

Modelling & Simulation

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Presentation

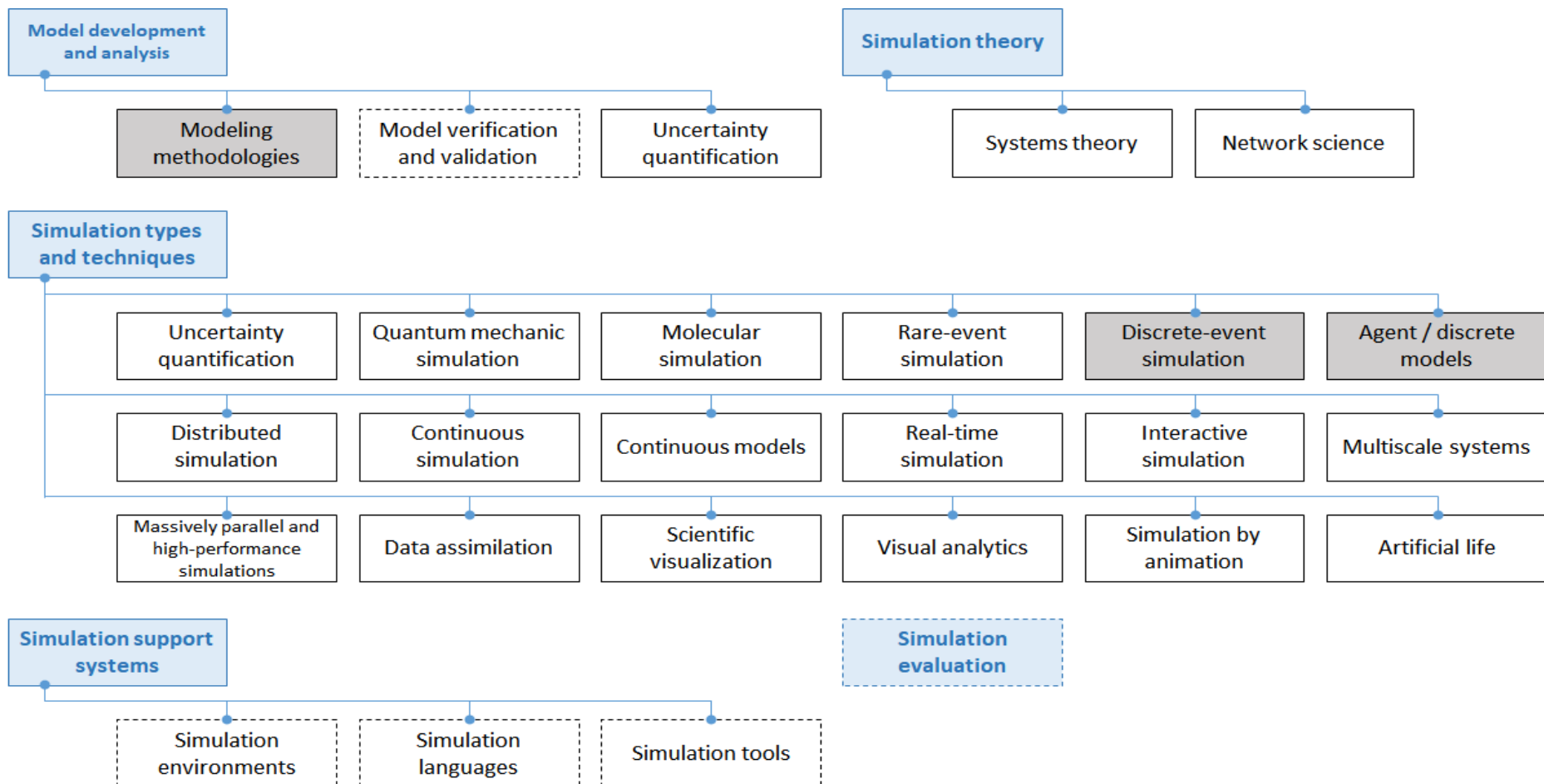
- Course programme at a glance
- Assessment system
- Recommended readings
- Some examples

Programme

- Lecturer: Dr. Rosaldo Rossetti (Assoc. Prof. FEUP-DEI/LIACC)
- Teaching language: English
- *Goals:*
 - *Present to the students the fascinating field of modelling and simulation as an important asset and imperative **tool inherent to engineering and to the scientific method**, for testing and validating concepts and theories, which will be invaluable in virtually all MSc/PhD projects in engineering, and throughout some careers in engineering.*
 - *Presentation of and open discussions on **contemporary modelling and simulation methods and techniques** are expected to motivate students to identify problems and to point out challenges that turn such a field into an interesting research domain within (Informatics) Engineering that is rather multidisciplinary.*

Programme

M&S in the ACM Computing Classification System (*Computing Methodologies*)



Programme

- Learning Outcomes

After concluding the course successfully, students will be able to:

- Identify problems, **devise models** and develop suitable simulation projects;
- **Analyse** and implement **simulation results**;
- **Select and use simulation techniques** within the scientific method as well as within engineering projects in different fields;
- **Demonstrate proper understanding** of main areas of interest and current challenges to the field of **modelling and simulation**;
- **Use modelling and simulation tools** effectively;
- **Design and implement modelling and simulation tools** and environments, either domain-specific or general-purpose.

