助教 Zeinab Galal (Theoretical computer science group)

My research is mainly focused on semantics of programming languages and it lies at the intersection of computer science, mathematical logic, category theory and combinatorics. The aim is to use mathematical structures to model programs in order to both prove properties of programming languages and enrich their syntax and expressiveness.

When considering richer semantical models, 1-categories are not always sufficient to capture their compositional properties and we are led to work in a bidimensional setting with the various notions of 2-categories, bicategories or double categories. In denotational semantics, using bidimensional categorical structures further allows to study program execution steps as primitive objects since they become explicit 2-morphisms carrying information on program reductions. The 2-dimensional approach also provides an important connection with combinatorics through the notion of species of structures.

I have first worked during my PhD thesis on the denotational semantics of λ-calculus and linear logic, and afterwards on fixpoint theory. One of my main current objectives is to develop the theory of bicategorical fixpoints and trace. Fixpoints play an important role to reason on recursively defined programs and to model data types obtained by induction or coinduction. Fixpoints operators are also connected to traced categories which capture the notion of feedback for cyclic computation and is also used in physics (most notably in quantum computing) and in topology with knot theory.

My aim is to generalize the existing theory to dimension two in order to study their dynamical properties and establish new connections with cyclic lambda-calculi, higher categories and topology.

Publications

[1] *On Computational Indistinguishability and Logical Relations*, with Ugo Dal Lago and Giulia Giusti, 22nd Asian Symposium on Programming Languages and Systems (APLAS 2024)

[2] *Combining fixpoint and differentiation theory*, with Jean-Simon Pacaud Lemay, 39th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS 2024)

[3] *Stabilized profunctors and stable species of structures*, with Marcelo Fiore and Hugo Paquet,Logical Methods in Computer Science, Volume 20, 2024

[4] *Fixpoint operators for 2-categorical structures*, 38th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS 2023)

[5] *Fixpoint constructions in focused orthogonality models of linear logic*, with Marcelo Fiore and Farzad Jafarrahmani, 39th Conference on Mathematical Foundations of Programming Semantics (MFPS 2023)

[6] *A Combinatorial Approach to Higher-Order Structure for Polynomial Functors*, with Marcelo Fiore and Hugo Paquet, 7th International Conference on Formal Structures for Computation and Deduction (FSCD 2022)

[7] *A Bicategorical Model for Finite Nondeterminism*, 6th International Conference on Formal Structures for Computation and Deduction (FSCD 2021)

[8] *A Profunctorial Scott Semantics*, 5th International Conference on Formal Structures for Computation and Deduction (FSCD 2020)

[9] *Ilyashenko algebras based on transserial asymptotic expansions*, with Tobias Kaiser and Patrick Speissegger, Advances in Mathematics, Volume 367, 2020