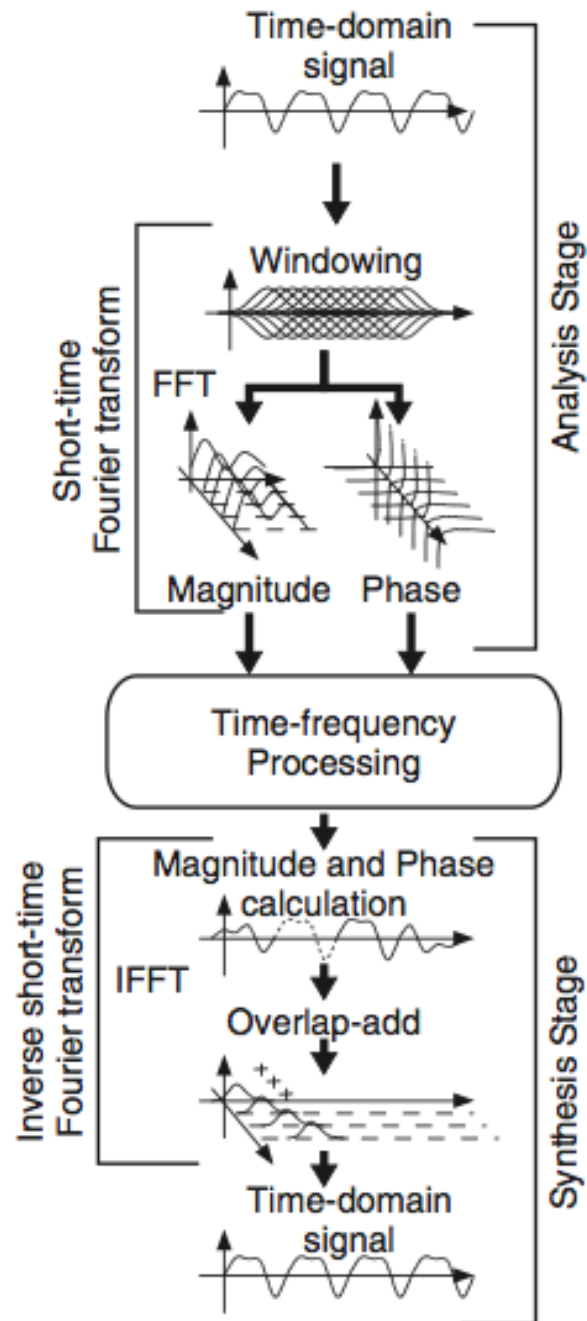# Time-frequency Processing

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Outline

- Framework
  a. analysis - transformation - synthesis
- Phase vocoder basics
  a. time stretching
  b. pitch shifting
- Effects
  a. robotization
  b. whisperization
  c. denoising

Time-domain signal

Windowing

FFT

Magnitude   Phase

Short-time Fourier transform

Analysis Stage

Time-frequency Processing

Magnitude and Phase calculation

IFFT

Overlap-add

Time-domain signal

Inverse short-time Fourier transform

Synthesis Stage

Time Stretching

- Analysis hop size and synthesis hop size are different.
- Phase change per sample is constant.

Pitch Shifting

- Analysis hop size and synthesis hop size are the same.
- Phase change per sample changes.

Robotization

- Put zero phase values on every FFT before reconstruction.

- Apply a fixed pitch onto a sound.

