Bioacoustic Monitoring in Realistic Scenarios

with an emphasis on periodicity in birdsong

Daniel Wolff(1, **daniel.wolff.1@city.ac.uk**),
Martina Koch(2), Rolf Bardeli(3), Klaus-Henry Tauchert(2),
Frank Kurth(4), Karl-Heinz Frommolt(2) and Michael Clausen(5)

1 CITY UNIVERSITY LONDON 2 Tierstimmenarchiv 3 Fraunhofer IAIS 4 Fraunhofer FKIE 5 universität bonn

Project: Bioacoustic Pattern Recognition

In 2006, a R+D project "Bioacoustic Pattern Recognition" funded by BfN and BMU was set up aiming at a transfer of established techniques in speech recognition and music information retrieval to problems typically met in bioacoustics. Its focus was set on the automated detection of particular animal species in natural environments.

The Animal Sound Archive at Humboldt University, Berlin delivered the precisely annotated data necessary for the development of recognition algorithms. Furthermore, the acquisition of a great amount of acoustic monitoring data was performed by experts from this institution. Afterwards, at the University of Bonn, detection algorithms were developed for specific endangered bird species, utilising newly developed methods for denoising in nature recordings and periodicity analysis. We here sketch the algorithms used for birdsong detection as well as a general overview of the project and subsequent research including special requirements for unsupervised monitoring.

Application Scenario: Parstein Lake

Parstein Lake in Brandenburg, Germany.

- acoustically well-conditioned landscape (flat, water, cane brake)
- Nature conservation area : habitat for endangered species

2 Scenarios:

Moving GPS-tracked boat

Stationary long-term recording

General Results

Evaluation of elementary assumptions on

- the scope of application scenarios
- efficiency of the computational monitoring approach

The computational evaluation of monitoring recordings introduces a potent technique complementary to existing means for monitoring animal populations:

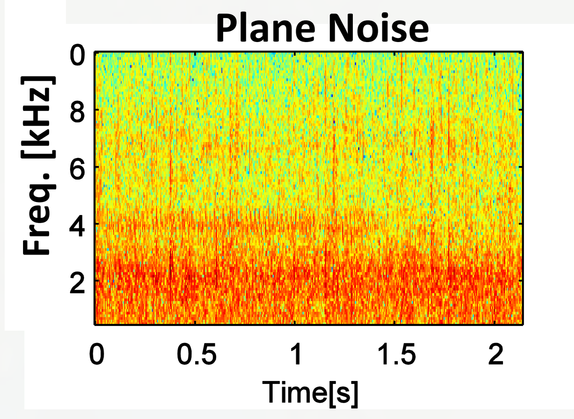
1. The data acquisition step can be efficiently performed during long periods in absence of a human observer: useful for the censusing of rare or nocturnal species.
2. Disruption of the monitored animals is highly reduced where presence of a human observer is no longer necessary.
3. Recording equipment can be placed in areas that are difficult to access
4. Consistent detection accuracy is achieved: the computational 'listener', is only subject to the quality of the recording.
5. Results can be verified by reinspecting the raw audio data. This can be done by ornithologists or improved algorithms.
6. Approved detection routines can be operated by technical personnel and with minimal interaction of trained ornithologists.

Robust Detection in Noisy Environments

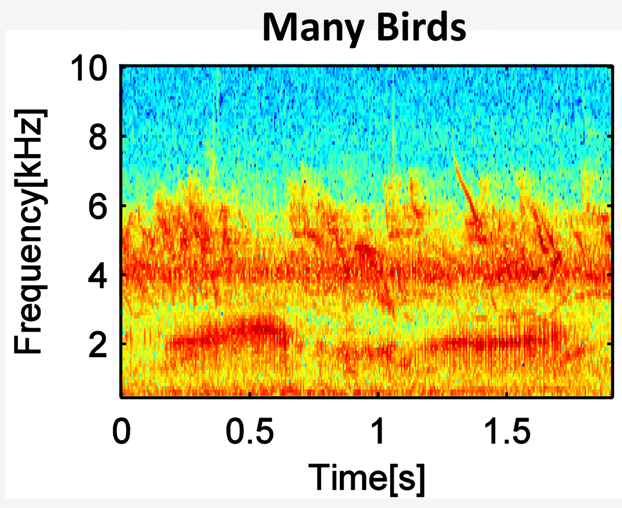
Unlike the usual recordings performed by ornithologists, monitoring recordings can contain a dense assemblage of acoustic events:

- Volume of a targeted species is outperformed by other animals.
- Complex mixture of diverse noise sources complicates the automatic detection of bird voices
- Environmental noise (wind, rain)
- Noise of planes and trains

