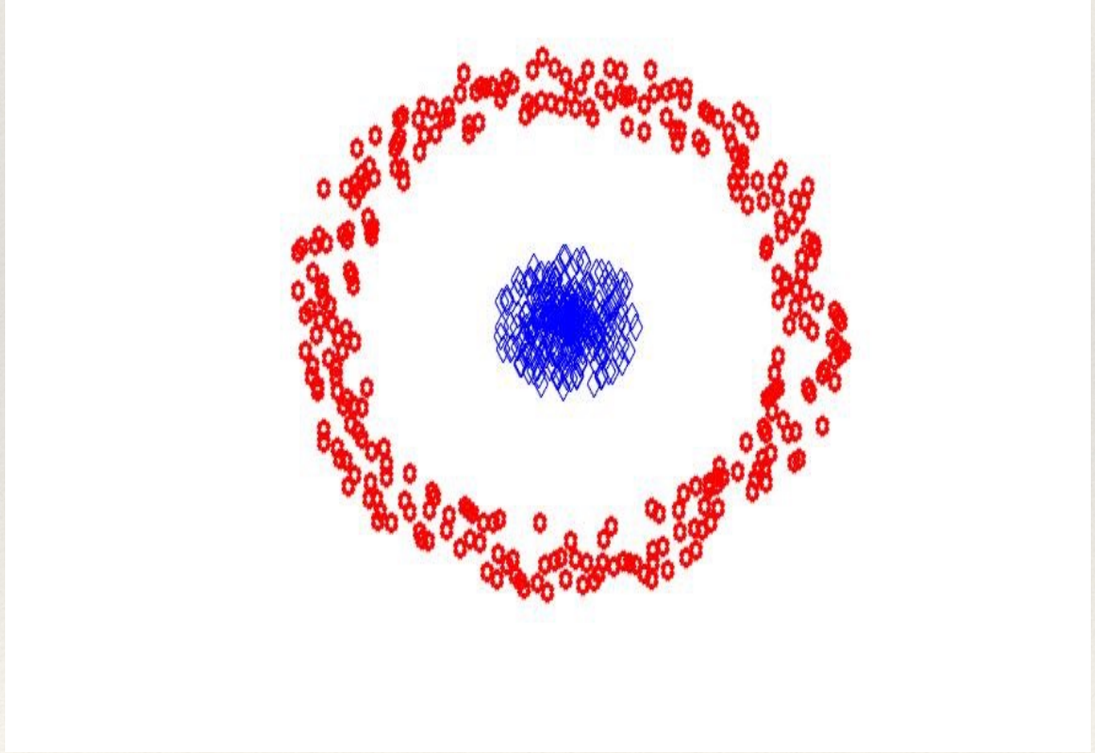
Feature Extraction

- Feature Extraction
  - Using measured data to build desirable values.
    - Attributes of the data that are informative and non-redundant.
    - Resilience to noise / artifacts.
    - Facilitating subsequent learning algorithm.

