Bat@Edge

Real-time on-device classification of bat and bird calls
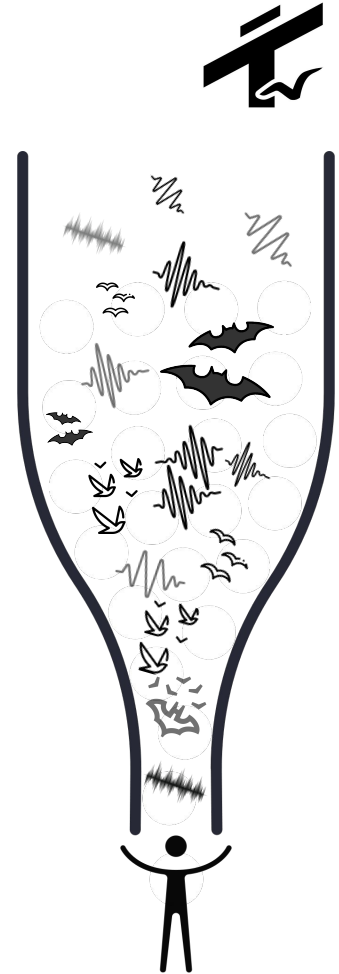
TDFF 2025 Blaubeuren
Dr. Jannis Gottwald, Dr. Artur Sterz, Dr. Jonas Höchst & Markus Vogelbacher

Motivation

Scalable solutions for the permanent monitoring of bats are urgently needed.

Acoustic monitoring is THE (non-invasive) method for monitoring bats.

➔ **Problem:** Automatic recordings lead to huge amounts of data that have to be analysed retrospectively
  ◆ Impossible to manage without the help of automatic classification software
  ◆ Time-consuming reclassification necessary
  ◆ Large time lag between recording and result
  ◆ Permanent monitoring installations unthinkable at many locations over several years

➔ **Solution:** Real-time AI execution on the detectors in the field
  ◆ Enables fast, flexible responses
  ◆ Reduces data volume
  ◆ Reduces human workload and enables long-term monitoring of multiple sites 24/7

The Bat@Edge Concept

- AI Model for the real-time recognition of **bats**, birds, amphibs, locusts...
  - needs to be fast, and precise with low computational power demands
- Power-autonomous stations equipped with AI-capable computing unit
- Operating system that allows for real-time data transmission and flexible configuration to reduce data
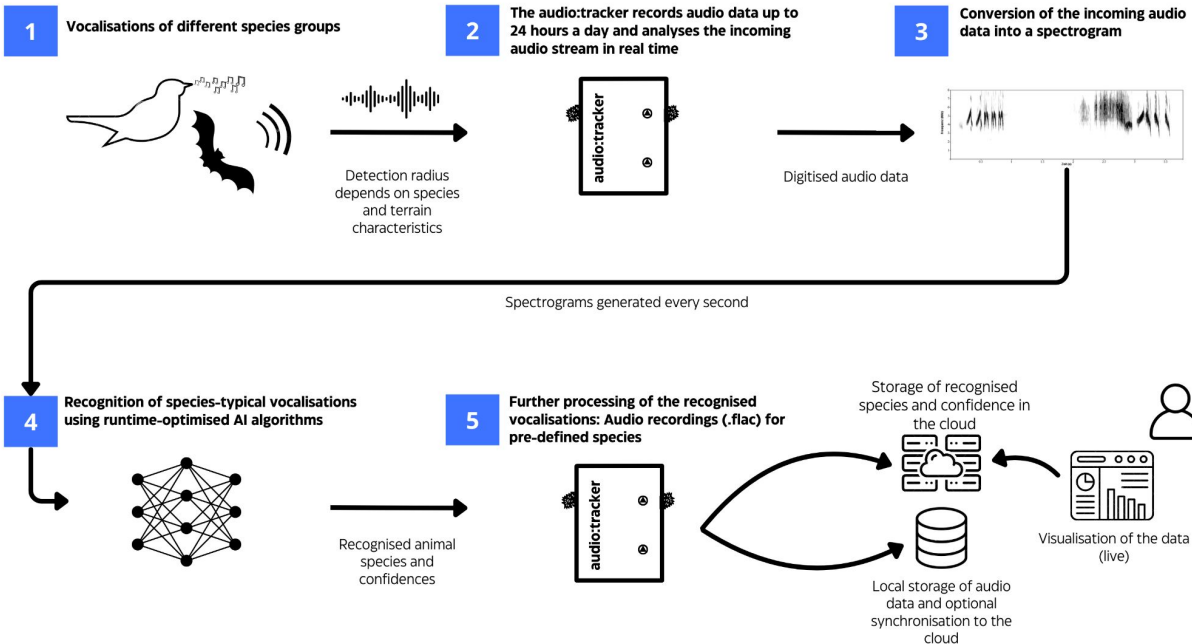
audio:tracker
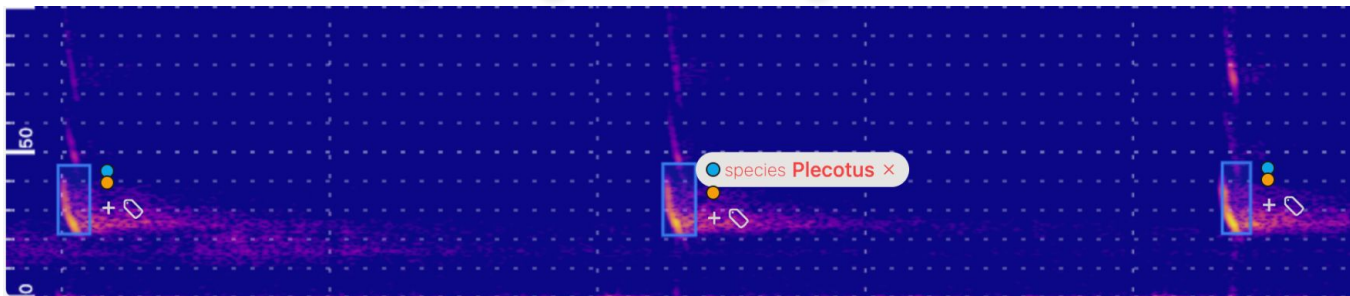## Flexibly configurable intelligent real-time audio monitoring system

