Ecole Doctorale STIC

Sciences & Technologies de l'Information et de la Communication

ED STIC - Proposition de Sujets de Thèse

pour la campagne d'Allocation de thèses 2017

Axe Sophi@Stic :	SystèmesRéseaux|
Titre du sujet :	Distribution of Artificial Neural Networks on Wireless Sensors for Energy-efficient Smart Cities
Mention de thèse :	Electronique
HDR Directeur de thèse inscrit à l'ED STIC :	François Verdier

Co-encadrant de thèse éventuel :

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Description du sujet :

The reduction of power consumption in the context of WSN and IoT (Internet of Things) becomes an important issue considering the prediction of the number of sensors to be deployed in the next years. According to CISCO, each individual on earth will have more than six devices connected to the Internet by 2020. However, the growth of connected objects is associated to different issues: the problem of energy consumption from the device to the data center and the communication infrastructure, the problem of the increase of the bandwidth and the Big data problem induced by the amount of data produced by this connected reality.

Several wireless technologies are already ready to tackle the global deployment of thousands of sensors on a territory, but these technologies are mostly designed for a local optimization of the power consumption, not for a global awareness of the entire network. The interconnection

network is also a great challenge in WSN, from the mesh networks of devices (BLE, Zigbee, WirelessHart…) to some star or tree networks (LoRa, Sigfox), and the routing of device data is still completely open. On another hand, biological brain shows unmatched capacities for the fusion and the processing of complex and heterogeneous (multimodal) data. And several computational models have been proposed following this biological inspiration, but these models have been essentially applied to the domain of mobile robotics.

This subject aims at studying the transposition of computational models of such Artificial Neural Networks (ANN) in the domain of Wireless Sensor Networks (WSN) for the joined fusion of data coming from multiple sensors and the minimization of the global power consumption.
This project will then deal with machine learning methods deployed in the context of WSN and Iot for Smart Cities in order to take advantage of the correlation in the data coming from the environment (through the sensors) i) to reduce the global consumption of the network and ii) to self-organize the network according to the variations of this environment. The self-organization of the network is obviously very dependent of the protocol supported by the devices. The project will specifically focus on ANN models derived from the Self-Organizing Maps (SOM) and adapted to an execution in an embedded context. The preliminary neural model that has been developed at LEAT Lab since March 2016 will serve as a starting point to study during the doctoral project the optimization, the deployment and the validation of machine learning algorithms in the context of Smart Cities. This work will be organized in collaboration with the IMREDD Institute of Université Nice Sophia Antipolis, which will provide the data coming from several thousands of sensors deployed in the Nice city.

A first prototype has been developed at LEAT lab and will be reused as starting point for this work.
After being studied and compared to the state of the art, the distributed model developed at LEAT Lab will be deployed both onto an industrial Gateway and micro-controllers hardware devices deployed onto the SophiaTech Campus, through software stacks dedicated to Internet of Things (IoT). The doctoral research project will bring the following contributions:
- Theoretical study of the SOM based artificial neural networks and bibliography,
- Adaptation of the model to the context of sensor fusion in low energy wireless networks,
- Exploration of the deployment of neurons (scalability, heterogeneous data and distribution of the execution) with system level simulation under the Omnet++ Environment,
- Partitioning of the algorithm in the network hierarchy,
- Embedded deployment onto an industrial gateway,
- Validation on real data coming from hundreds to thousands of sensors deployed in the Nice city.

The PhD will be supervised by Francois Verdier and Benoît Miramond from the LEAT Lab (UMR 7248). Professor François Verdier has a long expertise in the domain of power management in embedded devices through the previous PhD thesis of Hend Affes (in 2015) and Amal Ben Ameur (currently going on) and through the collaborative project HOPE (ANR 12 INSE 0003). Professor Benoît Miramond will bring the skills in artificial neural networks for embedded devices. He has a recognized interdisciplinary research activity in the domain of neural-based adaptive systems. Especially, he already studied and proposed optimized versions of Self-Organizing Maps through

the previous PhD thesis of L. Rodriguez and L. Fiack (University of Cergy Pontoise - 2015) and the collaborative research project SATURN (ANR JC 2011).

The PhD will be realized in the LEAT Lab (Laboratoire d'Electronique, Antennes et Télécommunications) of Université Côte d'Azur, in collaboration with the IMREDD (Institut de la Méditérannée, du Risque et du Développement Durable, http://unice.fr/imredd/presentation).

URL : http://leat.unice.fr/sujets-theses.html

English version: