PhD Position at IETR - Ecodesign of Embedded Systems applied to Smart Vision

Keywords: `Ecodesign`, `Carbon footprint`, `GHG emissions`, `Smart camera`, `Digital hardware design`, `Life cycle analysis`, `Circular economy`, `Sustainable electronics`.

Laboratory: Institut d'Electronique et des Technologies du numéRique UMR CNRS 6164, Rennes, France

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Context and Challenge

Like all industrial sectors, the electronics sector must, to be sustainable, drastically reduce its CO_2 emissions by 2050, and more globally commit to a logic of circular economy. While environmental impacts of electronics are increasingly understood, the evaluation of impacts in Life Cycle Assessments (LCA) is still an emerging practice that requires complex models, data and insights. Once the impacts are known, ecodesign strategies must be developed and assessed.

The impacts of an electronic system arise from its manufacturing, use and end-of-life. The system itself is composed of printed circuit boards (PCB), semiconductor integrated circuits (ICs), passive components, connectors, sensors, actuators, batteries and displays, each having environmental impacts. In particular, the greenhouse gas (GHG) emissions of semiconductor manufacturing represent an important share of the embodied carbon footprint of electronics systems and must be considered alongside energy consumption and end-of-life [M21][P22][U22].

A smart vision system is a combination of sensors and digital processing that captures, preprocesses and distributes a video or a semantic description of a visual scene. It can take the form of a smart camera, mono-sensor [B14] or multi-sensors [K07], or of a camera module in an embedded system comprising a sophisticated image processing pipeline [M20]. It can also comprise a set of distributed sensors [R10]. Current smart vision systems embed optics, Complementary Metal-Oxide-Semiconductor (CMOS) sensors, color processing, image enhancement, video compression and artificial intelligence for image and video analysis. The sophistication of these systems is increasing, as examplified in smartphones that combine several sensors, dedicated Image Signal Processors (ISPs) and software post-processing to implement computational photography [D21].

This thesis will explore ecodesign of smart vision systems as representative examples of high performance embedded systems. The carbon impact of such systems is currently dominated by the embodied emissions, i.e. the greenhouse gas emissions of system fabrication [G21], but results from a complex and difficult to evaluate combination of fabrication, use and end-of-life impacts of its components and software layers [G21] as illustrated in Figure 1. The thesis will aim at understanding how to model linear and non-linear factors influencing carbon emissions of such a system and developing ecodesign methods to minimize environmental impacts by leveraging on circular economy.

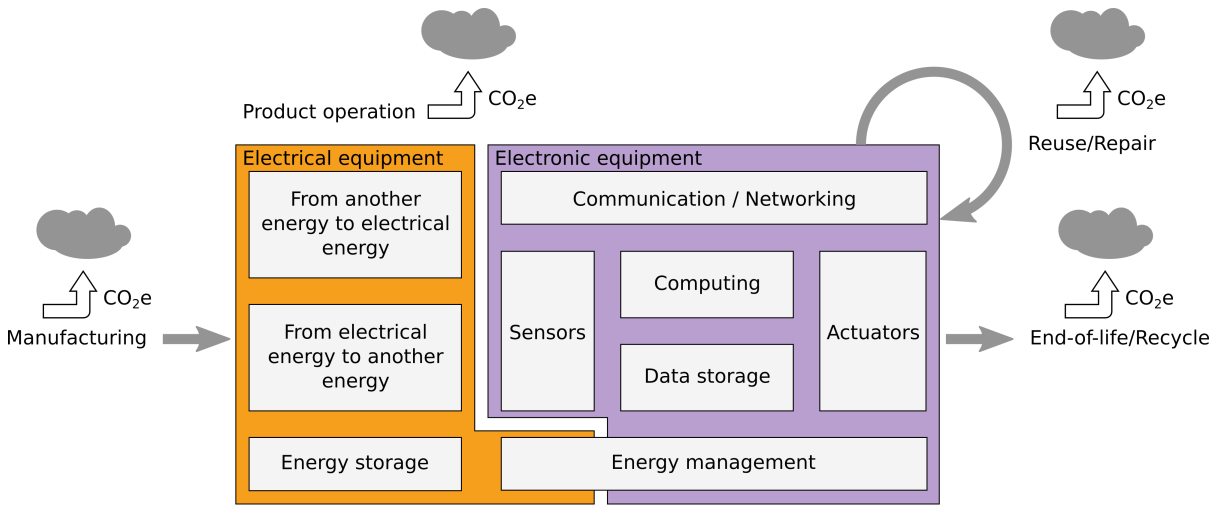

Figure 1: Carbon emissions of an embedded system (general case)