Real-time detection of vocalizing species with the audio:tracker

trackIT systems

1 Vocalisations of different species groups

Detection radius depends on species and terrain characteristics

2 The audio:tracker records audio data up to 24 hours a day and analyses the incoming audio stream in real time

Digitised audio data

3 Conversion of the incoming audio data into a spectrogram

Spectrograms generated every second

4 Recognition of species-typical vocalisations using runtime-optimised AI algorithms

Recognised animal species and confidences

5 Further processing of the recognised vocalisations: Audio recordings (.flac) for pre-defined species

Storage of recognised species and confidence in the cloud

Visualisation of the data (live)

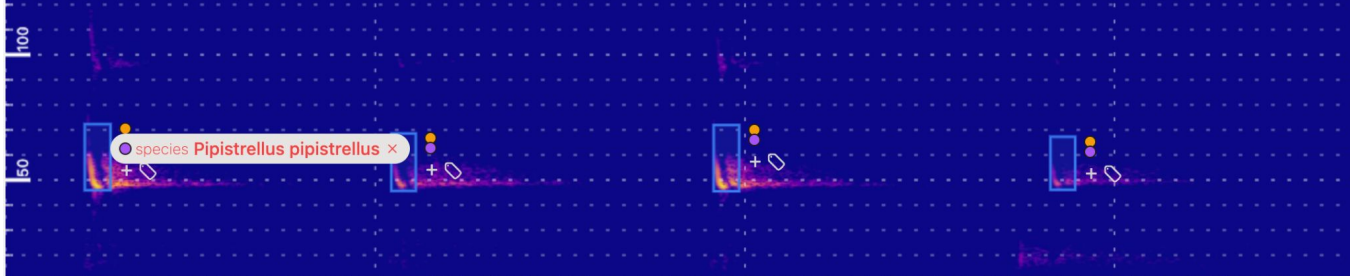Local storage of audio data and optional synchronisation to the cloud

audio:tracker
Flexibly configurable intelligent real-time audio monitoring system
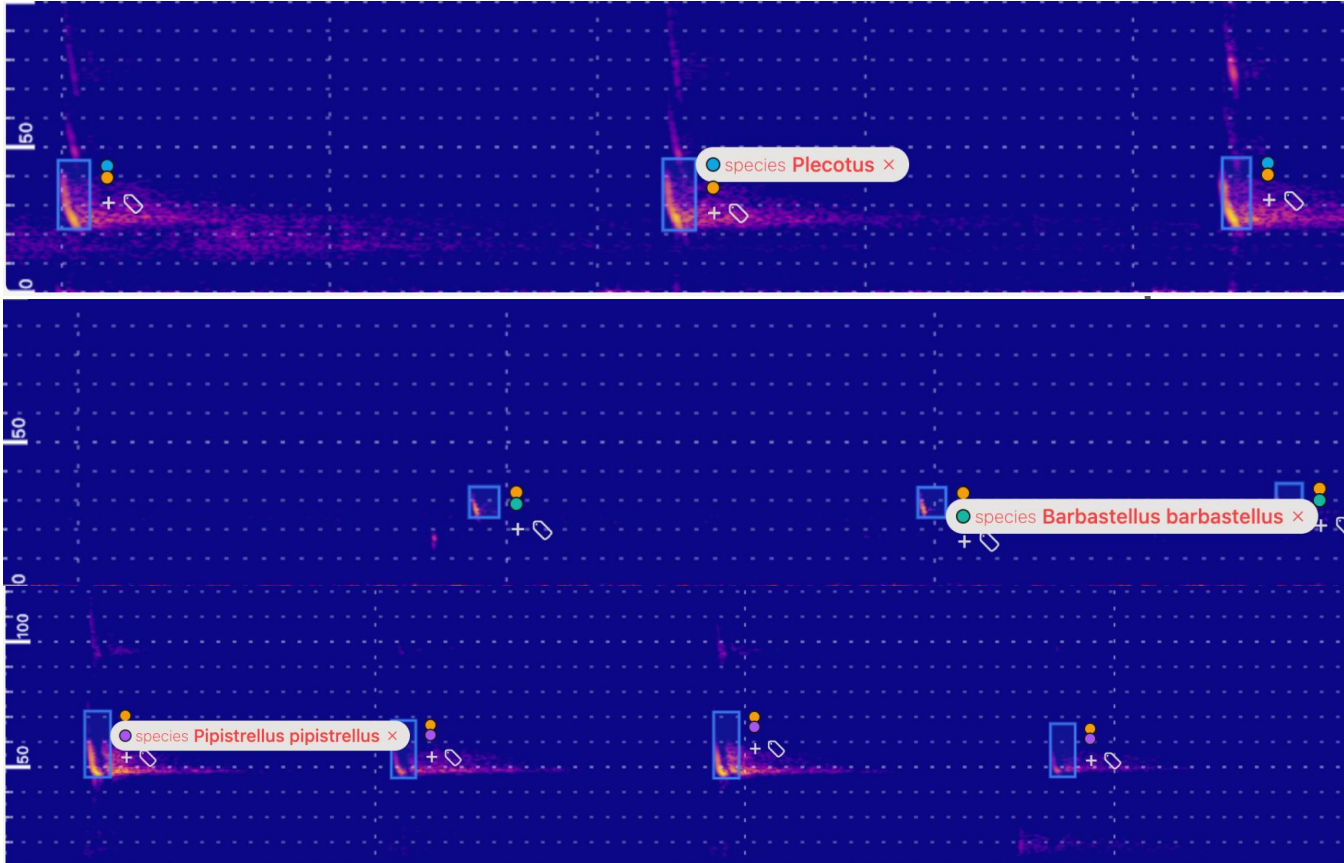