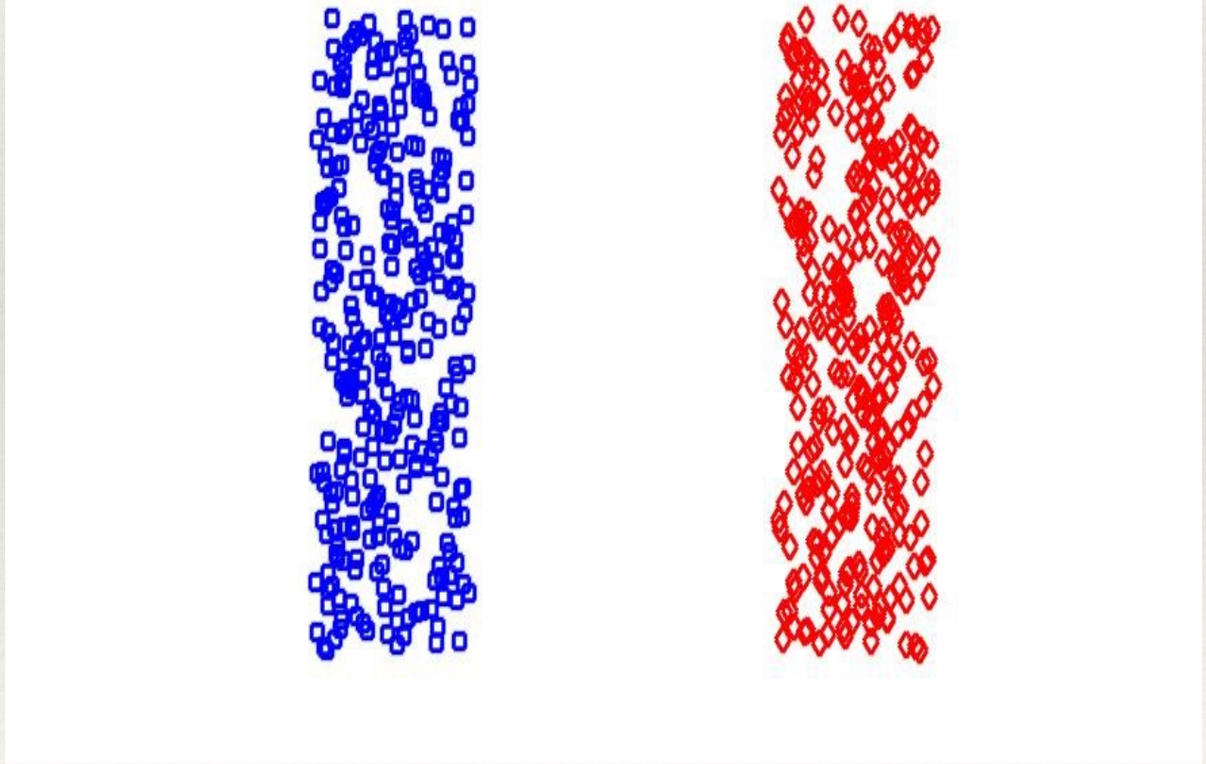
Feature Extraction

- Representation Problem

Cartesian Coordinates



Polar Coordinates



Feature Extraction

Scope for this course

I. Feature Extraction in Text.

II. Feature Extraction in Speech and Audio signals.

III. Processing of Images.

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Text Processing

Text Modeling - Introduction to NLP

- Definitions
  - Documents, Corpora, Tokens (Terms)
  - Term Frequency (TF)
  - Collection Frequency (CF)
  - Document Frequency (DF)
  - TF-IDF
  - Bag of words model

Example [Manning and Schutze, 2006]

Word	cf	df
try	10422	8760
insurance	10440	3997

► **Figure 6.7** Collection frequency (cf) and document frequency (df) behave differently, as in this example from the Reuters collection.

term	df_t	idf_t
car	18,165	1.65
auto	6723	2.08
insurance	19,241	1.62
best	25,235	1.5

► **Figure 6.8** Example of idf values. Here we give the idf's of terms with various frequencies in the Reuters collection of 806,791 documents.

https://nlp.stanford.edu/IR-book/pdf/irbookonlinereading.pdf

Perplexity

- Measuring the goodness of language modeling
-

$$\begin{aligned} \mathrm{PP}(W) &= P(w_1 w_2 \ldots w_N)^{-\frac{1}{N}} \\ &= \sqrt[N]{\frac{1}{P(w_1 w_2 \ldots w_N)}} \end{aligned}$$

On a Wall-street Journal Corpus

	Unigram	Bigram	Trigram
Perplexity	962	170	109

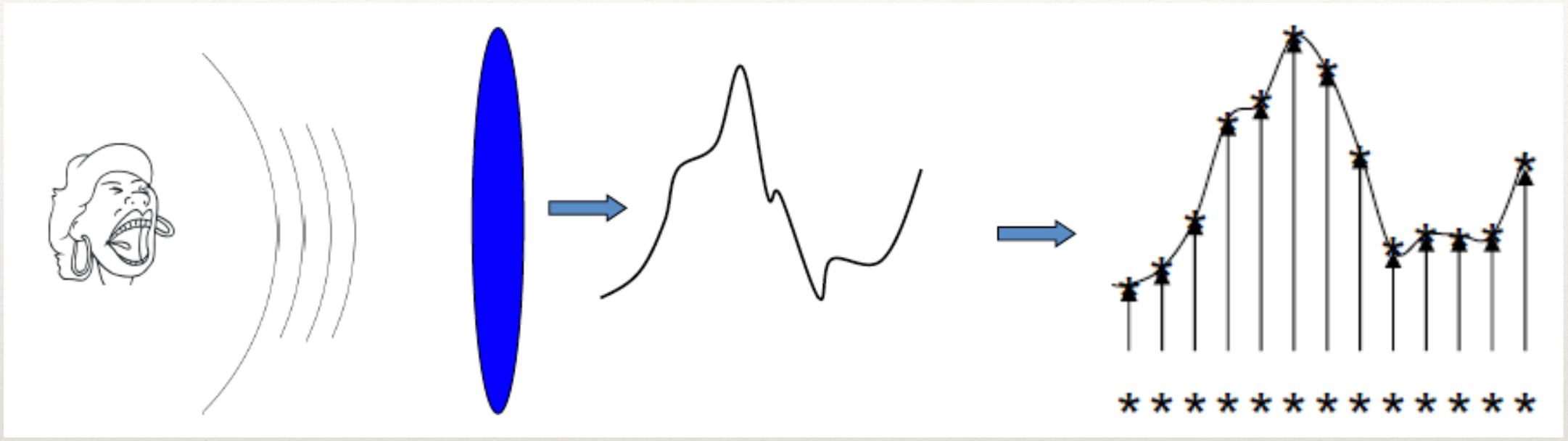
https://web.stanford.edu/~jurafsky/slp3/4.pdf

