Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

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PhD information	
Title	System Identification: from blind to informed processing
Main topics regards to CSC list (3 topics at maximum)	I-7

Required skills in science and engineering	Signal processing, probability & statistics, linear algebra

Subject description (two pages maximum)

System identification is necessary in many applications to understand and control the behavior of the considered system [1, 2]. In particular, in the inverse problems it is required to identify the relation between the output and input signals of the system in order to restore or extract some information on the latter [3, 4]. In many situations, one have to handle the identification problem using only the system output signal in addition to structural or statistical information about the system and its inputs. This is referred to as the blind system identification (BSI) problem [5].

The BSI problem has been deeply investigated during the last three decades and a plethora of solutions exist in the literature, especially for the parametric linear system case [6, 7]. However, eventhough this is a mature and well mastered research problem, one can notice that it remains limited in terms of genuine applications due to several reasons including the relatively high computational cost of the blind methods and the poor quality of the identification results in many of the considered real-life situations. Concerning the cost, one can expect reasonably that, thanks to the fast increase of the computational power and the new tools relative to the distributed or parallel computing, this limitation will be less and less restrictive in the future. For the identification quality, the limitation is inherent to the blind processing itself and one has almost reached its affordable performance bounds. Therefore, the only way to improve further the estimation quality would be to incorporate more information into the identification process.

This idea has been considered via the semi-blind processing [8], the Bayesian approaches [9] or other 'side-information' based methods [10]. However, these shy efforts are at their early stage and the research field needs to be boosted through some deep investigations we would like to consider in the proposed project. In particular, we intend to study the potential of the use of identification methods in conjunction with learning techniques, a research field that can highly benefit from the significant advances related to the learning methods [11].

In other words, the aim of the project is to change the identification 'paradigm' from a 'blind' to an 'informed' one in order to achieve higher performance levels not allowed by the blind processing. To meet this objective, one needs first to 'better understand' the current limitations and be able to measure the desired information amount required for a target quality. Such performance analysis would shed new lights on the problem and allows us to properly introduce original methods and solutions for system identification exploiting at best the 'side information'. Finally, we would like to illustrate and validate the outcomes of the project on a specific application related to telecommunication signal processing.

Based on this, one can distinguish the three following parts of the project:

- *Performance Analysis Part:* 'Understanding the needs': A natural approach to meet our objective starts by an analysis step to understand both the limitations and the needs of the considered problem.
- *Methods and algorithms:* 'Getting away from the blindness': The second stage of the project consists of developing 'informed system identification' (ISI) solutions in the light of the previous performance bounds study.
- *Application to telecommunication systems*: 'Proof of concept': Indeed, the telecommunications field is a fast growing one with many challenges including the large size of the systems (massive MIMO [12])

and the rapid variation of the channels making their estimation a difficult (somehow 'ill posed') problem which I believe, can be solved efficiently thanks to the ISI approaches we consider in this project.

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[4] Albert Tarantola, "Inverse Problem Theory and Methods for Model Parameter Estimation", Other Titles in Applied Mathematics Series, SIAM, 2005.
[5] Chi, C.-Y., Feng, C.-C., Chii-Horng, C., Chen, C.-Y, "Blind Equalization and System Identification: Batch Processing Algorithms, Performance and Applications", Springer, 2006.
[6] "Blind System Identification", special issue of Proceedings of the IEEE (Volume: 85, Issue: 8, Aug 1997)
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[8] V. Buchoux ; O. Cappe ; E. Moulines ; A. Gorokhov, "On the performance of semi-blind subspace-based channel estimation", IEEE Transactions on Signal Processing (Volume: 48, Issue: 6, Jun 2000).
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[12] Thomas L. Marzetta (Author), Erik G. Larsson (Author), Hong Yang (Author), Hien Quoc Ngo, "Fundamentals of Massive MIMO", Cambridge Univ. Press, 2016.