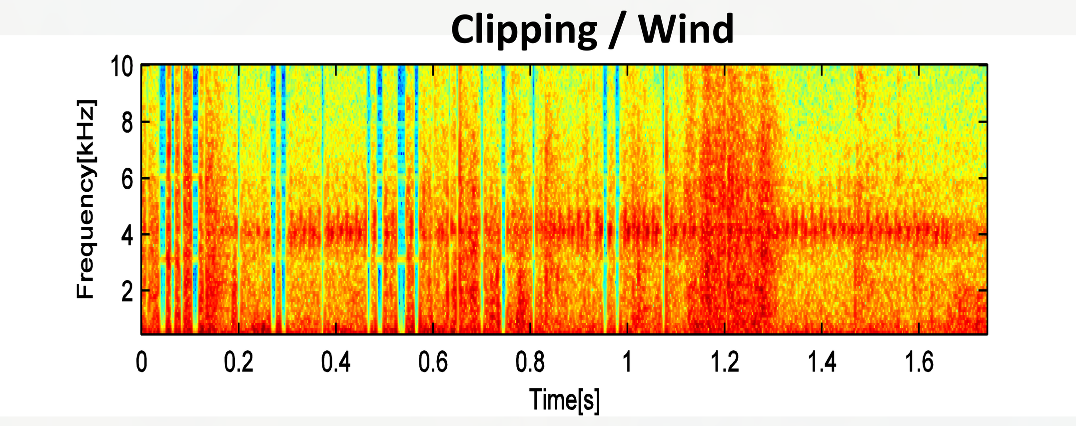
Plane Noise



Many Birds



Clipping / Wind

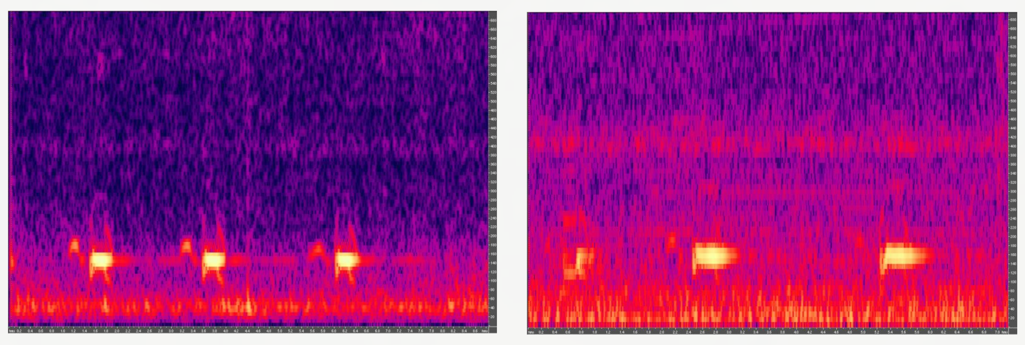


Simple Calls: Eurasian Bittern

- Endangered species
- Simple call consists of two sinusoidal tones
- Structural details lost with distance

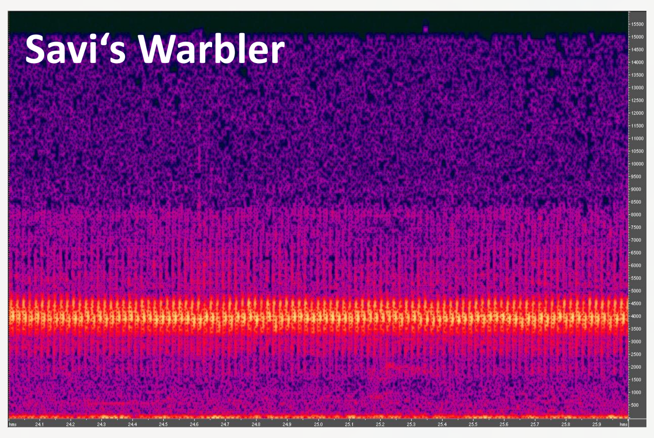
Detection:

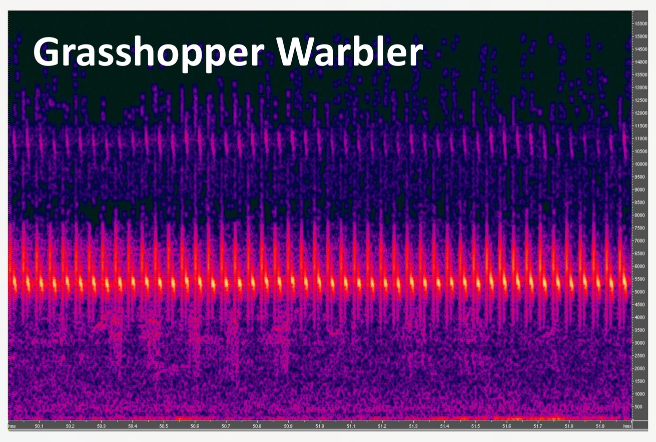
- Energy + autocorrelation in sub-band
- De-noising using flanking band w/o bird signal



Evaluation: On 7 hours audio annotated by experts. 246 detections, 84 false pos., 10 false neg.

