**Subject:** Distributed deep learning on a network of dynamically reconfigurable wireless smart cameras.

**Supervisor:** François BERRY

**Laboratory:** Institut Pascal

**Email and phone:** 04 73 40 72 52 – francois.berry@uca.fr

**Co-advisor(s):** Christophe Blanc

**Abstract (up to 10 lines):**

This thesis aims to address various issues related to the wireless networking of smart cameras. However, as opposed to a "classical" wireless sensor network, we aim to use a technology based on reconfigurable electronics in order to dynamically modify the computing architecture within each camera. Indeed, the use of cameras in a wireless sensor network can be seen as a paradox: the wireless network tolerates only a low bandwidth while the cameras produce a large amount of data. Part of our approach is therefore to try to solve this lock by proposing a methodology based on "real-time customization" of (mote)cameras according to the context. However, one of the main originality of this thesis is to consider each mote (node) as a computational element and thus potentially a part of a deep learning network. The great novelty here is not to see the learning network as a simple pipeline (path from input (image) to output (class)) but rather as a collaborative multi-input network. Since the words are made of dynamically reconfigurable circuits, it would then be possible to build the hardware architecture of computation according to the perceptual context.

**Skills:** Written & Oral Communication, high-level computer science research roles, extremely interested in computer science research, understand the fundamental nature of hardware and electronics

**Keywords:** Deep learning, wireless sensor network, IoT, Smart camera
Recent advances in wireless technologies is an opportunity for easy and low-cost implementation of distributed intelligent systems. In this way, this thesis aims to address various issues related to the wireless networking of smart cameras. A network of smart cameras involves main functions:

- Capturing the information of the environment
- Calculate data using these collected values to provide semantic information and minimize the amount of information to be transmitted.
- Communicate them through the network

However, as contrasts to a "classic" wireless sensor network, we aim to use technology based on reconfigurable electronics (FPGA) to dynamically modify the computing architecture of each camera. Indeed, the use of cameras in a wireless sensor network can be seen as a paradox: the wireless network tolerates only a low bandwidth while the cameras produce a large amount of data. Part of our approach consists in solving this limitation by proposing a methodology based on "context-driven use". In other words, each perception node (smart camera) can be adapted to its context (environment and events). For this purpose, we will focus on simple architectures based on a heterogeneous structure (Processor and FPGA). The first fully connected cameras (in the framework of L. Benkhelifa’s thesis) have been designed with these previous devices associated to a low-cost CMOS imagers and a wireless interface.

This "internet of objects" type approach led us to identify 3 clear issues:

- Objects (smart cameras) provide information according to requests made by other cameras. If the requests require a new hardware computing architecture, then a computing server (cloud computing) will generate the new computing architecture (reconfiguration data). In an ideal but currently unrealistic approach, the camera would be able to self-generate its computing configuration.
- Wireless systems can interoperate horizontally in a collaborative way: Several smart cameras can be associated in two ways:
  - By aggregating data from several cameras to provide more robust or complementary data. A trivial example is the tracking of people in buildings where the cameras will "pass the hand" in order to keep the target in sight.
  - by pooling the computing core. In this context, the calculation cores of the different cameras can be combined to provide more computing power.
- The notion of information is linked to the notion of service just like peripherals and the network: With such an approach (IoT), smart cameras become real Internet resources by producing data and also being a way of distributed calculations.

In a first thesis, the design of perceptual nodes (see figure on the right) was already designed and a first mathematical propositions modeled the interpretation of perceived information. In this approach, we have motivated the use of very simple nodes (low resolution and low computing capacity) but with a strong redundancy allowing a high robustness. In this way, the proposed system is based on an ontology (knowledge model) and sparse and ultra-distributed information.

Through this new thesis, we aim to address issues of distributed learning. The motivation consists in considering each mote (node) as a computational element and thus potentially part of a deep learning network. The big novelty here is not to see the learning network as a simple pipeline (path from input (image) to output (class)) but rather as a collaborative multi-input network. Since the words are made of dynamically reconfigurable circuits, it would then be possible to build the hardware architecture of the computation according to the perceptual context.
Références (up to ½ page):


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