Speech and Audio Processing

Speech and Audio

- Speech / Audio - 1D signals
  - Generated by pressure variations producing regions of high pressure and low pressure.
  - Travels through a medium of propagation (like air, water etc).
  - Human sensory organ - eardrum.
    - Converting pressure variations to electrical signals.
    - Action mimicked by a microphone.

Sound waves in a computer



- Analog continuous signal from the microphone
  - Discretized in time - sampling.
  - Digitized in values - quantization.

http://mlsp.cs.cmu.edu/courses/fall2014/lectures/slides/Class1.Introduction.pdf

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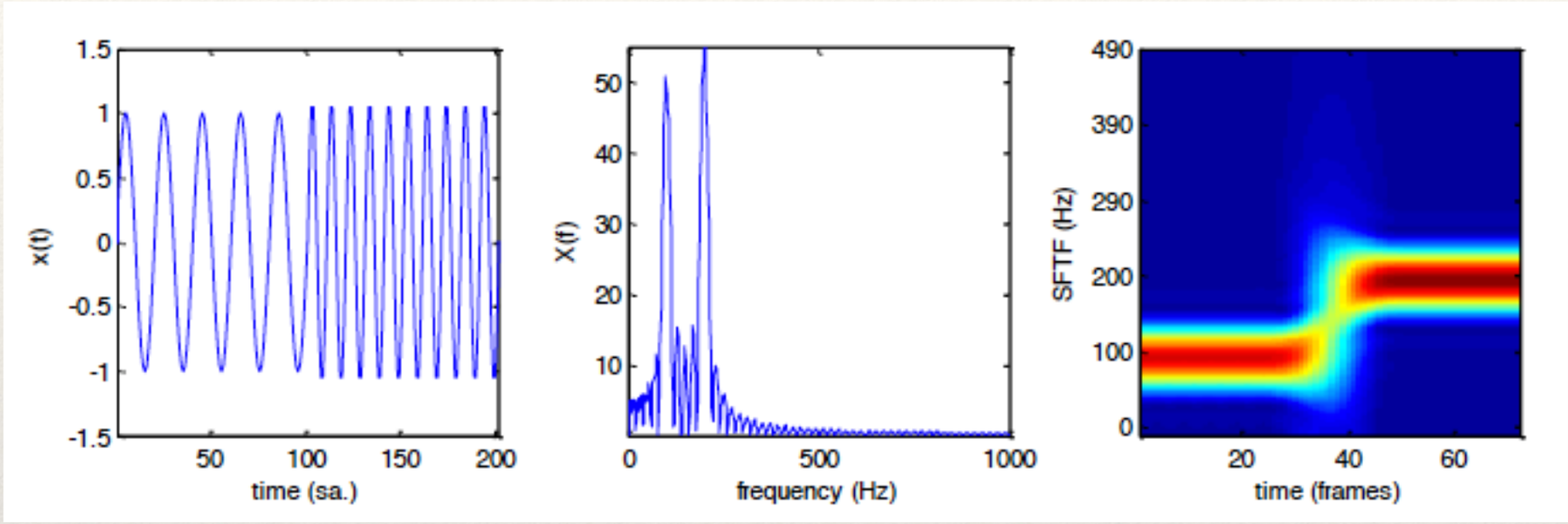
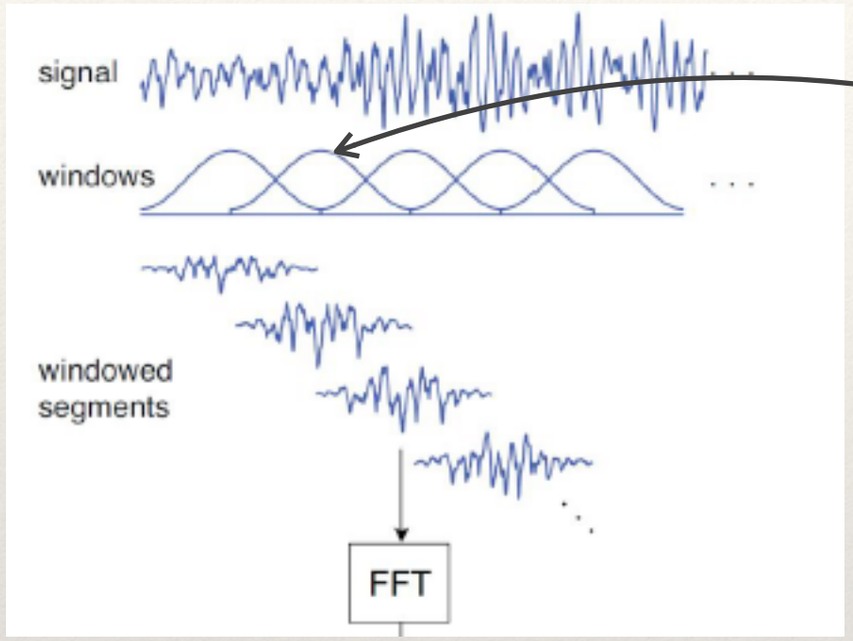
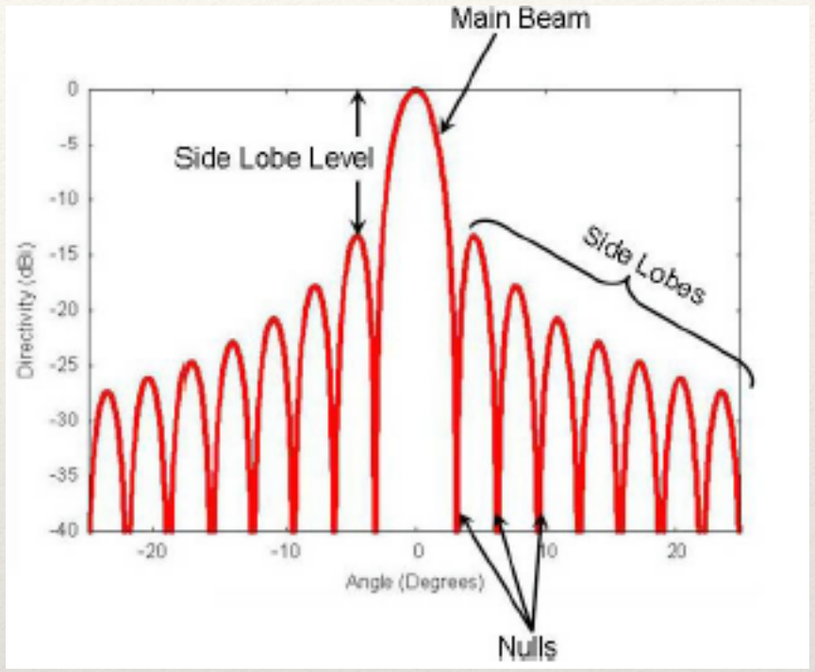
Why do we need time varying Fourier Transform



- When the signal properties change in time
  - DFT will only capture the average spectral character
  - Short-window analysis can indicate the change in spectrum.

