



INTERNATIONAL SCHOOL FOR GEOSCIENCE RESOURCES (IS-Geo)
KOREA INSTITUTE OF GEOSCIENCE AND MINERAL RESOURCES (KIGAM)

PUBLIC CUSTOMIZED TRAINING COURSE ON Statistical approaches for signal processing, application to seismic/infrasonic signals

The **International School for Geoscience Resources** of KIGAM presents an intensive training course on **Statistical Signal Processing**. The **10 day** course will take place at the Ara room of International School for Geoscience Resources of KIGAM in Daejeon (Korea) in **December 10, 2012** through **February 20, 2013** and will include the following topics:

Topic	Date	Instructor
Day 1. Introduction to Statistical Signal Processing. Introductory example: pure delay propagation model. Statistical assumptions.	Dec 10	Dr. Maurice Charbit (Telecom ParisTech)
Day 2. Parametrical statistical model. Definition of an estimator. Performances. Limit central theorem.	Dec 12	Dr. Maurice Charbit
Day 3. Linear model. Ordinary least squares (OLS), Gauss-Markov theorem. Confidence interval.	Dec 17	Dr. Maurice Charbit
Day 4 Definition of a test of hypothesis. Simple/composite hypothesis. Most Powerful (MP). Uniformly MP. Generalized Likelihood Ratio Test. Properties.	Dec 18	Dr. Maurice Charbit

Day 5

Detailed examples: composite hypotheses in the univariate/multivariate gaussian model. Tests on the mean, on the variance, on the equality of means.

Jan 7

Dr. Maurice Charbit

Day 6

Estimation problem: general approaches. Method of moments, Maximum likelihood estimation. Bayesian approach.

Jan 9

Dr. Maurice Charbit

Day 7

A fundamental limit for estimation: Cramer-Rao Bound. Useful expressions in the gaussian case.

Jan 14

Dr. Maurice Charbit

Day 8

Statistical approaches for array processing. Deterministic/stochastic models. Narrowband/broadband. Application: Fisher Statistic for SOI detection

Jan 16

Dr. Maurice Charbit

Day 9

Detection of a signal of interest in white additive gaussian noise. Applications to infrasound detection. Performance index.

Feb 18

Dr. Maurice Charbit

Day 10

Expectation-Maximization: a useful algorithm for parameter estimation of a distribution mixture (GMM).

Feb 20

Dr. Maurice Charbit

COURSE INFORMATION

• Agenda

- This course will provide an introduction to some statistical tools used in signal processing. Students will then be challenged with problem variants to expand their capabilities and understanding.

• Summary

- Some contents will be covered during the course, but students will be encouraged to develop their own problems at the end of the course.

- **Course Covered**

- Basic methods in statistical inferences: estimation and detection.

- **Course Requirements: Prerequisite**

- Knowledge of basic probability and Fourier representation
- Understanding of numerical methods for optimization
- Experience with Matlab will help but is not necessary
- Course language will be English

- **Who should attend?**

- This course is designed for scientists or engineers involved at statistical approaches, especially for infrasound/seismic detection.

- **Summary of topic content and learning objectives**

The main objectives of this course are to present useful knowledge on the statistical approach. It is why, in the opening day of the course, we adopt an inductive approach to introduce through the simple example of pure delay propagation model the useful theoretical aspects of parametrical statistical models. The final goal is to be able to translate a practical problem in mathematical objects, determine the performances and conduct simulations with clear protocols.

- **Day 1. Day Topic Name**

Introduction to parametrical statistical models

- Objective
- An elementary example,
- Statistical model, parameters of interest/nuisance
- Recall of useful probability definitions/results,
- Time difference of arrivals (TDOA) estimation between two sensors,
- Demos with Matlab.

- **Day 2. Day Topic Name**

Inference in statistic

- What do you expect from a good estimator?
- Mean square approach,
- A detailed example: estimation of the error probability
- Construction of a confidence interval, Limit central theorem.

- **Day 3. Day Topic Name**

Linear model

- Ordinary least squares, Gauss-Markov theorem
- Weighted least squares,
- Example: estimation of the direction of arrivals (DOA)
based on TDOA estimation.
- Important distribution: χ^2 , student,
- Selection of variables
- Underdetermined case.

- **Day 4. Day Topic Name**

Test of hypothesis

- Definition, simple/composite hypothesis,
- Most powerful (MP) test, likelihood ratio test,
- Uniformly MP (UMP) test,
- Generalized likelihood ratio test (GLRT)
- Receiver Operating Characteristic (ROC) curve for simple hypotheses.