Save everything as an audio file

Save everything > 70% confidence as an audio file

Save 10% of the calls as an audio file

audio:tracker
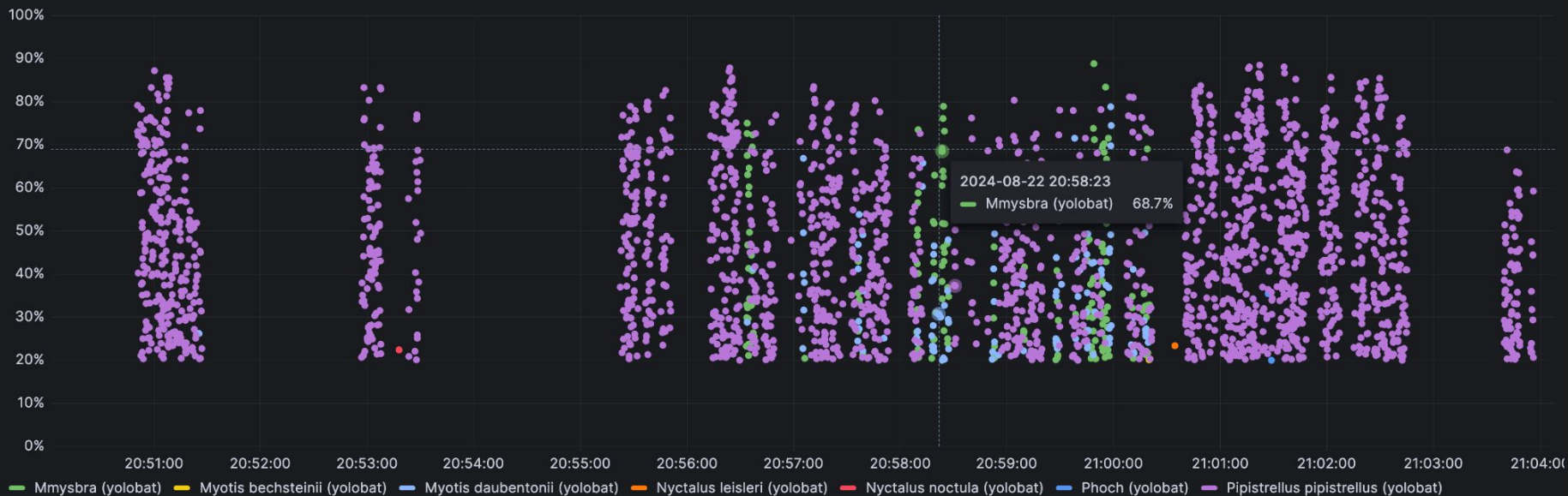## Flexibly configurable intelligent real-time audio monitoring system

Detections are sent COMPLETELY to the backend

The Bat@Edge Concept

YOLO:bat
State of the Art AI Model for the recognition of bat calls

YOLO11 (Ultralytics)

Highest accuracy, speed and efficiency in object detection and classification

Mehmet Emin Aruk LinkedIn'de: YOLO v11: Temel Düzeyde Görsel Nesne Tespiti Nasıl Yapılır?