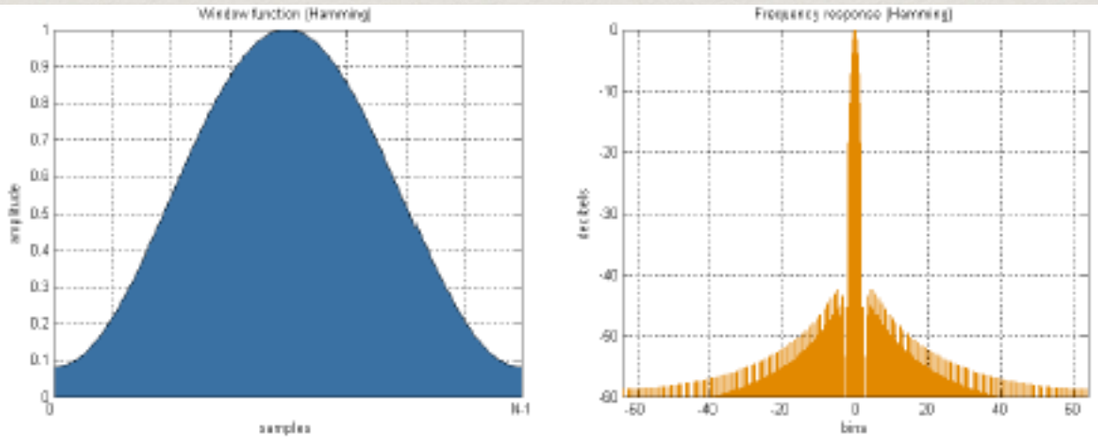
Summary of STFT Properties





$$X[k, n_0]$$

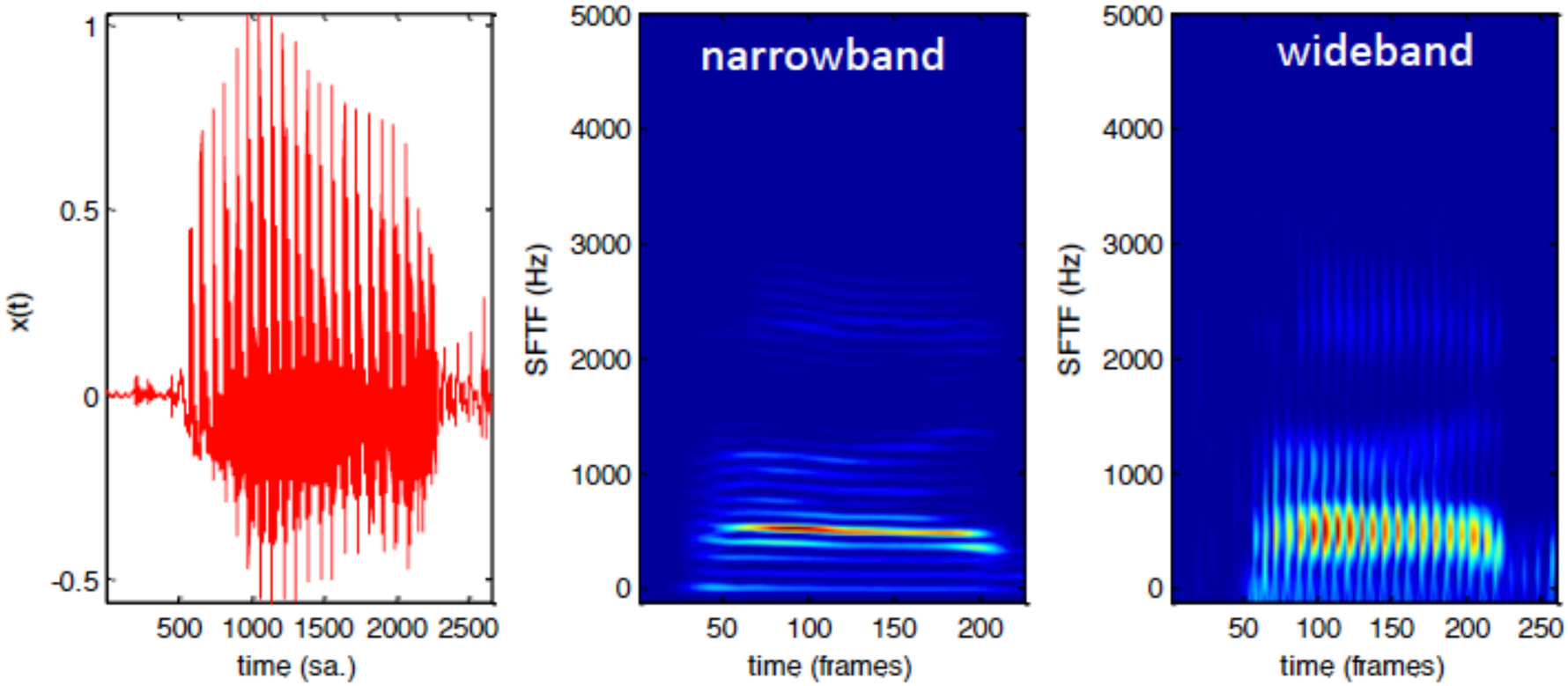
Hamming



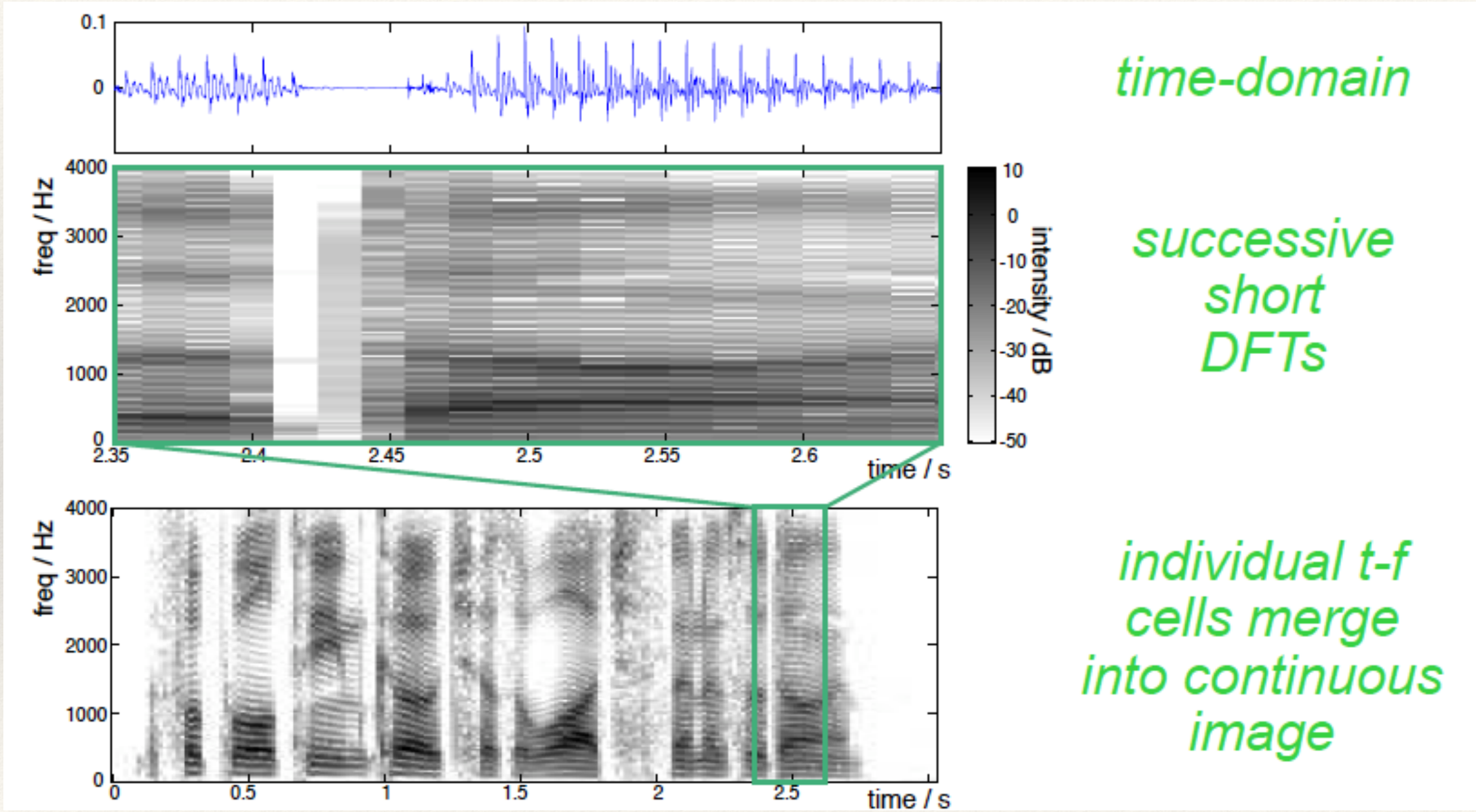
http://en.wikipedia.org/wiki/Window_function

Narrowband versus Wideband

- Short windows - poor frequency resolution - wideband spectrogram
- Long windows - poor time resolution - narrowband spectrogram



Spectrogram of Real Sounds



Dan Ellis, “STFT Tutorial”