UNIVERSITÀ DEGLI STUDI DI BRESCIA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in

Technology for Health

Stochastic Processes and Performance Modeling

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Abstract: If Math is the language of science, Stochastic Math is the language of Advanced Modeling and Performance Evaluation, from Event Driven Simulation (in the very end nothing else than a Monte Carlo solution of a Semi-Markov Chain), to the analysis of Digital Communications and Computer Science, to Hidden Markov Chains that are one of the key ingredients of Computational Biology and of many applications of computational methods applied to Health Care, as well as one of the tools available in the Machine Learning zoo.
This course, while trying to be very "light" in advanced math use, wants to lay a very solid theoretical background to tackle any (well, almost any!) scientific problem than needs to deal with non-deterministic phenomena of simply under-determined systems where lack of knowledge appears as random behavior, from bugs in software to errors in transmission systems, noise in electronic devices, disease spreading, efficiency of medical treatment, and many more.
Modeling and Performance Evaluation are key ingredients of any engineering project, as well as Business Plans and Industrial Innovation: revenues for industries must be properly forecasted in advance (to decide if the initial investment is worth) and forecasting requires a model. A Stochastic Model simply adds details and probabilistic interpretation of future events, granting a much better understanding (compared to deterministic models) of the system under analysis and proper interpretation of risks and their consequences, from money loss, to risks for the environment and the society at large.

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Program

- **Monday 23, March - 13.00-17.00**: Introduction and Motivation
  - Why Modeling
  - Why Stochastic
  - The role of Models in (Computer) Science and Engineering
  - Rehearsal of Probability (at least what we need to understand this course)
  - Definition of a Stochastic Process
- **Tuesday 24, March - 9.00-13.00:** Markov Processes and Markov Chains (continuous and discrete time)
  - Memory and Correlation
  - Why we cannot handle Stochastic Models beyond trivial ones (Memoryless, Markovian, Gaussian)
  - The importance of first order memory (vs. memoryless and deeper memory structures)
- **Wednesday 25, March - 9.00-13.00:** Solving Markov Chains
  - Transient solution
  - Steady State solutions and their interpretation
- **Thursday 26, March - 9.00-13.00:** Higher level descriptive languages with underlying Markov Chains
  - Queueing and Queueing Networks
  - Petri Nets, TML, ...
- **Friday 27, March - 9.00-13.00:**
  - Hints to Hidden Markov Models and their role in ML, Computational Biology, and Health Care
  - Examples of Markov Theory applications that changed the world, from Language Analysis to Shannon Theory to Page Rank and much more!

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