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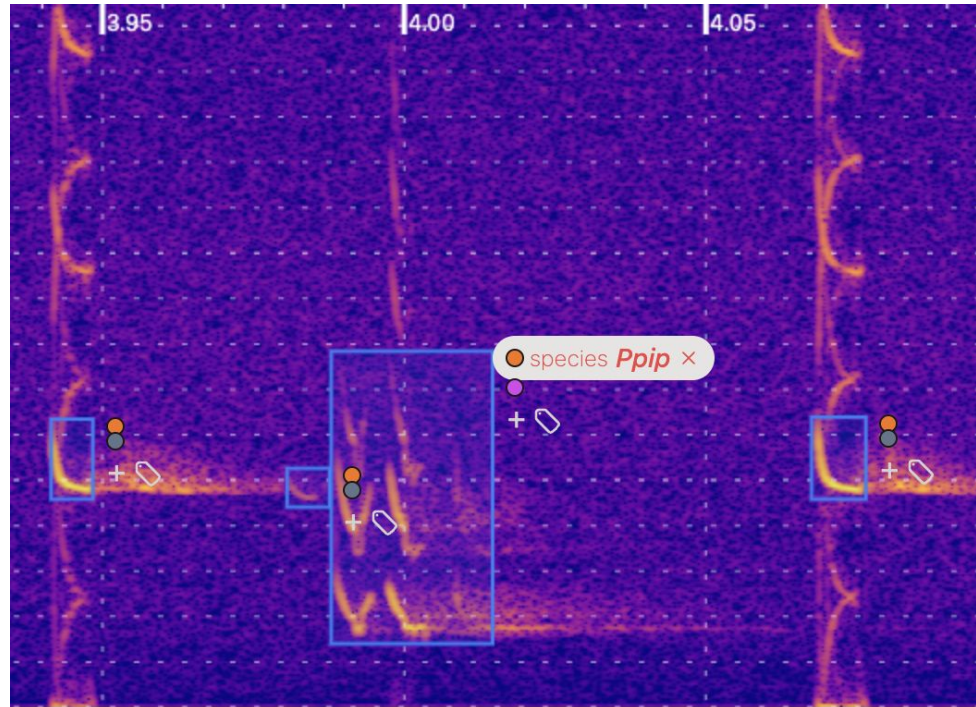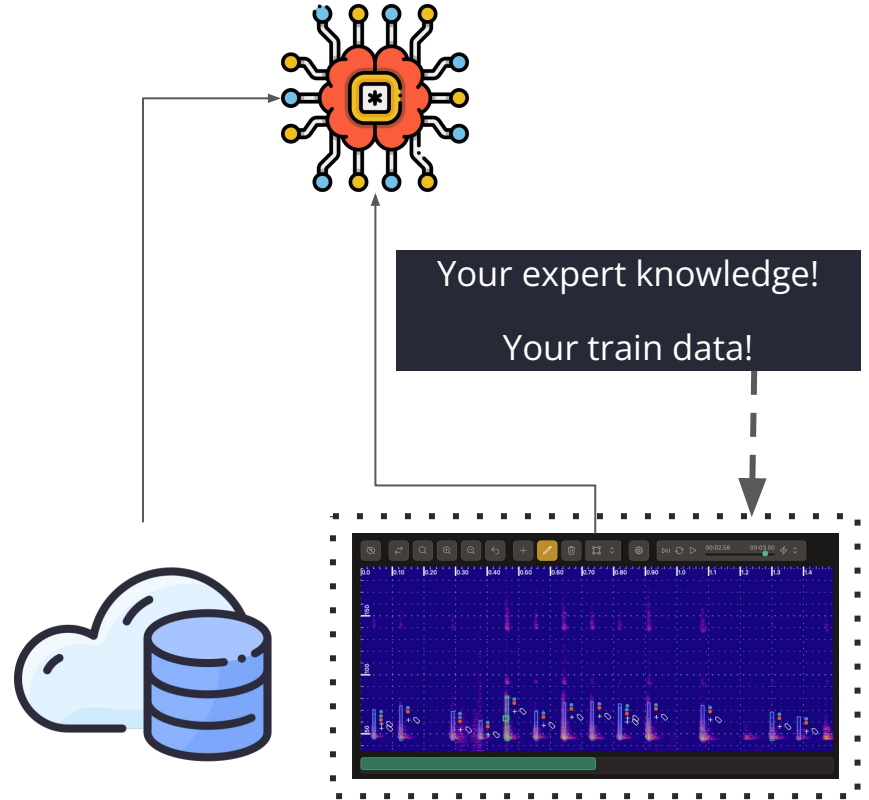
YOLO:bat

Results for uncorrelated training and testing (file-based split)

Species	n calls train	n calls test
Mbart	4797	937
Ppip	3297	685
Mdau	2814	767
Mmyo	2623	590
Eser	2491	587
Mnat	2244	641
Pnat	2142	557
Mbec	2068	740
Bbar	1904	423
Malc	1588	382
Mema	1583	332
Ppyg	1496	522
Plecotus	1445	379
Rhip	1300	192
Nlei	904	167
Mdas	838	292
Nnoc	721	166
Rfer	661	213
social-call	83	12
feeding-buzz	71	14

