PhD Thesis Proposal:
Distributed Estimation over Compressed Data

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Place: Lab-STICC; Signal and Communications department, Telecom-Bretagne, Brest, France
Dates: The PhD will start in September or October 2016, for a period of three years
Keywords: Distributed source coding, Signal processing, Information theory.

Since the PhD will be funded by DGA, the PhD candidate shoud have a European Union nationality.
The deadline for application is the 1st of May 2016.

I. Context

Connected things participate to an increasing part of our everyday life, with smartphones, connected watches and cars, etc. They also play an important role in the development of smart cities, in which they may offer new possibilities in terms of data analysis, knowledge sharing, and services to users. The connected things are all equipped with sensors (temperature, pressure, video, etc.), and they may collectively realize complex monitoring tasks by sharing their sensor measurements and by exploiting the diversity of the collected data. In a city, examples of such monitoring tasks include pollution detection, road traffic monitoring, or map construction.

Here, as a general formulation of this problem, we will consider a network of sensors dedicated to the estimation of a given process. The sensors will be allowed to exchange some data in order to perform the estimation. We will assume that the sensors realize the estimation in a fully decentralized setup, without the support of a fusion center that would be difficult to set up in a city.

II. Motivations

Consider a network of N sensors dedicated to the estimation of the set of parameters $\Theta = \{\theta_1, \cdots, \theta_J\}$. Each sensor n captures K measurements denoted $X_{n,k}$ $(n \in \{1, \cdots, N\}, k \in \{1, \cdots, K\})$, and the sensors are allowed to transmit some data to the other sensors. Each sensor then produces an estimate of Θ from its own measurements and from the data received from the other sensors.

The sensors should transmit their data in a compressed form. Indeed, the network potentially captures an important amount of measurements $X_{n,k}$ for only a few values θ_j to estimate. It thus makes sense to perform compression in order to eliminate the redundancies in the data exchanged inside the network. Taking into account not only the local redundancies (redundancies inside one sensor's measurements), but also the global redundancies (redundancies between different sensors' measurements) could significantly reduce the amount of data transmitted within the network.

Existing works on compression for distributed estimation usually consider quantization only [ZSX15], which is not sufficient to eliminate the global redundancies. When considering distributed compression techniques such as compressed sensing [BPSF15] or error correcting codes [DRK14], the main problem is to design estimators that can apply directly to the compressed data, without requiring the reconstruction of the other sensors measurements. Indeed, since the objective for the sensors is only to estimate Θ, the amount of data transmitted by the other sensors should be sufficient to estimate of Θ, but not necessarily to reconstruct all the other sensors measurements.

III. Objectives

The objective of the PhD will be to construct an efficient distributed estimation system with minimal data exchange in the network. The proposed system will be based on tools from signal processing, source coding, and information theory.

The first part of the PhD will be dedicated to the information theoretical analysis of the minimum amount of information that should be exchanged by the sensors in order to realize the estimation with a given quality constraint. This analysis will help us not only to dimension the system (energy consumption, rate links, etc.), but also to study the influence of each of its parameters (sensors density, transmission power, etc.). The second part of the PhD will be on the construction of a distributed estimation system that relies on compression. We will consider compression solutions such as compressed sensing and error correction codes, and we will design estimators that apply directly to the received compressed data. We will then work on the joint design of the data exchange strategies (transmission power, number of transmission phases, etc.) and of the estimation/compression system.

IV. How to apply

The candidate should have a strong background in mathematics. He should have good knowledge about signal processing and/or source coding/information theory. To apply, send an email at elsa.dupraz@telecom-bretagne.eu and abdeldjalil.aissaelbey@telecom-bretagne.eu giving motivations for the topic, a full CV, student's university transcripts, recommendation letters or contacts of former teachers/supervisors, MSc project or thesis report (if available).

References

[BPSF15] A. Aissa El Bey, D. Pastor, S. Sbai, and Y. Fadlallah. Sparsity-based recovery of finite alphabet solutions to underdetermined linear systems. *IEEE Transactions on Information Theory*, 61(4):2008–2018, 2015.

[DRK14] E. Dupraz, A. Roumy, and M. Kieffer. Source coding with side information at the decoder and uncertain knowledge of the correlation. *IEEE Transactions on Communications*, 62(1):269–279, 2014.

[ZSX15] Shanying Zhu, Yeng Chai Soh, and Lihua Xie. Distributed parameter estimation with quantized communication via running average. *IEEE Transactions on Signal Processing*, 63(17):4634–4646, Sept 2015.