PhD thesis: Intermittent IA for embedded bird sound recognition.

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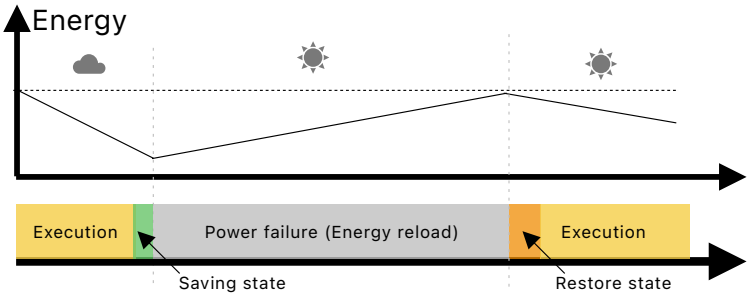
1 Thesis Context

This thesis is part of the collaborative research project OWL aiming to create energy-efficient architectures for wildlife monitoring. It relies on two strong research axes: intermittent processing architectures and circadian AI.



Intermittent architectures are ultra-low-power computing with strong energy constraints [MBK]. Typically, embedded systems must adapt their workload to available energy [AAGB]. In the context of intermittent architectures, the device can shut down and resume activity when regaining energy [RPR+]. Checkpoints ensure task execution progresses [RBB+]. Spreading task processing over phases with energy allows complex computing on architectures without a battery, only a super-capacity with very low charge [SAS+]. These systems have multiple energy harvesters [PW] controlled by an efficient energy planner.

Adding intelligence to highly energy-constrained embedded sensors is possible using intermittency and performing tasks over multiple wake cycles. Circadian AI schedules tasks at the appropriate time of day e.g., identifying wild animal sound patterns by listening when they likely make noise. The goal is optimizing wake phases for these tasks [LBB+]. It's no longer just syncing task execution with energy but finding the opportune moment automatically.
Intermittent architectures allow deploying heavier tasks if spread over time. In wildlife monitoring, neural network-based classification shows interesting bird species detection [SBF+]. A reference network [KWEK] recognizes 980+ bird species in Northern Europe and the United States, but its 27M parameters make it unviable on embedded architectures. The bird song recognition solution needs reducing complexity for intermittent architectures. Targeted architectures are low-cost microcontrollers with limited processing and storage.

2 Research axis of the PhD

The thesis is situated within the context of Circadian AI: an edge AI tailored to the computational capacity of deployed nodes, leveraging the intermittency of processing units and capable of selecting opportune wake periods. The thesis aims to propose Circadian AI architectures based on 3 main aspects:

- Assessing methods for handling discontinuous data processing: given the intermittent nature of architectures, it becomes essential to evaluate algorithms using signals acquired sporadically.
- Designing AI architectures adapted to intermittent processing : in this scope of tinyML[LWA], neural networks should be adapted in terms of architecture (pruning and quantization) and memory mapping to intermittency.
- Implementing a proof of concept for bird song recognition on a platform developed within the project and compare its performance with classic non-intermittent approach.

These research axis align with the collaborative OWL project and will be subject to ongoing discussions and cross-collaborations throughout the thesis duration.

3 Interaction with past activities

This thesis builds on the collaborative project NOP, with key advantages:

- An intermittent board, currently in development, includes a non-volatile computing unit and innovative features [BGDW$^+$, PW], ideal for circadian AI. It will be used for the proof of concept and benchmarking.
- The SCHEMATIC checkpoint tool [RBB$^+$], from the NOP project, will assess architectures for intermittency.
- Preliminary work on bird song recognition provides access to databases, preprocessing tools, and functional neural networks. This framework forms the foundation for further work.
- The team has developed a tool to create microcontroller-compatible neural networks from high-level descriptions, to be expanded and tested on the new board.

4 Required skills for the PhD candidate

Holder of a master's degree or an engineering degree, you have excellent skills in digital architecture, digital signal processing, and artificial intelligence. Experience in microcontroller implementation is also desired. You have a strong interest in research and are capable of conducting scientific research.

5 Information and Contacts

The thesis is conducted within the GRANIT team of the IRISA laboratory in collaboration with the STR team of the LS2N laboratory.

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Important dates:

Application deadline	April 26th 2024
Notification of acceptance	Mid-may 2024
PhD starting date	October 2024

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