Confusion Matrix Normalized
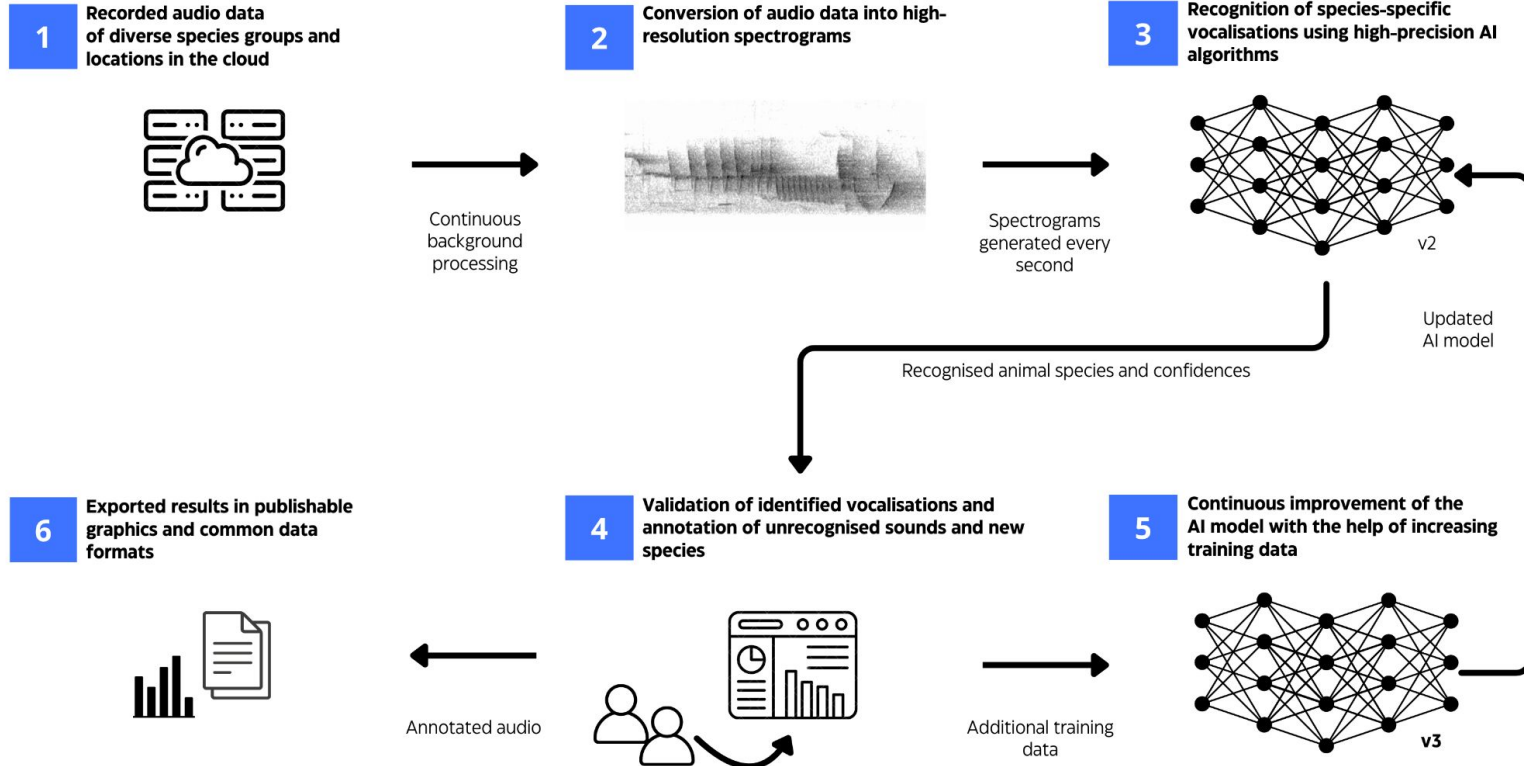
Getting better!

AI is not perfect:

⟹ Needs training data   →**YOU!**

⟹ Needs verification by experts →**YOU!**

Currently available:

- On-device AI for real-time classification
- Powerful server AI for the classification of data from other sources (BC, BL, Audiomoth...)
- Annotation tool for validation
  - Verified data goes back to AI
  - AI is constantly improving

Your expert knowledge!

Your train data!

Active AI learning process through automatic recognition and interactive validation of vocalizations

1 Recorded audio data of diverse species groups and locations in the cloud

2 Conversion of audio data into high-resolution spectrograms

3 Recognition of species-specific vocalisations using high-precision AI algorithms

Continuous background processing

Spectrograms generated every second

v2

Updated AI model

Recognised animal species and confidences

6 Exported results in publishable graphics and common data formats

4 Validation of identified vocalisations and annotation of unrecognised sounds and new species

5 Continuous improvement of the AI model with the help of increasing training data

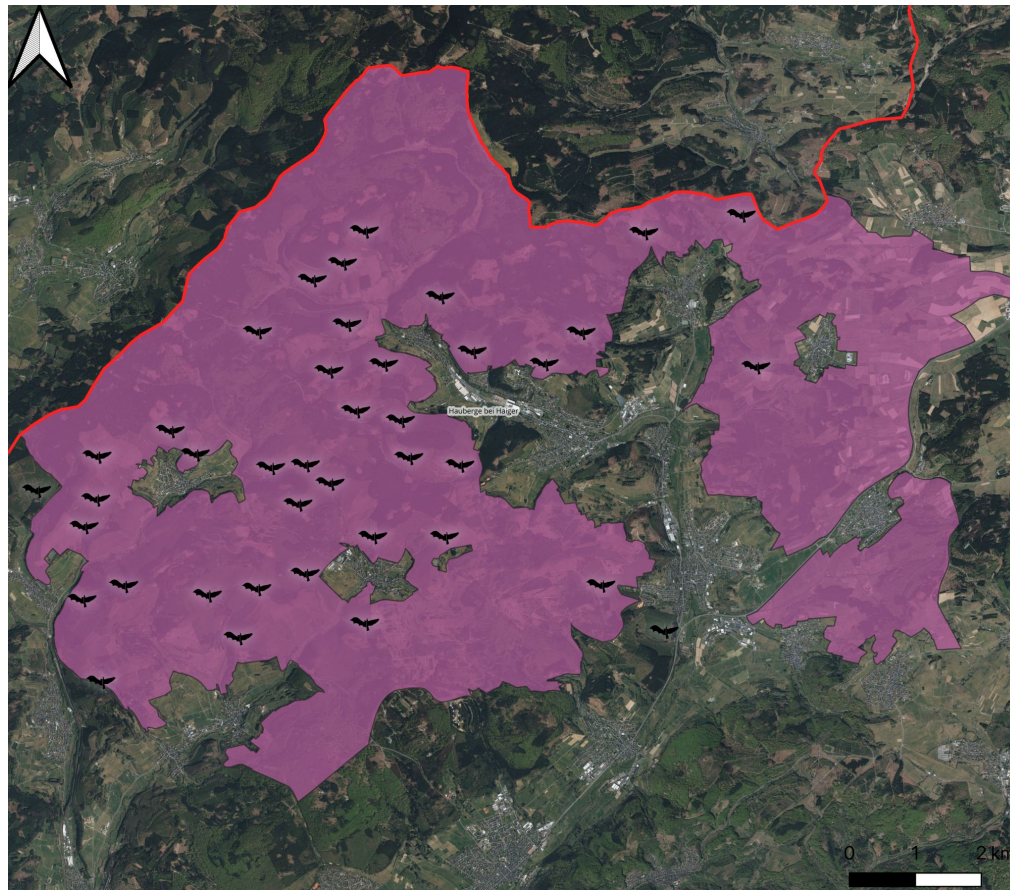Annotated audio

Additional training data

v3

Field test

40 stations for bird and bat monitoring in the Natura200 area "Hauberge bei Haiger"

- Sunrise to sunset = birds
- Sunset to sunrise = bats

Financed by:

Field test

13 (15) Species

Barbastella barbastellus
Pipistrellus nathusii
Pipistrellus pipistrellus
Pipistrellus pygmaeus
Myotis brandtii/mystacinus
Myotis bechsteinii
Myotis daubentonii
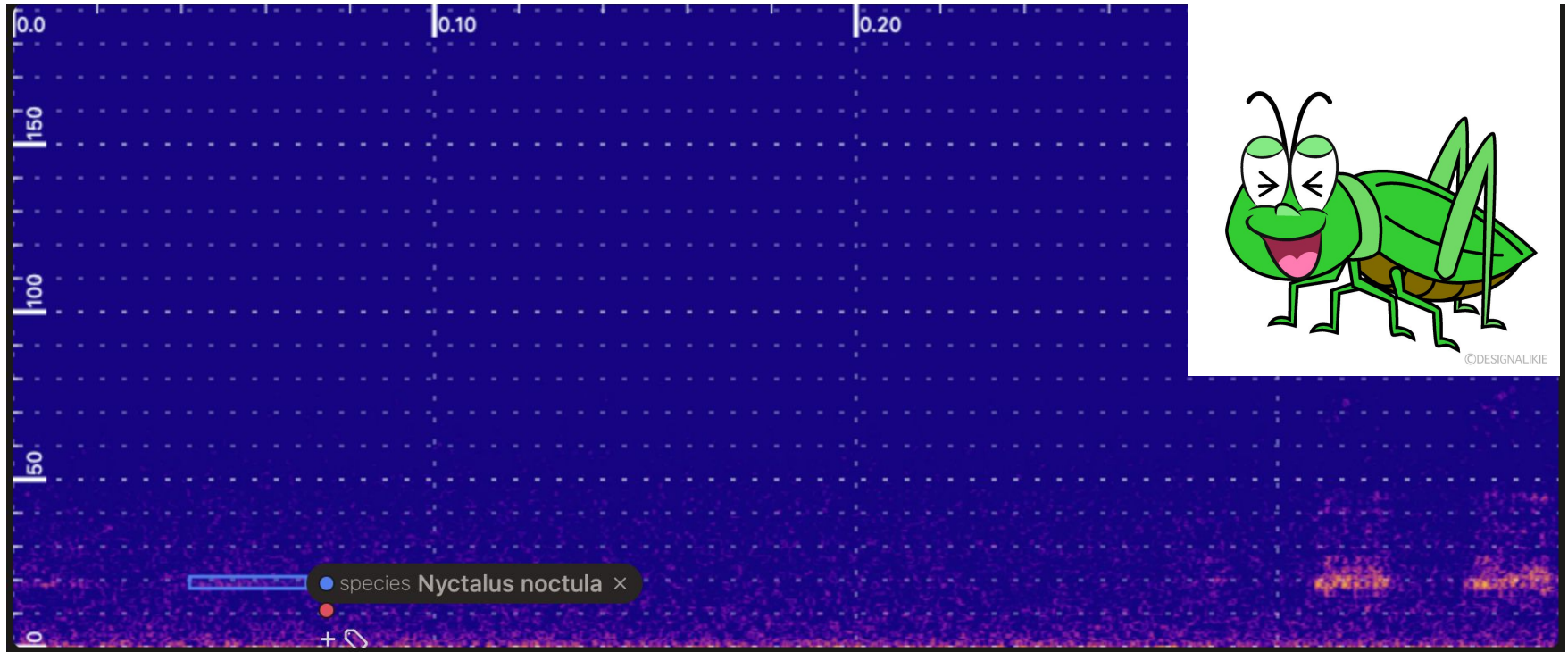*Myotis nattereri*
Myotis myotis
Nyctalus leisleri
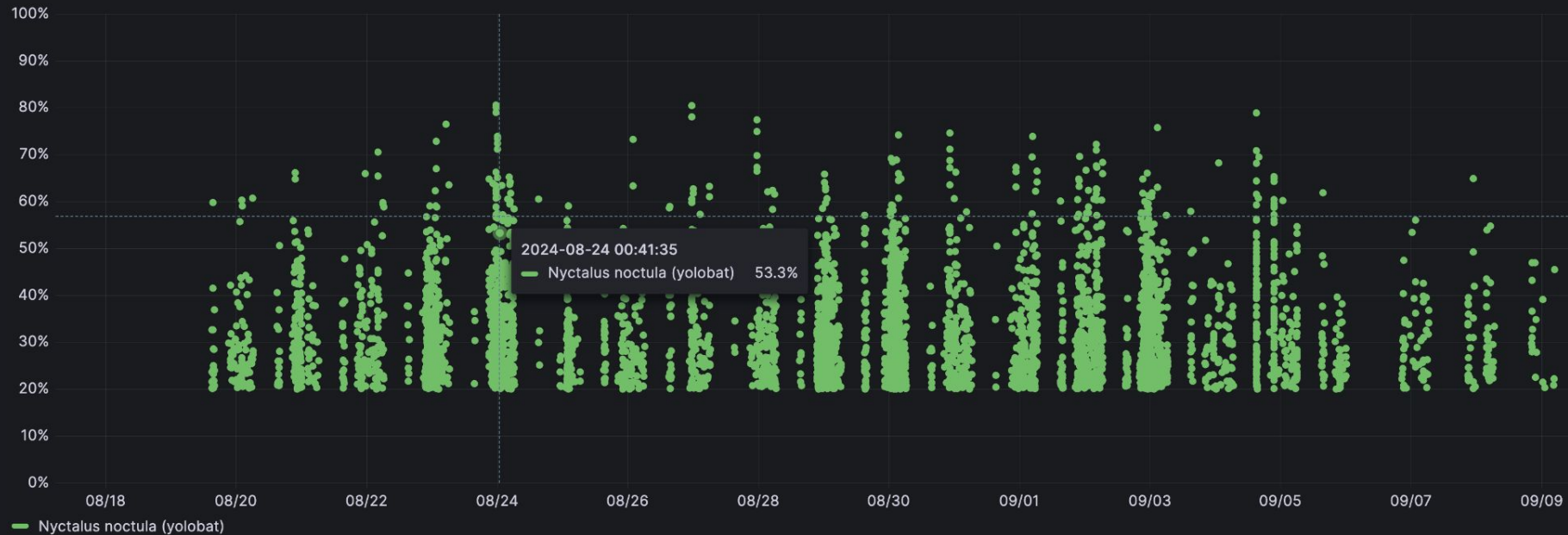*Nyctalus noctula*
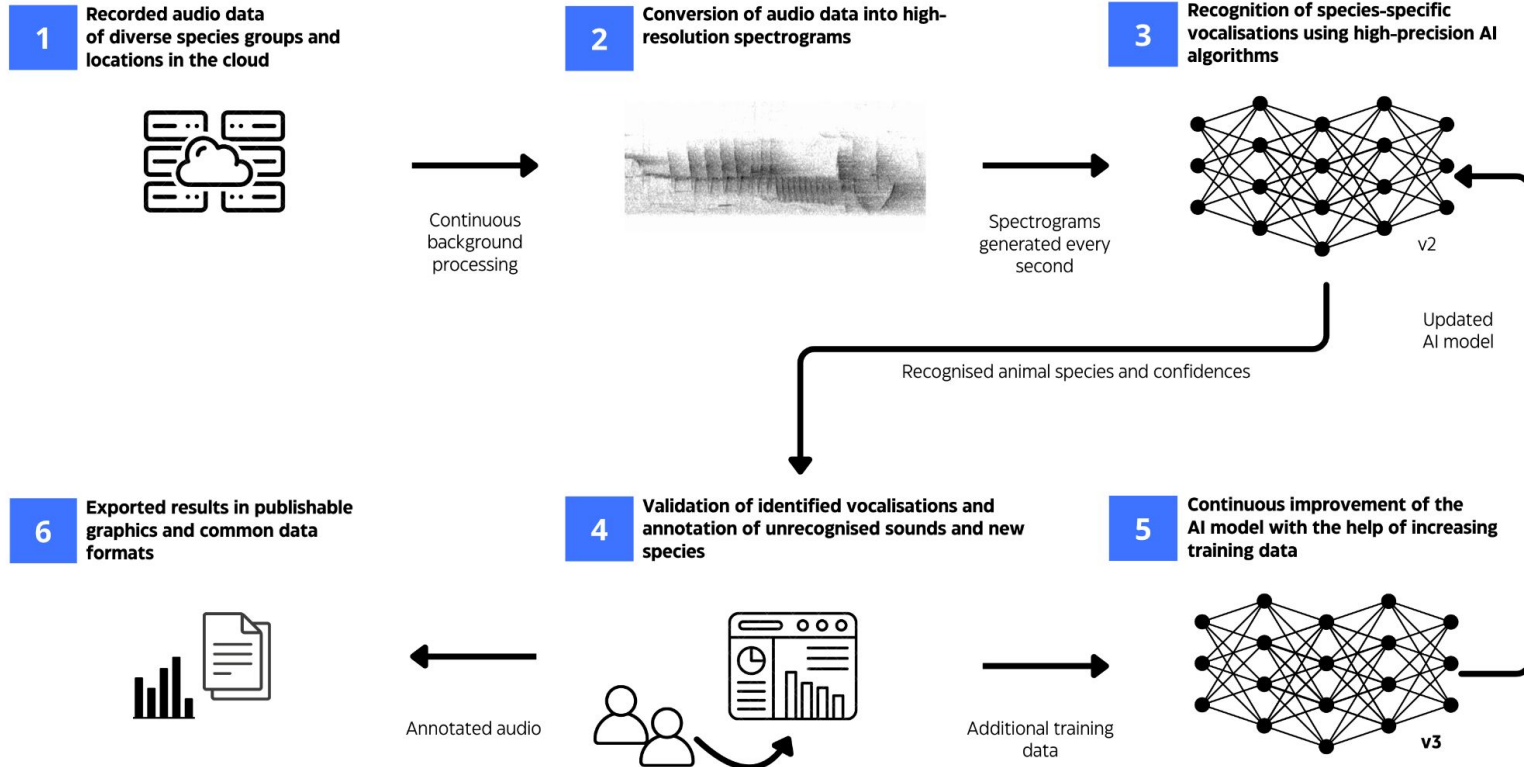*Eptesicus serotinus*
Plecotus austriacus/auritus