Objectives

1. Novel methods for life cycle analysis of embedded systems. System ecodesign requires precise information of the impacts of system design decisions (types of CPU/GPU, FPGA, memory, busses, connectors, PCBs, etc.) and on the use phase of the system (idle time, workload, etc.). Thus, the first objective of this thesis will be to improve Life Cycle Analyses (LCAs) of embedded systems, especially applied to carbon emissions evaluation of smart vision systems. New forms of LCA will be designed, adapted to the specific context of smart vision systems, and exploiting the research teams expertise in system design. In particular, real-life smart camera cases will be analyzed, prototyped, and measured for energy consumption, based on the experience of Institut Pascal in smart camera prototype design.

2. Ecodesign for reducing carbon impacts. A second objective will be to analyse the options for modifying such systems towards a more sustainable form while preserving performances. Ecodesign means designing the embedded system with the goal to be part of circular economy, i.e. decreasing the need of new materials, increasing reuse, lengthening system lifetime, and avoiding waste. Novel scene observation strategies will be analyzed as well as system downsizing, remanufacture [K06], reuse of recovered or low impact sensors, improve repairability, and trade-offs between processing and sensing costs. This study will aim at proposing novel hardware design methods that, for a given level of system service, provably reduce environmental impacts.

Environment and Expected Impact

The thesis will be held at IETR (Institut d'Electronique et des Technologies du NuméRique) in the VAADER team and within the context of the ESOS project (Electronique Soutenable, Ouverte et Souveraine - https://esos.insa-rennes.fr), in collaboration with the DREAM team at Institut Pascal, Clermont Ferrand. The thesis will benefit from the dynamism of the ESOS project (6.4M€ budget, 2023-28) that develops a strong expertise on electronics life cycle analysis and eco-design. Past ESOS seminars can be found here: https://codimd.math.cnrs.fr/s/XBacPiRc9#

The thesis will be co-directed by Dr. Maxime Pelcat and Prof. François Berry, and advised by Dr. Thibaut Marty. Prof. Berry is leader of the DREAM team specialized in smart camera design at Institut Pascal and Professor at Université Clermont Auvergne. Prof. Berry has a long-term research experience on designing and studying smart cameras. Prof. Berry is also scientific advisor at Sma-RTy, an Italian SME designing smart cameras, including near-sensor image processing and deep learning. Dr. Pelcat is leading the ESOS project on sustainable, open and sovereign electronics. His research focuses on studying the physical properties of computational systems. Dr. Marty is specialized on digital architectures design, and member of the ESOS project team.

Candidate

The candidate shall hold **a master degree in electrical engineering or computer science**, with experience or skills in the following areas:

Required experience or skills	Experience to be gained during the PhD
• Skills in C, C++, Python (required), • VHDL or Verilog (required) • Statistical models (appreciated) • Optimization and machine learning (appreciated) • English speaking and writing is compulsory	• Sustainability and life cycle analysis • Vision system design • Hardware ecodesign • Research process • Team work and collaborations

Characteristics

- Location: Vaader teams, IETR laboratory - INSA Rennes, 20 Avenue des Buttes de Coësmes , 35708 Rennes, France
- Duration: 3 years, Start: october 2024
- Salary per month: 2100€ brutto per month
- Supervisors
    - Maxime Pelcat (IETR, INSA Rennes, Univ Rennes) - maxime.pelcat@insa-rennes.fr
    - François Berry (Institut Pascal, UCA) - francois.berry@uca.fr
    - Thibaut Marty (IETR, INSA Rennes, Univ Rennes) - thibaut.marty@insa-rennes.fr

Applications

You may request details on the subject, and send your resume and application letter to maxime.pelcat@insa-rennes.fr

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