Periodic Songs: Savi's and Grasshopper Warbler



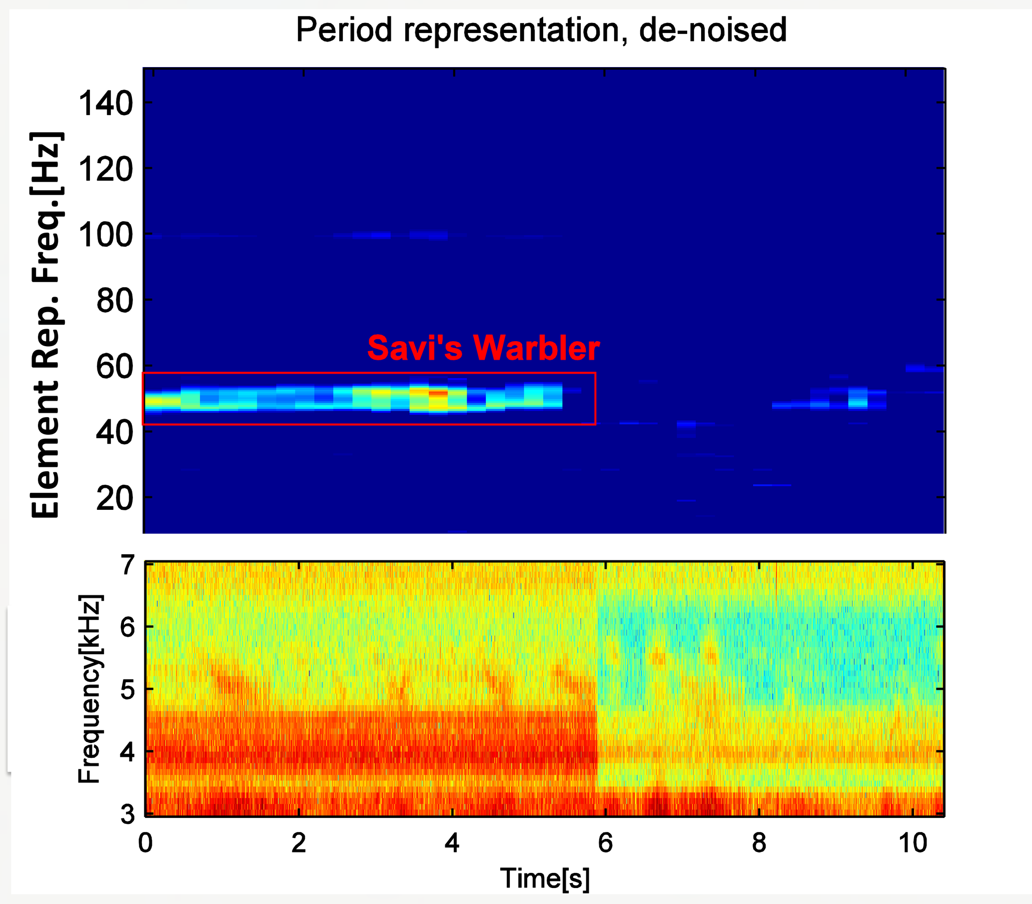


Songs of many birds of the Locustella family are based on the fast repetition of simple spectral elements.

Parameters of this repetition can be robustly extracted:

- Center frequencies,
- Element repetition frequencies
- Bandwidths

Songs of many songbirds contain such phrases of repeating patterns, which encourages an application on more complex songs.



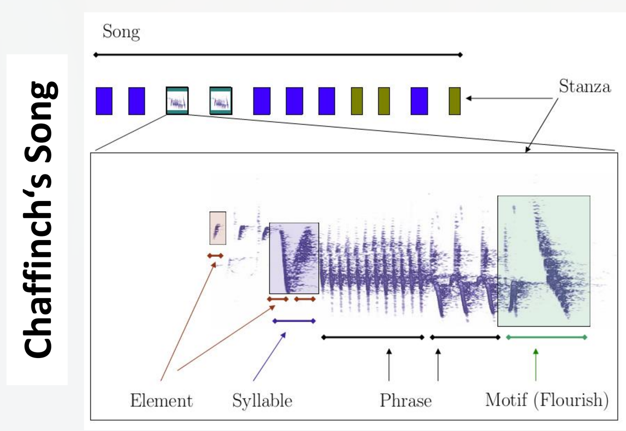
Rule-based detection using robust features:

