

The Research Group
Artificial Intelligence Lab

has the honor to invite you to the public defence of the PhD thesis of

Samuele Pollaci

to obtain the degree of Doctor of Sciences

Joint PhD with KU Leuven

Title of the PhD thesis:

**Fixpoint Theory and Biworlds:
the Power of Approximations in Knowledge Representation**

Supervisors:

Prof. dr. Bart Bogaerts (VUB)

Prof. dr. Marc Denecker (KU Leuven)

The defence will take place on

**Thursday, October 22, 2026 at 5 pm
in auditorium Q.B**

The defence can be followed online. Contact
Samuele.pollaci@vub.be for more information.

Members of the jury

Prof. dr. Geraint Wiggins (VUB, chair)

Prof. dr. Lynn Houthuys (VUB)

Prof. dr. Joost Vennekens (VUB)

Prof. dr. Pieter Bonte (KU Leuven)

Prof. dr. Dominique Devriese (KU Leuven)

Prof. dr. Panos Rondogiannis (University of
Athens, GR)

Prof. dr. Annie Liu Yanhong (Stony Brook
University, USA)

Curriculum vitae

Samuele Pollaci completed his M.Sc. in Mathematics at Bonn University (Germany) in 2022. Afterwards, he started his Ph.D. in Sciences in the Knowledge Representation and Reasoning group at the AI Lab of the VUB. This later transitioned to a joint Ph.D. when he started his Ph.D. in Engineering Science at the Declarative Languages and Artificial Intelligence group of KU Leuven. His research interests lie in the generalization and applications of Approximation Fixpoint Theory, multi-agent Autoepistemic Logic, Datalog, and Justification Theory.

Abstract of the PhD research

Approximations arise in countless scientific fields: either by design, to make an otherwise too complicated problem more tractable; or by lack of information. Hence, formally representing and using incomplete information is fundamental. In Knowledge Representation and Reasoning, this is achieved through various devices, like partially-defined functions, or four-valued semantics. In this thesis, we showcase the capabilities of approximations by employing them to define semantics through two formalisms: first, via Approximation Fixpoint Theory (AFT); secondly, in multi-agent autoepistemic logic, using the novel concept of biworlds. Even though the settings are rather different, the ways we use approximations share some similarities: we encode approximations as pairs of bounds, and we define a precision order. Then, the versatility and relative simplicity of the approximations allow for the construction of complex objects, which are fundamental to defining the desired semantics.

In the first part of this thesis, we focus on AFT: a powerful algebraic tool meant to unify the semantics of various non-monotonic formalisms, like logic programming, default logic, and autoepistemic logic, with numerous applications. We start by providing yet another application of AFT, namely DatalogMTL⁻: an extension of Datalog with metric temporal operators and enriched with negation. By using AFT, we define the stable, well-founded, Kripke-Kleene, and supported model semantics for DatalogMTL⁻. We then extend AFT to a higher-order environment. We achieve this by devising a mathematical framework employing the notion of Cartesian closed category to inductively construct higher-order approximation spaces while preserving the structures necessary for the correct application of AFT.

In the second part of this thesis, we study the interplay of common knowledge and only knowing, which capture two intuitive notions, useful in a variety of settings, for example, to reason about coordination or agreement between agents. We propose a solution by defining a notion of μ -biworld for countable ordinals μ , which approximates not only the worlds that an agent deems possible, but also those deemed impossible. This allows us to define a multi-agent epistemic logic with common knowledge and only knowing operators, a three-valued model semantics for it, and an equivalent Kripke semantics on a canonical Kripke structure. Finally, we discuss issues regarding negative introspection and truthfulness, and show how positive introspection can be integrated into our logic.