- The result of IFFT is a pulse-like sound and summing such grains at regular intervals gives a fixed pitch.
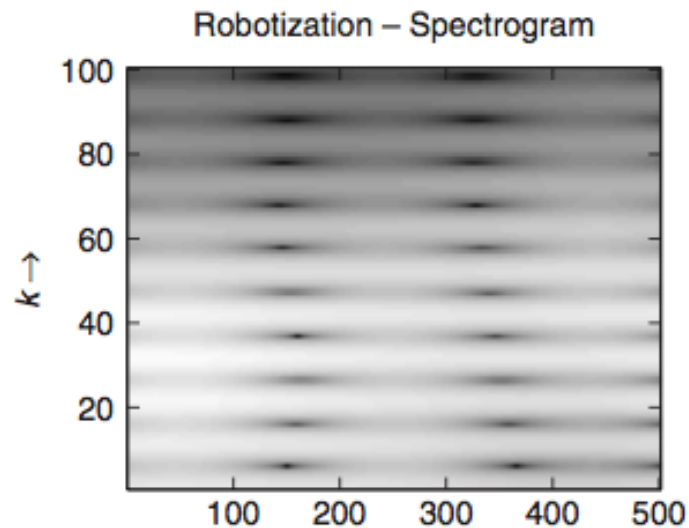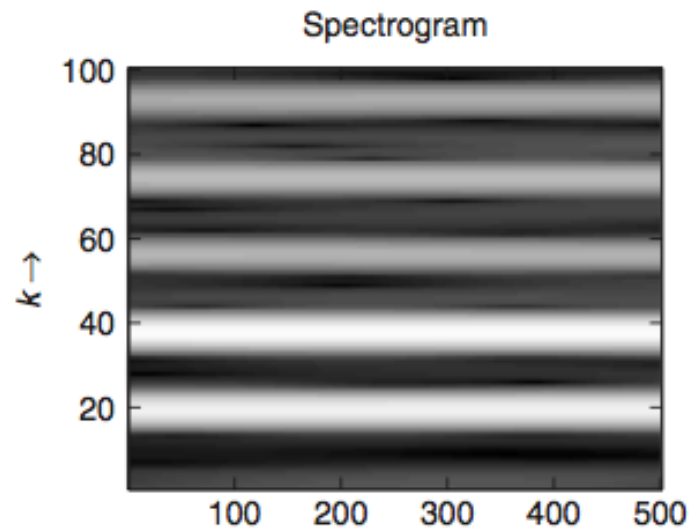
Whisperization

- Impose a random phase on a time-frequency representation.

- Small window will enhance the spectral envelope.

- Alternatively, make a random variation of the magnitude and keep the phase.

Spectrogram

Whisperization – Spectrogram
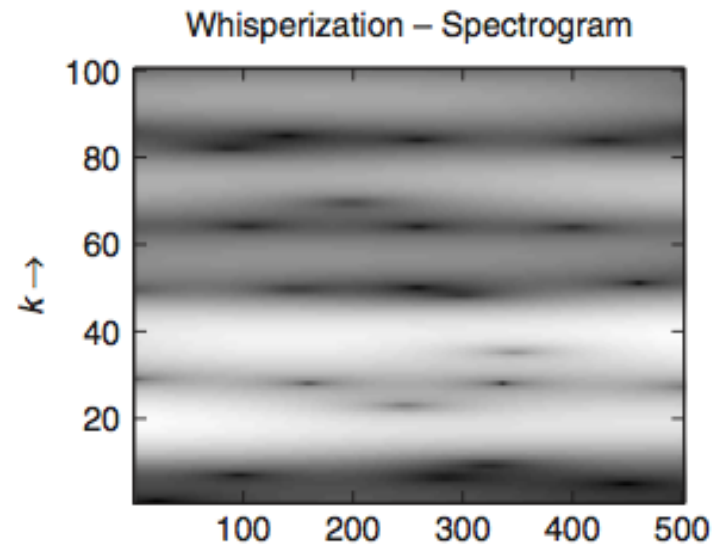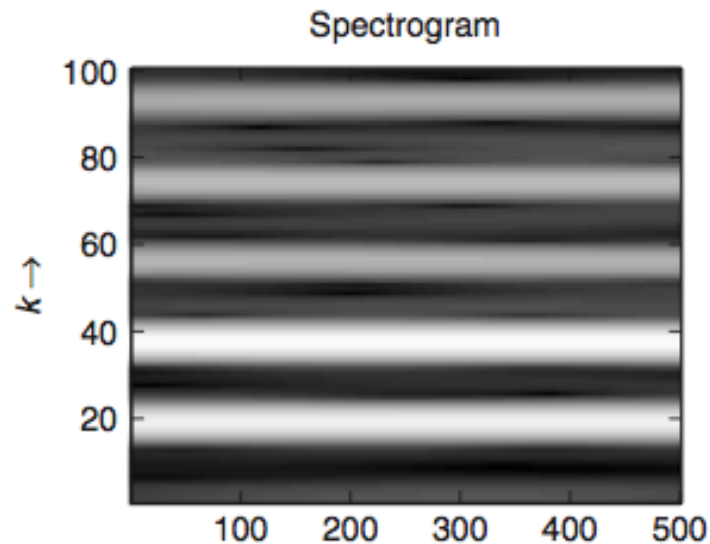
Denoising

- Keep the phase. Attenuate the lower level values of magnitude.

- Apply non-linear noise-gate functions.

$f(x) = x^2/(x+c)$ $f(x) = x/(x+c)$