Listening to what's below us: designing an open source preamplifier for soil ecoacoustic research

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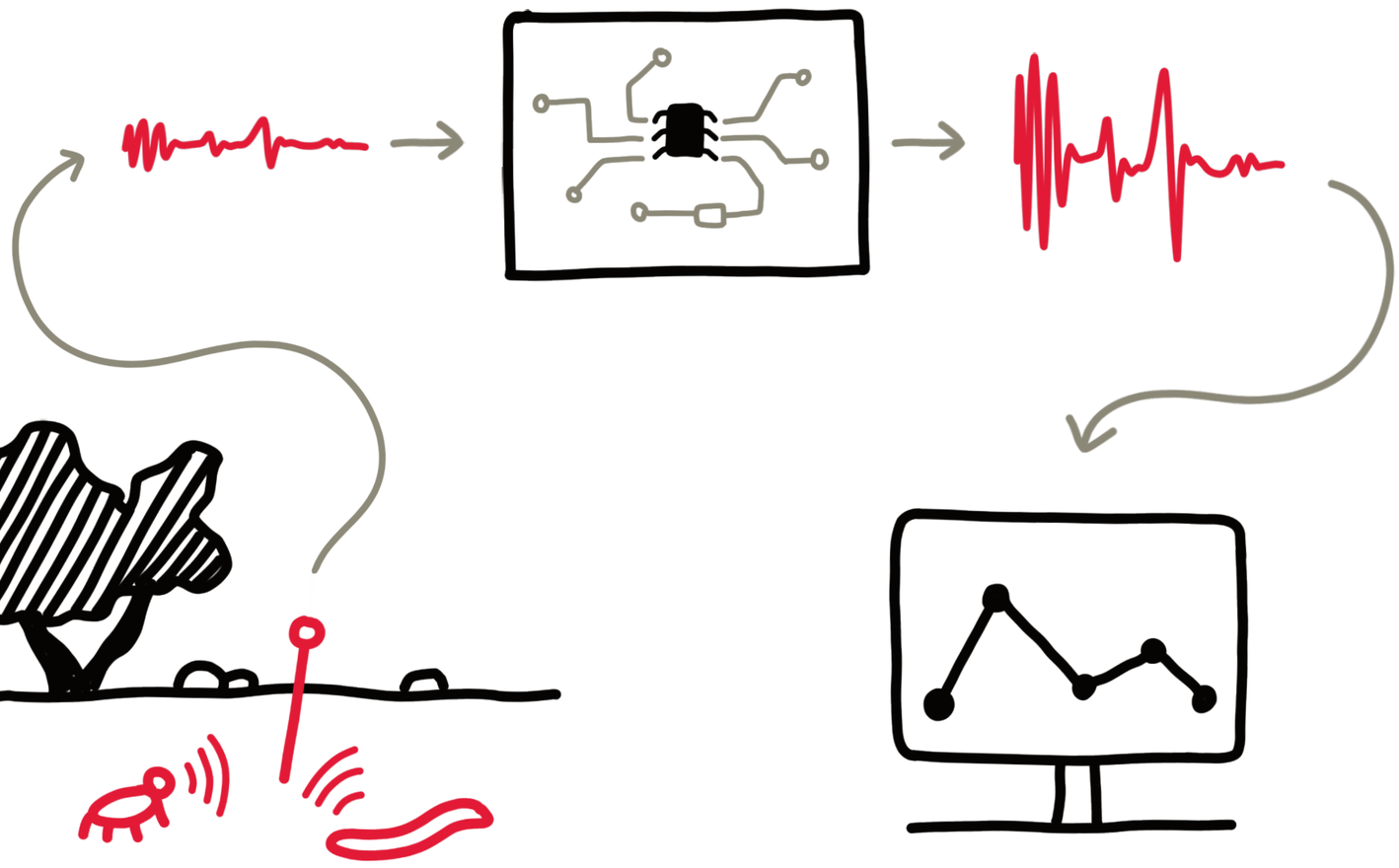
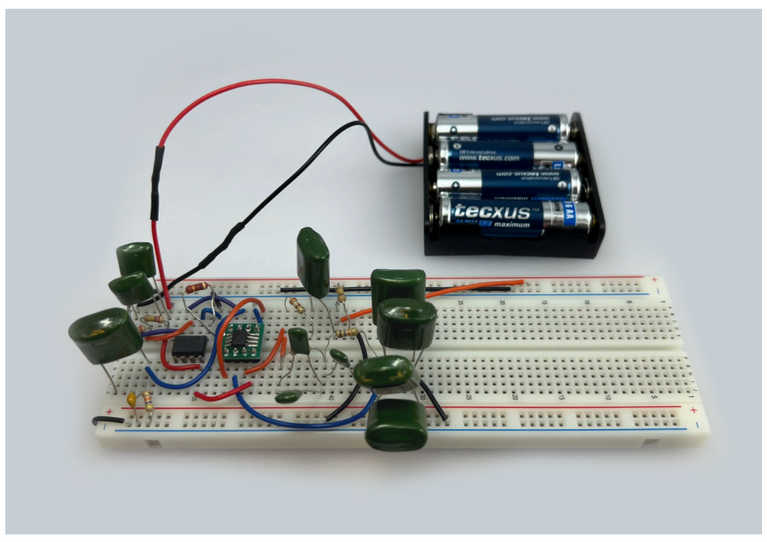
The workplace

The internship has taken place at Malmö University in the IOIO Lab, a mechatronics lab open to students who want to borrow components or receive assistance.

Project goals

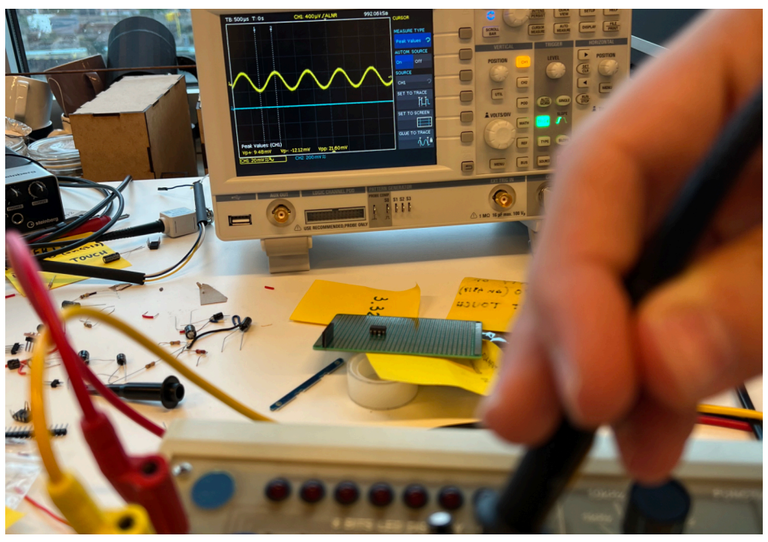
Ecoacoustics is a multidisciplinary field that uses environmental sound as a material to understand ecological metrics such as biodiversity, habitat health and frequency competition (Farina & Gage, 2017). The same theories and methods apply to soil ecology. Recording soil flora and fauna requires high quality but often expensive equipment. The goal of the internship is the development of an open source, low noise preamplifier to record the sounds of soil ecologies.





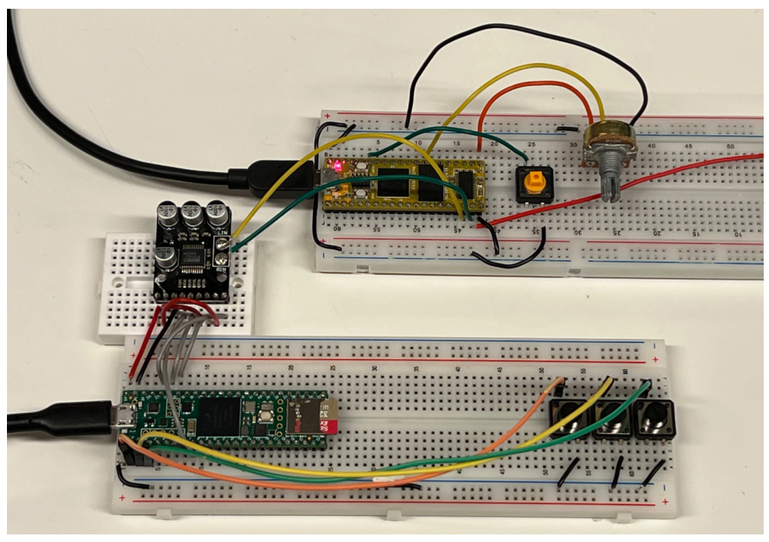
Designing the preamplifier

The preamplifier has the role of taking the faint signal from a contact microphone and amplifying it to a level that can be recorded and later analysed. The process of designing the circuit involved a lot of research and practice-based learning to acquire familiarity with the subject and the components. Prototyping was used both as a method for learning and as a way to refine the design of the preamplifier. In addition to physical prototypes, the design process involved the use of circuit simulation software to predict the circuit's performance and test ideas.



Measuring performance

The design process was informed by a benchmark that was set at the start of the internship. This benchmark defined the desired gain and noise performance, therefore all design decisions were measured in relation to it. Gain performance was easy to test using the lab equipment I had at my disposal. However, accurately measuring the noise performance proved more challenging. Nonetheless, I was able to use audio analysis software to get an estimate of the noise performance which I then used to improve and iterate on the circuit design.



Recording sound

After finalizing a working prototype, I started recording sound using a self-crafted contact microphone and a microcontroller. Two different platforms were tested: Daisy and Teensy. The latter is an Arduino-compatible platform that supports the I^2S protocol, which is commonly used in audio systems. Using I^2S I was able to test two analog-to-digital converters and compare their noise performance. The recordings are saved to a microSD so the system can run without being attached to a computer.

Project timeline

September	Early October	Late October	Early Novermber	Late november
Research & practice-based learning	First working prototype	Battery powered circuit	Recording with Teensy	Improving noise performance

Future work

Solar power recharging → Power with LiPo batteries → Teensy processor on Micromod's plaftorm

Outcomes

The internship brings two major outcomes. Firstly, there are concrete deliverables like the physical preamplifier PCB and the associated design files that can be used to improve upon the work. Secondly, there is a website that details the decisions made throughout the design process that other people can use to continue working on the design. The project can be completed in the future by designing a power supply system that uses solar power to keep the device running without supervision.

References
Farina, A., & Gage, S. H. (2017). Ecoacoustics: A New Science. In A. Farina & S. H. Gage (Eds.), *Ecoacoustics* (1st ed., pp. 1–11). Wiley. https://doi.org/10.1002/9781119230724.ch1