Ph.D. in Information Technology:
Final Dissertations

DEIB- Seminar Room
January 8th, 2016
2.00 pm

First Ph.D. presentation and discussion:
Dr. Simone PECORINO – XXVIII Cycle
Information Rate of Channels with Memory by Bayesian Tracking
Supervisor: Prof. **Arnaldo Spalvieri**

Abstract: Increasingly, in many engineering fields, a more appropriate characterization of the dynamical systems leads to a model where an accurate description of the underlying dynamics is obtained by including elements of non-linearity and non-Gaussianity. In the context of digital transmission systems the computation of posterior probabilities of the hidden Markov state of such systems is often required. In these cases the exact Bayesian tracking of a posteriori probabilities of the state often becomes not feasible and, therefore, resorting to approximated methods becomes necessary. Among the techniques that realize approximated tracking, the extended Kalman filter, the state-space quantization, and the particle filtering method can be taken into account. Specifically, this last technique is a sequential Monte Carlo approach based on point mass representations of probability densities. Particle filtering, that can be seen as a generalization of the traditional Kalman filtering, can be applied to any state-space model, starting from the definition of the state transition and observation models and without restrictive assumptions. For these reasons, it has found widespread application in many research fields.
The Thesis focuses on computing the information rate of Markov channels, where the a posteriori probabilities cannot be exactly tracked, such as Wiener's phase noise channel, autoregressive moving-average phase noise channel, and Gauss-Markov fading channel. Starting from the definition of mutual information, that is very difficult to compute for these channels, approximated Bayesian tracking can be used to calculate upper and lower bounds to the information rate. The goal of the work is to obtain upper and lower bounds as close as possible to each other, in order to compute an information rate close to actual one.
The Shannon information rate of a Markov channel can be achieved also by ideal demodulation, which cannot be often adopted in practical system. The iterative demodulation and decoding scheme try to reach the performance of ideal demodulation. Another goal of the work is the study of the Bayesian tracking methods to extract all the information about the transmitted symbols in a new iterative demodulation and decoding scheme.

Second Ph.D. presentation and discussion:

Dr. Silvio MANDELLI - XXVIII Cycle

Analysis of Wiener Phase Noise Issues in Optical Transmission Systems

Supervisor: Prof. **Maurizio Magarini**

Abstract: In optical communications, local oscillators and propagation introduce multiplicative phase noise that must be taken in consideration, estimated and compensated at the receiver. In the literature such channels are dealt with by considering a symbol-spaced discrete-time model where the transmitted symbol is impaired by both AWGN and a multiplicative phase noise given by a first order Wiener process. The issues given by such channels are objects of several works in the literature.

The aim of this thesis is to discuss some of them and trying to extend those dissertations. First of all, in the literature this model is assumed by considering "small" phase noise but nobody has ever discussed how much ``small" it must be. A statistical and mathematical analysis is derived by the author, and a threshold of validity of the so called Discrete Model is worked out, proving that the assumption is correct in almost all practical scenario and it is conservative in term of performance simulation. The analysis of phase noise channels is then deepened by studying Bayesian tracking techniques to extract all the information about the transmitted symbols. An iterative demodulation and decoding scheme is proposed and compared to others in the literature. The major gain is given by the greater spectral efficiency obtained by not transmitting Pilot Symbols and still working better than other considered similar schemes. Bayesian tracking allows also to derive the information rate of the considered Discrete Model channel and to verify that the proposed algorithm can achieve it. The focus is then moved to analyze short reach access optical scenarios where, for spectral efficiency and receiver sensitivity, OFDM has been considered instead of single carrier systems. For cost, footprint and power consumptions requirements, Direct Detection has several advantages compared to Coherent schemes since the multiplicative phase noise introduced by the transmitting laser can be neglected. However, if dispersive compensating fibers are not used, Chromatic Dispersion impairs the signal and the phase noise cannot be canceled. The author has proposed the literature analysis of this phenomenon, enlightening its weaknesses and comparing the new results of the thesis with experimental measurements given by other authors.