

Design and Implementation of a Sound-based Environmental Monitoring System

Bachelor Thesis / Master Project Proposal

Environmental monitoring is key to understanding and protecting vulnerable ecosystems. Battery-powered wireless sensor networks promise unattended, distributed sensing of environmental processes, but the high cost and short lifetime prevent large-scale deployment. Battery-free devices instead can be operated maintenance-free for decades, facilitating unprecedented insights into these environments.

The activity of humans or animals is often accompanied by noise, making audio signals a rich source of information. For example, recording and classifying animal calls yields insights into behavior, habitats and well-being of wildlife. Another important application is the detection of illegal woodcutting or poaching. The capabilities and processing power of state-of-the-art microcontrollers have enabled acquisition, processing and on-device classification of audio signals. However, signal acquisition and classification on intermittently powered, battery-free devices remain largely unsolved.

The goal of this project is to develop and implement a software solution on a low-power microcontroller to acquire an audio signal from a microphone and to process and classify this signal, taking into account the intermittent execution of a battery-free device. The first milestone is a sound level detection algorithm that executes intermittently on a development board and signals to the user the excess of a dynamically changing sound level threshold. The next step is a classification algorithm to detect a specific sound using on-device machine learning inference. Finally, the implemented solution can be ported from the development board to a real battery-free device provided to the student. The exact scope and requirements of the project can be adjusted according to the student's interest and the type of work (bachelor/master thesis or study project).

The student will be provided with all necessary hardware and tools to develop and debug the software for the microcontroller. They will be supported with setting up the development environment and provided with example code as a starting point. They will receive feedback and guidance in weekly meetings with their advisor. The deliverables include a git-managed repository with well-written and sufficiently documented code, a written report describing the implementation and essential evaluation results and a final presentation with a short live demonstration of the implementation. Supervision will be possible in German or English.

Requirements

- Good coding skills in C.
- Basic knowledge of microcontrollers.
- Motivation to learn new embedded machine learning concepts.

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