Modelling & Simulation

- What is (computer) simulation?
 - It is a technique for handling (complex) **systems** through **models**, which represent their properties, behaviours and interactions partially or totally.
- Why to model and simulate systems?
 - Observation, understanding, forecasting, training and learning, entertainment, communication, decision support, etc.
- Invaluable decision-support tool – useful for *what-if* analysis
 - Descriptive
 - Normative (optimisation)
 - Predictive
 - Prescriptive
 - Speculative (scenarization)

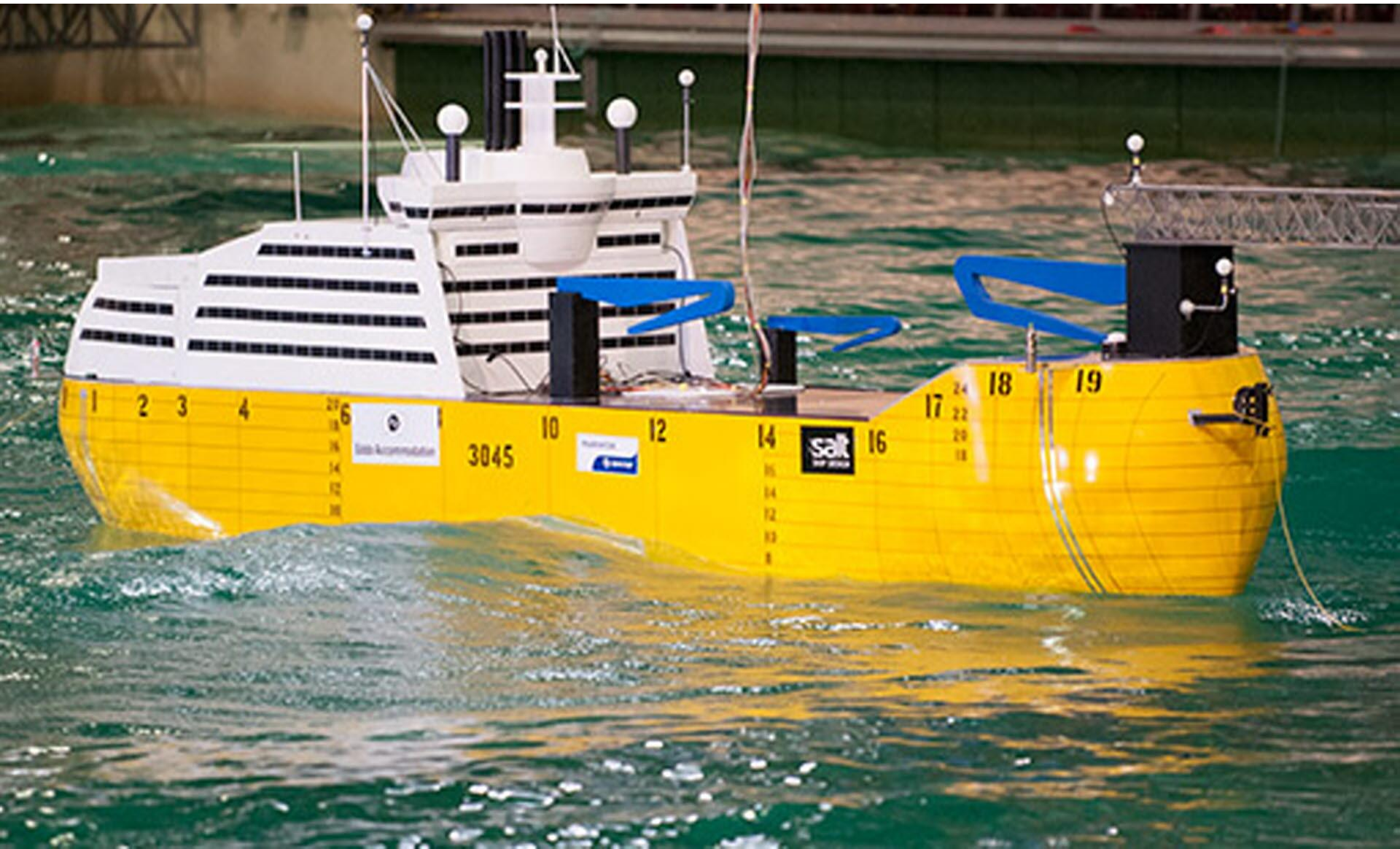
Modelling & Simulation



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- How to carry out a simulation project?
 - It basically involves:
 - Modelling
 - Simulating
 - Analysing/Reporting/Implementing results
 - These steps will depend on the purpose, system, and methodology, though!