- **Day 5. Day Topic Name**

Test of hypothesis (continued)

- Detailed examples: composite hypotheses in the univariate/multivariate
gaussian model. Tests on the mean, on the variance, on the equality of means
- Demos on Matlab.

- **Day 6. Day Topic Name**

Estimation

- Estimation problem: general approaches.
- Method of moments,
- Maximum likelihood estimation.
- Detailed examples,
- Demos in Matlab



- **Day 7. Day Topic Name**

- Estimation (continued)
 - Fundamental limit: Cramer-Rao Bound (CRB) of quadratic errors,
 - Application to Gaussian models.
 - Bayesian approach.

- **Day 8. Day Topic Name**

- Statistical approaches for array processing
 - Formulation, narrow-band/broadband signals,
 - Application to Gaussian models., deterministic/stochastic model,
 - Narrow-band approaches: MLE, MUSIC, ESPRIT
 - Broadband approaches

- **Day 9. Day Topic Name**

- Statistical approaches for array processing (continued)
 - Fisher statistic for signal detection.
 - DOA estimation,
 - ROC curve for threshold tests, AUC, EROC and EAUC.
 - Constant False Alarm Rate (CFAR) test

- **Day 10. Day Topic Name**

- Expectation-maximization algorithms,
 - Formulation,
 - Applications to Gaussian Mixtures Models (GMM)

About the instructor – Dr. Maurice J.C. CHARBIT



Maurice CHARBIT has currently a full Professor position at the Institut des Télécommunications de Paris. He is teaching in Probability theory, Signal processing and Digital communications and Statistical signal processing. His main areas of interest are (i) 3D model based approach for face tracking in video sequences, (ii) Audio and Speech Processing in automotive environment, (iii) Multiple sensors array and application to geo-localization and tracking of mobiles of a radio communication network, (iv) Object tracking (HMM inferences). He is working for two years with the Commissariat à l'Energie Atomique (CEA) from France on infrasound signal processing. He is co-author of a book for undergraduated and graduated students on signal and image processing, which is supported by many exercises and computer simulations relating to real applications.

A few recent publications

1. N. Castaneda, M. Charbit, and E. Moulines, *A new approach for mobile localization in multipath scenarios, Communications, 2007. ICC '07. IEEE International Conference on, 24-28 June 2007, pp. 4680–4685.*
2. J.A. Ybañez-Zepeda, F. Davoine, and M. Charbit. *Local or global 3D face and facial feature tracker. In Proceedings of the IEEE International Conference on Image Processing, volume 1, pages 505–508, San Antonio, Texas, USA, 16–19 September 2007.*
3. M. Charbit and L. White, *System design for temporally correlated MIMO channels Communications Theory Workshop, 2008. AusCTW 2008. Australian, Page(s): 156-160.*
4. M. Keen Choong, M. Charbit, and H. Yan, *Autoregressive Model-based Missing Value, Estimation for DNA Microarray Time Series Data.* IEEE Transactions on Information Technology in BioMedicine. 2009.
5. Audière, S., Charbit, M., Angelini, E., Oudry, J., Sandrin, L.: *Measurement of the Skin-Liver Capsule Distance on Ultrasound RF Data for 1D Transient Elastography.* In: Jiang, T., Navab, N., Pluim, J., Viergever, M. (eds.): Medical Image Computing and Computer-Assisted Intervention – MICCAI 2010, Vol. 6362. Springer Berlin / Heidelberg (2010) 34-41
6. Audière, S., Angelini, E., Charbit, M., Miette, V.: *Evaluation of in vivo liver tissue characterization with spectral RF analysis versus elasticity.* In: Fichtinger, G., Martel, A., Peters, T. (eds.): Medical Image Computing and Computer-Assisted Intervention – MICCAI 2011, Vol. 6891. Springer Berlin / Heidelberg (2011) 387-395
7. M. Charbit, K. Abed-Meraim, G. Blanchet, A. Le Pichon and Y. Cansi, *Maximum Likelihood Approach to Detect and Estimate Infrasound Wave Parameters, Infrasound Technology Workshop, Dead Sea, Jordan - 2011.*
8. Maurice Charbit, Karim Abed-Meraim, G. Blanchet, Alexis Le Pichon et Y Cansi, *OLS vs WLS for DOA Estimation Based on TDOA Estimates: Application to Infrasonic Signals*, EGU, Vienna, 2012.
9. G. Blanchet and M. Charbit, *Digital Signal And Image Processing Using Matlab*, Iste Publishing Company, 2006.