Microphone Optimization and Development for AI-Based Detection of Flying Wildlife

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Motivation and Context

- Renewable energy growth can impact sensitive ecosystems.
- Wind and solar farms may affect bird and bat populations.
- Environmental assessments require accurate, non-invasive monitoring.
- Bioacoustics is a key strategy: passive, and continuous.
- AI can enhance species identification and tracking.

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The Problem with MEMS Microphones

- MEMS microphones are small and cheap.
- But they have problems in field.
- Sensitive to electromagnetic noise.
- Recording have a lot of background noise.
- Bad quality affects AI detection.

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Study Goal

- Improve sound quality for bird detection.
- Compare MEMS vs electrect microphones.
- Test in a significant environment.
- Help AI detect birds better.
- Use Hardware for nature protection.

Methodology: Experimental Design

- Used bird sounds from Monfragüe National Park
- Selected 12 bird species (low, mid, high tones)
- Played sounds with a speaker in a quiet room
- Used Raspberry Pi + AudioMoth for recording
- Tested 3 setups: MEMS, electret without membrane, electret with membrane
- Same position and distance for all devices

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Methodology: Evaluation Metrics

- SNR (Signal-to-Noise Ratio): Clarity of the recording.
- THD (Total Harmonic Distortion): Sound distortion.
- ADI (Acoustic Diversity Index) Background noise level. Calculated with white noise record.
- Spectrograms: Show the sound over time and frequency.
- Compare recordings to original bird sound.

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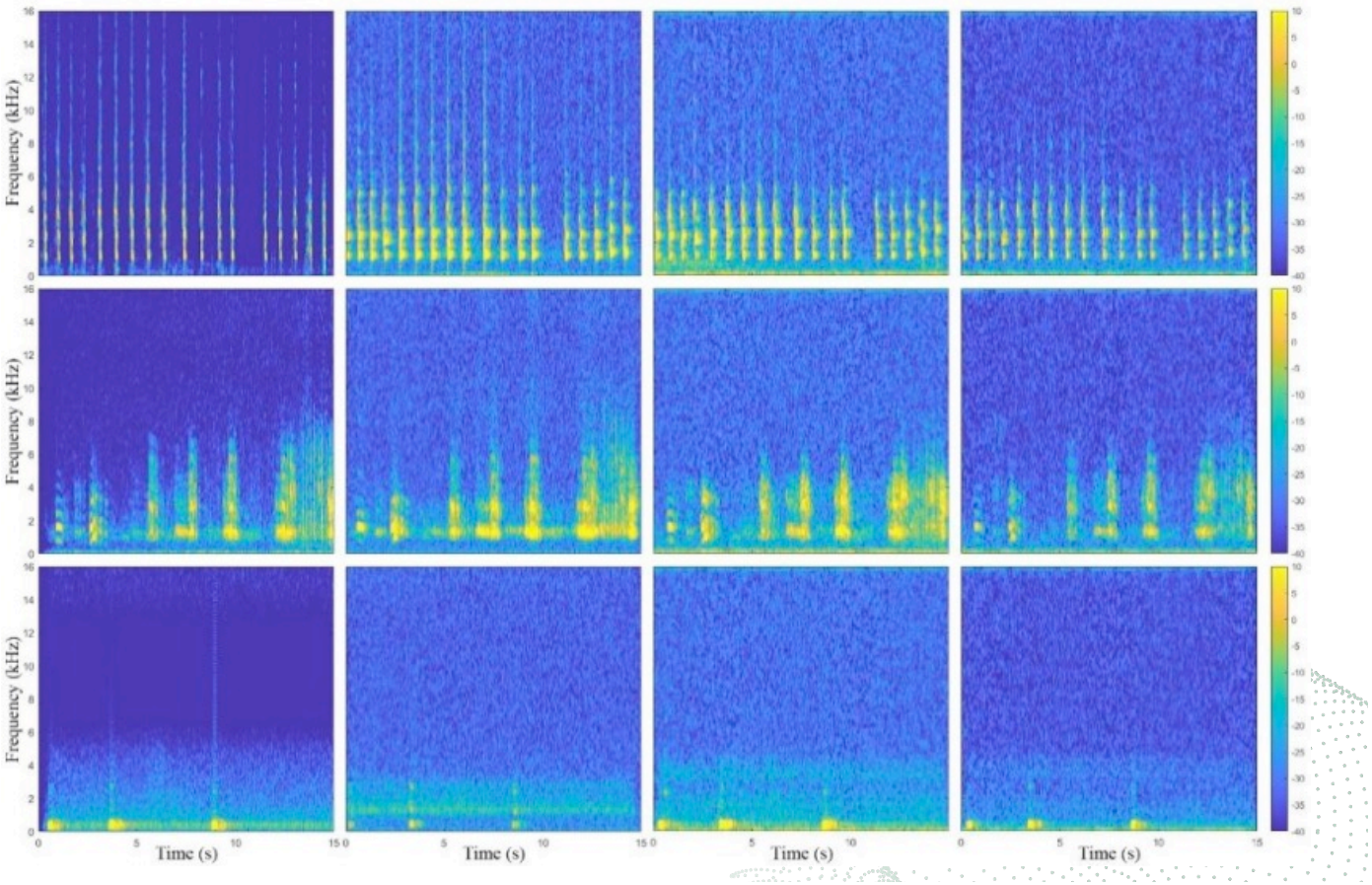
Key Results: Spectrograms

- Spectrograms show frequency (vertical) over time (horizontal).
- Brighter colors = stronger signal.
- MEMS shows more noise (vertical lines, blurred areas).
- Electret with membrane shows cleaner patterns.
- More similar to the original sound.



Key Results: Metrics

	MEMS Microphone			Electrect without membrane			Electrect With membrane		
	SNR (dB)	THD (%)	ADI*	SNR (dB)	THD (%)	ADI*	SNR (dB)	THD (%)	ADI*
Arithmetic mean (bass, mid and treble)	-4,488	6,675	3,24	-4,425	25,57	2,28	-1,015	20,89	2,78

* ADI calculated from white noise records

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Conclusions

- Electret microphone with membrane improves audio quality.
- Better signal-to-noise ratio for species detection.
- More robust against noise and interference.
- Suitable for real field conditions.
- Ideal for AI-based wildlife monitoring.
- Helps protect biodiversity near wind farms.

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Future Work

- Can be integrated into microphone arrays in the nature.
- Connect these recording to AI detection systems
- Can be useful for long-term biodiversity sound databases
- Improve energy efficiency of recording systems

IA4birds: Plataforma de IA Explicable para la predicción y protección de aves en espacios destinados a ser parques eólicos

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