Causality relationships between frequency components of the firing rate of neurons in patients with Parkinson disease

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Outline
- Parkinson disease/tremor
- Motivation
- MER recordings. Extracting "useful" signals from MER.
- Traditional vs. non traditional methods to analyze tremor
- How to determine the "driving process"?
- Conclusions

What is Parkinson disease?
- Brain disorder that occurs when nerve cells in a part of the brain die or become impaired.
- Most evident symptom is limb tremor.
- The analysis of microelectrode recordings suggest a relationship tremor/neuron spiking

Goal
Determine if there is a causal relationship between frequency components of the intensity process of an MER.

Why is this important?
If there is a causal relation between harmonics of the intensity process, this can be used to improve detection procedures and diagnosis during brain surgery.

MER recordings: Is there any tremor?

Methodology
What do we get from non parametric methods if the signals are non-stationary?
Can we use STFT?
- STFT creates segments of the signal and assumes stationary in each segment.
- If the segments are too short, frequency resolution is poor.

What approach was used in this work?

\[
y(n) = \sum_{k=0}^{\infty} a_k(n) y(n-k) + d(n)
\]

\[
P_y(e^{\omega}, \omega) = \frac{1}{\pi} \sum_{k=0}^{\infty} a_k(n) e^{-j \omega k}
\]

Results

**Patient A**
- Activity around “fundamental” frequency
- 4th harmonic with high intensity.

**Patient B**
- Activity around “fundamental” frequency
- Weak activity at harmonic frequencies

What information about causality can we extract from these results?
- My assumption: “Any change in the frequency components of the firing rate function can be observed as a change in the magnitude of the estimated instantaneous PSD”

Determine profiles at fixed frequencies
- The intensity of the instantaneous estimation of the PSD was calculated at fixed harmonic frequencies.

Conclusions
- Traditional methods to calculate PSD can be misleading when interpreting non-stationary signals.
- Accuracy of the Kalman filter estimates is determined by several factors:
  - Convergence time
  - Initial values of the filter
  - Order of the filter
- A more detailed analysis of the convergence of the filter is required to assure better estimators of the PSD. Nevertheless, the information provided by the filter is a good platform to apply additional techniques.
Better approaches to deal with this problem

- Routines to track the intensity of the PSD over time

Questions?