Modelling & Simulation

- Topics
 - Review and presentation of concepts:
 - Simulation as an engineering methodology;
 - Modelling (realism, abstraction) and types of models (normative, behavioural....);
 - Modelling metaphors and simulation techniques;
 - Data preparation and treatment;
 - Modelling of complex systems and stochastic processes;
 - Simulation methodologies:
 - Basic techniques of simulation: continuous, discrete and probabilistic simulation;
 - Simulation life cycle: data modelling, collection and preparation; test, calibration and validation of models, results analysis and implementation;
 - Languages and environments of simulation.
 - Advanced topics in modelling and simulation:
 - Object-oriented simulation;
 - Distributed simulation;
 - Visual interactive modelling and simulation;
 - Intelligent simulation;
 - Agent-based modelling and simulation;
 - Simulation environments and simulation of environments;
 - Applications of simulation (**Invited Seminars**);
 - Project.

Modelling & Simulation

- A few examples of applications
 - **Games**
 - Film Industry
 - Manufacturing
 - Bank operations
 - **Airport and Airlines**
 - Flight Simulation
 - **Military Operations**
 - **Transportation**
 - Satellite Navigation
 - **Robotics**
 - Biomechanics
 - Molecular Dynamics
 - **Logistics, supply chain, distribution**
 - Hospitals: emergency, operation, admissions...
 - Computer networks
 - **Business processes**
 - Chemical plants
 - Fast-food restaurants
 - Supermarkets
 - **Stock Exchange**
 - Thematic parks
 - Emergency-response systems
 - **Sports**
 - **Social sciences**

Modelling & Simulation

- Professional opportunities
 - **Industry, manufacturing, and productive processes**
 - Services, banking and financial markets
 - **Sports**
 - **Health care systems**
 - **Engineering SW, CAD, CAE/CAM**
 - **Military applications**
 - Entertainment and games
 - Robotics and home automation
 - **Transport and logistic operations**
 - Education and training
 - **Research & Development**
 - ... and many others!

Modelling & Simulation

- Professional opportunities (**Simulation Engineer/Scientist**)



AMG
PETRONAS
FORMULA ONE TEAM

Eng. João Neto
former MIEIC/FEUP

Assessment System

- Distributed throughout the term
 - Project development (P): 40%
 - Project report/paper (R): 20%
 - Project demo/presentation and discussion (D): 10%
 - Individual assessment test (T): 30%
 - Theory + Case-study analysis
- Final mark (F)
 - **$F = 0.4 * P + 0.2 * R + 0.1 * D + 0.3 * T$**

all components should have marks ≥ 8.0

Assessment System

- Project Deliverables
 - Reports
 1. Problem statement, and problem formalisation
 2. Final report (paper format for submission to a conference)
 1. Literature review: background and related work
 2. Methods and materials
 3. Result analysis and discussion
 - Presentation (15+10 min)
 - Slides (PPTX, commented)
 - Demo video
 - Oral (recorded) presentation and discussion
 - Source code (documented)
 - Git repository
 - “How-to- Build & Run” script

Assessment System

- Class plan:
 - introduction and discussions of selected topics
 - project-based practicals;
- Calendar
 - Group formation (3 students preferably)
Week 3 (25 Sep – 29 Sep)
 - 1st assignment: problem formalisation; methods & tools
Week 5 (12 Oct)
 - Mini-test
Week 11 (23 Nov)
 - Presentation & demo
Exam 1 (4 Jan)
 - Project submission (code/paper)
Exam 3 (18 Jan)

Assessment System

- Topics of interest
 - Multi-paradigm, open-source, simulation-as-a-service framework
 - Simulation-games
 - Behavioural-modelling through simulation-games; Behavioural model validation methodologies
 - Human-in-the-loop simulation; peer-designed agent methods
 - Simulation projects in NetLogo, Mesa, SimPy
 - Simulation projects in SUMO
 - Macroscopic traffic simulator
 - Meta-models and methodologies
 - Calibration and validation methodologies
 - Other topics ...
- **OBS: all must include statistical/quantitative analysis!**

Recommended Readings

- Recommended and suggested literature
 - Law, A. (2007)
Simulation Modeling and Analysis, McGraw-Hill
 - Banks, J.; Carson, J.; Nelson, B. (2005)
Discrete-event System Simulation, Prentice Hall
 - Chung, C. (2003)
Simulation Modeling Handbook: a practical approach, CRC Press
 - Brito, A. (2001) Teixeira, J.;
Simulação por computador: fundamentos e implementação em C e C++, Publindústria
 - Conferences and scientific journals on Modelling & Simulation
- Other resources
 - [Moodle](#) (course id=5348)
 - [Sigarra webpage](#)