

M2 LMFI

Preuves et Programmes: outils classiques

Teachers:

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INSTITUT
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Organization

0 Lectures:

Tuesday 11h00-13h00

Wednesday 16h15-18h15

0 Exercises:

integrated to lectures.

0 Grading:

- homework projects

Plan

0 Focus: **foundational study of programs**

- Focus first part: **operational semantics**
- Focus second part: **denotational semantics** of functional programming,

- Both build on *proof theory* (Types, Curry-Howard isomorphism, Linear Logic) and the theory of *lambda-calculus*.
- Openings towards active research topics

0 Courses from first term we build on:

- *Proof Theory*,
- *Functional programming and formal proofs in CoQ (not strictly required)*

Plan: first part (C. Faggian) *HANDS-ON*

- Theoretical tools to study the operational properties of a system:
 - Rewrite Theory (rewriting=abstract form of program execution)
- Induction and Co-induction proof principles.
- Linear Logic and Proof-Nets.

- Bridging between lambda-calculus and functional programming.
 - Call-by-Value and Call-by Name, weak and lazy calculi.
 - Big-Step and Small-Step operational semantics.
 - Observational equivalence

- Reasoning on programs equivalence:
 - Bisimulation and coinductive methods.

- Beyond pure functional:
 - Probabilistic programming and Bayesian Inference:
Probabilistic lambda calculi, Bayesian proof-nets

Plan: second part (G. Vanoni)

HANDS ON AGDA

- Introduction to the Agda proof assistant, de Bruijn notation, and recap on the untyped lambda-calculus.
- The denotational semantics of untyped lambda-calculus, formalized.
- Soundness and adequacy, formalized.
- Contextual equivalence, filter models, and intersection types.

Resources

○ Reference Books:

- *AMADIO : Operational methods in semantics*
(available on HAL <https://hal.archives-ouvertes.fr/cel-01422101v1>).
- *SANGIORGI: Introduction to Bisimulation and Coinduction*
(Cambridge University Press, 2011)
- WADLER, KOKKE, SIEK. Programming Language Foundations in Agda. Available at <https://plfa.inf.ed.ac.uk/>. 2023.

○ Lecture Notes (by O. Laurent, L. Ong)