## PhD Seminar on

# The Probabilistic Analysis of Systems in Engineering

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In engineering analysis we are repeatedly faced with the problem that we need to assess, model or predict the behavior of natural and/or engineered systems. Typical for the systems we are dealing with is that they often are constituted by a close interrelation between processes of nature and actions of humans. Examples of systems in engineering include infra-structure systems such as roadway systems and electricity distribution systems. A main characteristic of the systems is that they are constantly evolving over time under the influence of basic laws of nature and in many cases also the interaction with humans. Generally our understanding of the behavior of systems is limited; the systems are complex due to their internal structures and may not easily be synthesized. In addition, a large number of the physical and/or human influences which affect the systems behavior are subject to significant uncertainty.

In the development and maintenance of the societal infrastructure as well as in the management of natural and manmade hazards, systems analysis as a focused research area is becoming increasingly important. Systems which are built and maintained to support societal functions are constantly being extended to meet increased requirements. However, whenever a system is extended also the characteristics of the system are changed. Systems may through their internal structure become unstable in regard to influences which are hard to control; this effect may also imply that risks are increased. The understanding and the ability to analyze systems in regard to these characteristics is major factor for improving engineering support of societal decisions.

The present study group seminar is concerned about the understanding, assessment and modeling of systems from a probabilistic perspective. First we will take a look at the basic theory of systems and the basics of Bayesian probability theory. Thereafter we will approach systems modeling and analysis from the bottom up and the top down perspectives and study how in these two approaches data may be utilized to support the modeling. Hierarchical Bayesian models will be introduced as a main model framework and approaches for model to data adaptation using modern probabilistic schemes will be outlined.

### Who should attend?

Researchers, Ph. D. students, post-docs and graduate students interested in the general modeling and analysis of systems subject to uncertainties.

### Mode

The seminar will be conducted as a study group under the responsibility of Prof. Faber. All participants will in turn be responsible for presenting a part of the material and for developing the examples. Self study, presentations and discussions will constitute main components of the course.

**Literature**

Books:

Gelman, A.B., Carlin, J.B., Stern, H.S., and Rubin, D.B., Bayesian Data Analysis, CRC Press, 2004

Congdon, P., Bayesian Statistical Modelling, John Wiley & Sons Inc, 2007

Selected papers

**When and where?**
Wednesdays, 16:45 – 18:00, ETH Hönggerberg, HIL E 6.

**Agenda (course plan)**

| W | Date | Speaker | Topic |
|---|---|---|---|
| 1 | 26.09.07 | Prof. M.H. Faber | Basic theory of systems<br>- Definition of systems |
| 2 | 03.10.07 | Prof. M.H. Faber | Basic theory of probability<br>- Classical probability theory and Bayesian probability theory |
| 3 | 10.10.07 | K. Nishijima | Bayesian probabilistic networks<br>- Definition and use of Bayesian probabilistic networks |
| 4 | 17.10.07 | | Bayesian probabilistic networks<br>- Algorithms used in Bayesian probabilistic networks |
| 5 | 24.10.07 | | Bayesian probabilistic networks<br>- Introduction of available software tools<br>- Statistical inferences |
| 6 | 31.10.07 | | Bayesian probabilistic networks<br>- Hierarchical modeling |
| 7 | 07.11.07 | | Assessment of system reliability and robustness |
| 8 | 14.11.07 | J. Qin | Application example<br>- Performance of structural systems |
| 9 | 21.11.07 | | Application example<br>- Propagation of degradation |
| 10 | 28.11.07 | Y. Bayraktarli | Application example<br>- Analysis of portfolio losses |
| 11 | 05.12.07 | | Application example<br>- Process of natural hazards |
| 12 | 12.12.07 | | Application example<br>- Electricity distribution systems |
| 13 | 19.12.07 | | Application to other fields |