1. Extract sub-bands with high periodicity.
2. Energy change on/offset detection
3. Element repetition freq. via autocorrelation
4. Subtract flanking band periodicities
5. Spectral centroid and bandwidth features
6. Classification via thresholds determined by experts on long-time recordings

Evaluation: On 19 hours, 92.5% singing time correctly identified. 80.5% in rainy / windy recordings

Application to Further Species

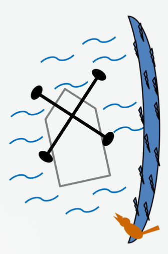
- Robust periodicity features useful for multiple species
- Directly applicable to Locustella family, frogs, crickets
- Open Source: implemented in XBAT
- Implemented into Animal Sound Archive Web Interface
- Application into higher-level models promising

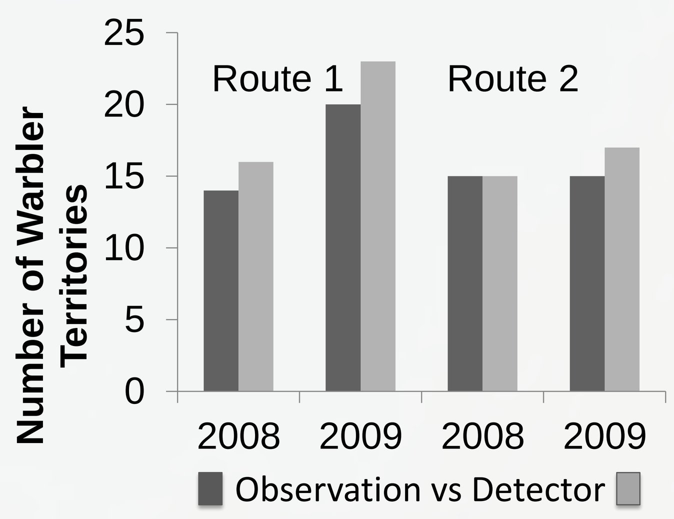


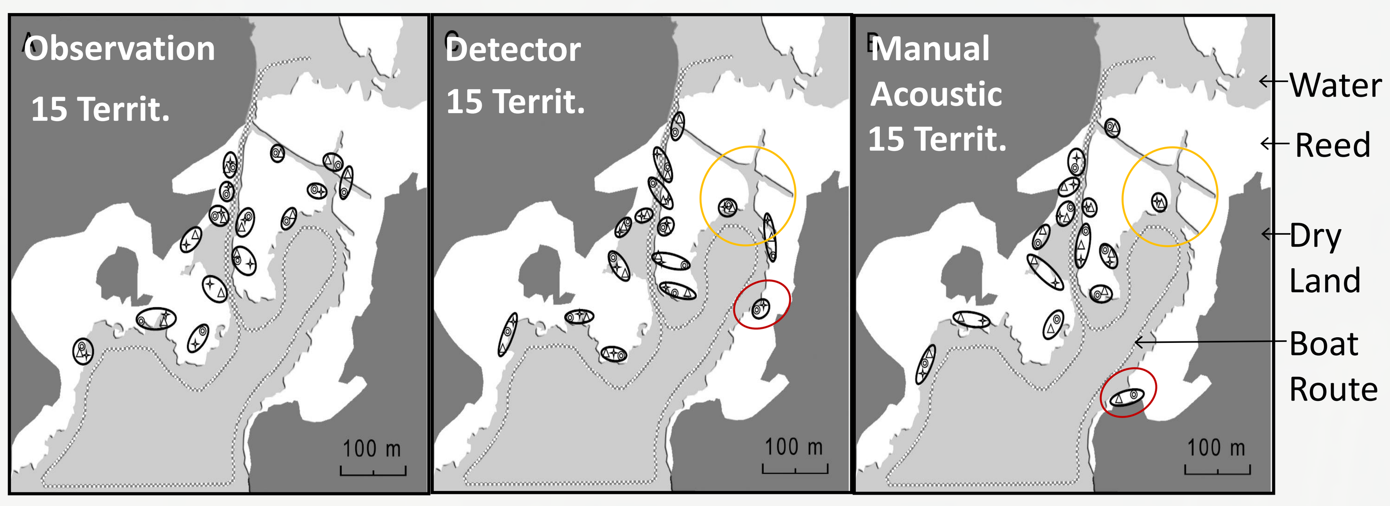
Territory Detection: Moving Recording + GPS

A boat is used to move along the reed edge with constant pace (30m/h) whilst recording audio with 4 channels. The audio recording is annotated with the boat's GPS position every 30 seconds.

- 2 parts, 2 hours of audio in total per trip
- Territories are annotated during trip for ground truth
- Localisation using GPS + 4 channel audio with direction estimation via periodicity







Legend: ◎ 27.04.2008 △ 02.06.2008 ✧ 09.06.2008 ⬭ Deducted Territory

References:

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