M2 Internship Offer: AI and Embedded System

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**Research teams and schools involved:** Institut Polytechnique de Paris
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**Internship duration:** 6 months.

**Funding:** legal amount

**Host laboratory:** SAMOVAR, Télécom SudParis - 19, Place Marguerite PEREY - 91120, Palaiseau.

**Required skills:** C/C++ and Python programming, basic microcontroller knowledge.

**Keywords:** embedded systems, AI, fog computing, edge computing, cooperative learning.

**Context:**
Nowadays, the electric energy resource management is a real concern. Many connected objects, smartphones and computers are surrounding us, and of course, they need a certain amount of electric energy to operate. For an efficient use, predicting the electric consumption in a building will contribute to an optimal energy production in various climate conditions. This fits fully the smart cities and grids, which are currently an enthusiastic research area.

Various works have been carried out in order to model and predict the energy consumption as it could have been done for a building. Recent results [1] show that Artificial Intelligence (AI) algorithms based on Long Short Term Memory (LSTM) Neural Networks (NN) present a minimal error in energy prediction. It seems clearly that AI algorithms will contribute in the energy resource management.

These AI algorithms rely on the collection of a long-term data history of the electric consumption and some associated meteorological data. Consequently, this huge amount of data requires important computational and network resources, as routing algorithms, to establish the prediction and send data, leading to an additional energy consumption since cloud-based computers will be involved. Practically, Graphic Processor Unit (GPU) cards, lot of memory and a communication network are required to train and deploy the AI model.

To overcome this issue, low cost small embedded systems can play an important role in predicting energy in different climate context when working in harmony. Typically, these small systems are based on a microcontroller and present an interesting trade-off in terms of computation power, energy consumption, programming flexibility, size and low cost.
Classically, the NN model parameters, named weights, are determined using the well-known BackPropagation (BP) algorithm, requiring a high computing power. When compared to a computer, a microcontroller includes a limited resources processor and few amount of data and program memories. For this reason, the AI model is first trained and tested using a computer (associated to a GPU). Then, in a second time, a compression / optimization and a computational complexity decreasing are applied on the model in order to be deployed on the small embedded system [2]. This is performed by reducing the model parameters number and by using an efficient bit quantization (floating to fixed-point conversion) without degrading too much the accuracy [3]. Moreover, interesting work [4] have been done in order to perform the BP algorithm on the embedded system. Another interesting and promising solution is the Transfer Learning (TL) approach, as described in [5, 6]. It is a well-suited technique to train and deploy a NN on a small embedded system and fully autonomous.

**Objective of the work:**
The objective of this work is to implement AI algorithms, including the training step, on small embedded systems, based on microcontroller, for electric energy consumption time series prediction, and in a distributed manner. Database should include meteorological data from the available station at the "Plateau de Saclay". The association of adapted routing algorithms would allow the communication between these distributed IoT nodes. This could be carried out by:
- Adapting AI algorithms, including the backpropagation algorithm, to limited resources embedded system.
- Study the weight quantification effect on the prediction accuracy.
- Study resilience and cooperative learning on several circuits (several nodes working in a distributed manner).

**Acquired skills:**
At the end of the internship, the student will be able to:
- Analyze historical time series data.
- Identify the well-suited NN architecture for the prediction and in accordance with the embedded target.
- Program an embedded system (microcontroller) with constraints related to low memory capacity and power computation.

**References:**

