

CLASSIFICATION TOOL FOR BIRD SONG

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Participants

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The Great Reed Warbler-Trastsångare





- The Great reed warbler has exceptional song capacity and song complexity.
- It sings 50% of the time during the day.
- 30 years of collected data especially at lake Kvismaren.
- Colouring of the birds make it possible to follow a specific individual over a long time.



Sonogram



It is one of the bird species that has been thoroughly studied in terms of song complexity. Usually the sonogram is visually evaluated and the number of different syllables are counted, (approx. 2 hours/bird).



Results: Great Reed Warbler

- Male harem size is connected to long lasting song.
- Song repertoar increases with age for an individual.
- The size of the song repertoar for the male predicts the survival of the children.

Possible for ONE bird but if we would like to compare many birds?



Huge amounts of data and unknown parameters





Possible new questions



- How 'similar' do different birds sing, at the same place and at different places?
- Do they learn from each other over the years?
- What happens when an immigrant moves

in?



What we are going to do.

- A tool that visualizes similarities and differences for a huge amount of recorded data, (different places, birds, years), (2012-13).
- A data base with all collected data, (2012-13).
- Robust methods for extraction of classification features, (2012-14).
- Evaluation, (2012-14)



Automatic segmentation of syllables



An adaptive threshold for the detection and segmentation of syllables is created using two filters of different lengths.



Example: Time-frequency spectra



Two syllables (from different birds) have different lengths and different basic frequency. We are interested to compare structures, not differences frequencies.



There is nothing ambiguous about the ambiguity domain.



Two syllables can have the same structure and just differ in frequency. For a relevant comparison the timefrequency ambiguity domain can be used as this is not related to frequency but to other structures.



Problem: The spectrogram is 'noisy'





Possible solution: Multitapering





What is multitapering?

- An average of (almost) uncorrelated spectrograms, (typically 4-10).
- Suggested by D. Thomson in 1982 using the Slepian functions as multitapers.
- The Welch method or WOSA is also a multitaper method, where the same time-shifted window are applied.
- The variance (noise) is reduced with increasing number of tapers.
- Possible to design the tapers as well as weighting for the different spectrograms for small bias or small variance for a specific shape of spectra, e.g., peaked spectra.



Multitapers cont'd

- Any quadratic (Cohen's class) time-frequency kernel can be implemented using multitapers.
- Using multitapers result in a very computationally efficient implementation of time-frequency realizations!
- Other properties, such as pre-defined bandwidth can be included in the design.
- Optimal time-frequency kernels and multitapers can be computed for special types of non-stationary processes.



Example of ERP from the brain





 Using optimal weighting of the multitaper spectrogram we can have both better bias and variance properties compared to usual spectrogram and equally weighted multitaper spectrogram.



SSVEP at 12 Hz between 5-10 s.



0.1

0.05

0

Ό

200

400

Time

600



Example

The Wigner-Ville and Choi-Williams kernels are approximated using special multitapers from a pre-defined time-frequency resolution bandwidth. The method was also shown to be very robust to noise.



Optimal time-frequency estimator for local stationary processes (LSP).



Different types of LSP

- The LSP process could be an appropriate model for bird song syllables.
- The mean square error optimal timefrequency kernel and multitapers can be computed from known parameters.
- New: The parameters of the LSP can be estimated from data UNIVERSITY

The end: Thank you!





Some references

- D. J. Thomson, Spectrum estimation and harmonic analysis. Proc. of the IEEE, 70(9):1055-1096, Sept 1982
- M. Hansson, Optimized Weighted Averaging of Peak Matched Multiple Window Spectrum Estimates, IEEE Trans. on Signal Processing, Vol. 47, No. 4, 1141-1146, April 1999
- M. Hansson-Sandsten, Multitaper Wigner and Choi-Williams distributions with predetermined doppler-lag bandwidth and sidelobe suppression, Signal Processing, vol. 91, pp. 1457-1465, 2011.
- M. Hansson-Sandsten, Optimal estimation of the time-varying spectrum of a class of locally stationary processes using Hermite functions, EURASIP Journal on Advances in Signal Processing, Volume 2011, Article ID 980805, 2011.