Field test

Field test

Recognition Confidence

2024-08-24 00:41:35
— Nyctalus noctula (yolobat)   53.3%

— Nyctalus noctula (yolobat)
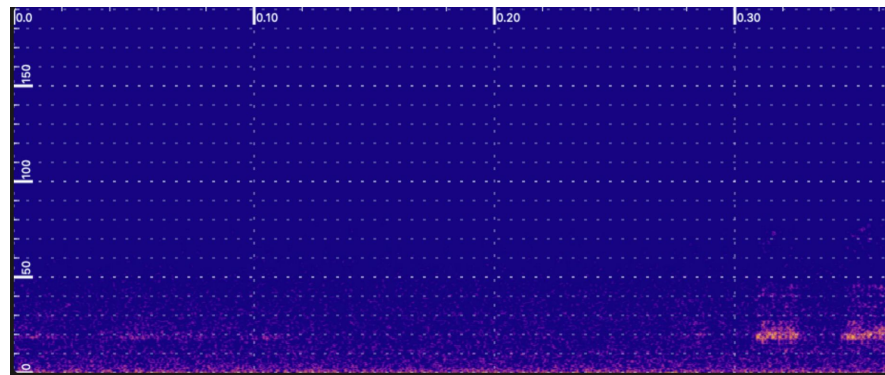
Active AI learning process through automatic recognition and interactive validation of vocalizations

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Annotated audio

Additional training data

v3

Getting better!

Old

New

Crickets

Getting better!

Time: 4.4864 s, Freq: 183.76 kHz
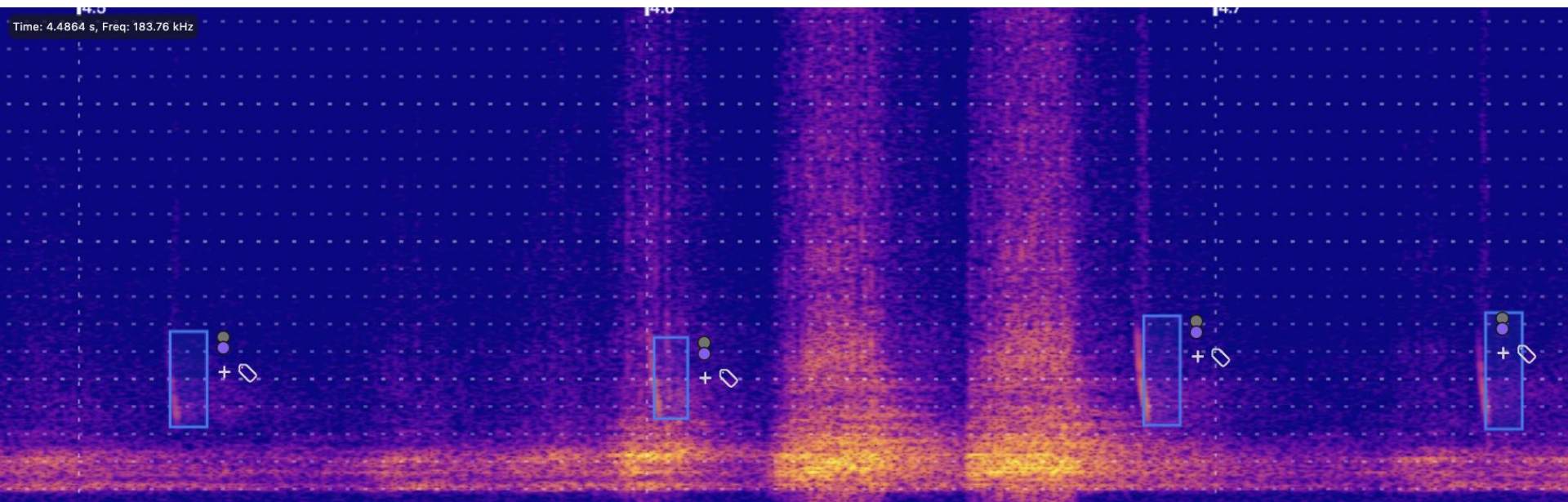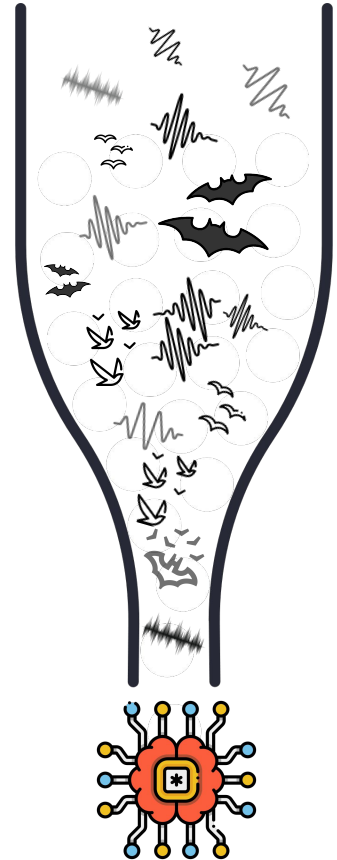
Conclusion

Real-time processing of animal voices:

- significantly reduces the amount of data to be analysed
- enables permanent monitoring installations
- allows timely detection of relevant events (migration?)
- is the future of acoustic monitoring

But: Must constantly improve!

Workshop on real-time acoustic ai: 11.02.2025

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Simon und Widdig

...

Simon Ripperger

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und Naturbildung

Thank you!

Jannis Gottwald

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