Hardware Implementation of Machine Learning Techniques for IoT devices

1 Context and Scope of Study

One of the main objectives of a connected object platform is to ensure communication between various heterogeneous sensors providing intelligent services [1]. These smart sensors generally have reduced resources as they are often powered by simple batteries and also have limited compute and storage capacity. Today, in order to ensure their communication, they rely on a few protocols, the best known of which are 6LoWPAN, Bluetooth, IEEE 802.15.4, ultra-wideband WiFi, RFID as well as near-field communication. (NFC).

Due to the this multiplicity of standards, the various characteristics of wireless channels (path loss, fading, shadowing ...), the frequency allocations, and the mobility features of wireless devices, the operating environment is becoming more and more complex to comprehend. In our work we are considering smart systems that must have the ability to reconfigure themselves to adapt to channel conditions and to the environment in general. Our proposed system is built on several steps.

The first step consists in sensing the environment continuously, and then analyze and understand the environment. Upon the analysis, the system can decide whether to reconfigure itself or not. If a reconfiguration decision is performed, reconfiguration is applied and the system continues sensing the environment again. Each step within this process may be considered as a specific domain of research. For example, finding the right parameters to be sensed and analyzed is a real issue to make an efficient decision. Another example deals with the decision making process itself, which can be implemented by a lot of algorithms.

In this thesis we would like to focus on the decision process that leads to system adaptation. Several works have already been led in the team [2], [3], [4] that have opened the way to the implementation of dedicated solutions. We would like to carry on these works and extend them to other Machine Learning techniques such as reinforcement learning.

Furthermore, the various techniques presented in the state of the art are, for the most part, very expensive in terms of computing resources and energy consumption. Moreover, they are difficult to implement in small connected objects with few resources [5].

2 Objectives

In this thesis, we strive to identify the most promising solutions in terms of performance and low complexity in the context of IoT devices adaptivity.

We will consider the following steps:

- Perform a state of the art study on Machine Learning for platform adaptation
- Identify the relevant parameters that we can consider to perform learning
- Propose the corresponding Machine Learning Architecture that takes into account the design constraints (limited amount of resources, low latency, low-power)
- Accelerate this architecture in an FPGA reconfigurable platform

The thesis will take place at the IETR (http://www.ietr.fr) in which several theses have been led in the domain of embedded computing and reconfigurable systems, for many years. Researchers involved on this subject have already developed original and efficient algorithms to manage the platform in real-time.

3 Pre-requisite

A good knowledge in machine learning, computer science is required. Furthermore, the candidate should also be familiar with Hardware Description Languages and reconfigurable devices.

4 Contact and Organization

The thesis will take place at IETR/INSA, 20 av. Des buttes de Coësmes, 35043 Rennes Cedex)

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