University Academic Curriculum Vitae

Alessandro Daniele

February 6, 2026

Personal Information

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Education Since Leaving School

Nov 2016 – Dec 2020 **PhD in Smart Computing**, obtained on December 2020 at *University of Florence - Fondazione Bruno Kessler*. Thesis title: "Neural Networks Enhancement through Prior Logical Knowledge" (supervisor: Luciano Serafini).

Oct 2011 – Oct 2014 **Master's Degree in Computer Science** (*Laurea Magistrale in Informatica*), obtained on October 2014 at *University of Padova*. Thesis title: "Multiple Sequence Alignment through a stochastic local search algorithm" (supervisor: Giorgio Valle). Final mark: *110/110 cum Laude*.

Oct 2007 – Feb 2011 **Bachelor's Degree in Computer Science** (*Laurea Triennale in Informatica*), obtained on February 2011 at *University of Padova*. Thesis title: "Prototype of an information system for a wellness facility" (Supervisor: Tullio Vardanega). Final mark: *102/110*.

Professional Experience

From/to	*Job title*	*Name of academic institution*	*Academic level*	*Responsibilities*
Jan 2023 – Jan 2026	Researcher	Fondazione Bruno Kessler, Trento	Researcher (R4)	Conducted research in Neurosymbolic Integration, focusing on logical constraint injection, symbolic rule learning from perceptual data, and temporal logic frameworks. The role also involved co-supervising PhD and Master's students.

From/to	*Job title*	*Name of academic institution*	*Academic level*	*Responsibilities*
Jan 2020 – Jan 2023	Postdoctoral Researcher	Fondazione Bruno Kessler, Trento	Researcher (R4)	My activity focused on the design and development of novel neurosymbolic frameworks, including KENN2 and Deep Symbolic Learning. This work was also part of my contribution to the European project AI4EU.
Sep 2021 – Dec 2021	Visiting Researcher	Vrije Universiteit Amsterdam	Visiting Researcher	Visiting period funded by a HumanE-AI-Net microproject. The research aimed to generalize the KENN theory, leading to the development of ILR, a new method for injecting logical constraints into neural networks.
Nov 2016 – Oct 2019	PhD Student	University of Florence – Fondazione Bruno Kessler	Doctoral Candidate	My doctoral project involved research on enhancing neural networks with prior logical knowledge. The main outcome was the design and implementation of the KENN model, which formed the core of my PhD thesis.
Sep 2015 – Aug 2016	Research Fellow	CRIBI, University of Padova	Research Fellow	My role involved bioinformatics research, with a specific focus on the design and implementation of stochastic local search algorithms to address the Multiple Sequence Alignment problem.
Nov 2014 – Aug 2015	Junior Developer	Engineering Ingegneria Informatica S.p.A.	Industry	As part of the SpagoBI team, I was responsible for software development on their business intelligence platform, including the implementation of services for European projects like FIWARE, and Prosperity 4 All.

Experience in Academic Teaching

I have a profound interest in academic teaching and mentorship. Unfortunately, during my time at Fondazione Bruno Kessler, a non-university research institution, formal teaching duties were not part of my role. A primary motivation for my transition to an academic environment is precisely the opportunity to engage in teaching.

My experience to date has consisted of delivering guest lectures at various universities. I have found these to be incredibly positive and rewarding experiences, both for the knowledge gained and the satisfaction of engaging with students. Notably, one of these lectures sparked the interest of a student (Andrea Mascari) who subsequently completed his Master's thesis on a topic related to my work, a project I had the pleasure of co-supervising.
My teaching activities to date include:

- **Invited Lecture:** "Neuro-Symbolic techniques for Knowledge Injection in Neural Models", held at TU Wien (Vienna, Austria) on April 30th, 2025.
- **Invited Lecture:** "Injecting Prior Knowledge into Neural Networks", held at the University of Milano-Bicocca (Milan, Italy) on October 23rd, 2022.
- **Invited Lecture:** "Knowledge Enhanced Neural Networks", held at the University of Padova (Padova, Italy) on May 23rd, 2022.
- **Invited Lecture:** "Multiple Sequence Alignment", part of the Bioinformatics course, held at the University of Padova (Padova, Italy) on October 23rd, 2014.

Supervision and Evaluation of Theses

Co-supervision of Master's Theses

- **Student:** Riccardo Mazzieri, University of Padova (A.Y. 2020-2021).
  Thesis Title: "Towards Explainability in Knowledge Enhanced Neural Networks".
  (Main supervisor: Prof. Luciano Serafini)
- **Student:** Andrea Mascari, University of Padova (A.Y. 2022-2023).
  Thesis Title: "Beyond Material Implication: an Empirical Study of Residuum in Knowledge Enhanced Neural Networks".
  (Main supervisor: Prof. Luciano Serafini)

PhD Thesis Evaluation and Committee Membership

- **Role:** Thesis reviewer and Member of the PhD Evaluating Committee.
  Candidate: Elvira Amador Domínguez, Universidad Politécnica de Madrid.
  Thesis Title: "Methods for Knowledge-Based Systems and Deep Learning Integration".
  Defense Date: July 26, 2022.

Memberships

PC Membership at International Conferences and Workshops

- **2024** Program Committee Member, *21st Int. Conference on Principles of Knowledge Representation and Reasoning (KR).*
- **2024** Program Committee Member, *18th Int. Workshop on Neural-Symbolic Learning and Reasoning (NeSy).*

– **2023** Program Committee Member, *Workshop on Neurosymbolic Generative Models (NeSy-GeMs) @ ICLR 2023.*

– **2023** Program Committee Member, *17th Int. Workshop on Neural-Symbolic Learning and Reasoning (NeSy).*

– **2022** Program Committee Member, *16th Int. Workshop on Neural-Symbolic Learning and Reasoning (NeSy).*

– **2018** Program Committee Member, Doctoral Consortium of the *17th Int. Conference of the Italian Association for Artificial Intelligence (AI*IA).*

Review Activity for Journal Papers

– Journal of Artificial Intelligence Research (JAIR)

– Evolving Systems (EVOS)

– Machine Learning

Research and Scholarships

1 Earlier Research Lines

1.1 KENN: A Neuro-Symbolic Framework for Constraint Injection

My initial research journey into neuro-symbolic integration was driven by a critical observation of the prevailing methods. The standard approach of encoding logical knowledge as a soft constraint in the loss function was elegant, but it presented two fundamental weaknesses: it offered no guarantee of constraint satisfaction at inference time, and it inflexibly treated all prior knowledge as equally and perfectly correct.

This led me to develop KENN (Knowledge Enhanced Neural Networks), a framework designed to overcome these limitations by embedding logical reasoning directly into the model's architecture. The core concept is a final, differentiable layer that actively corrects the neural network's predictions to align them with a given set of logical constraints (clauses in a CNF formula). A key innovation of this approach is that each constraint's importance is determined by a weight that the model learns from the data, empowering it to autonomously discover the relevance of each clause of the prior knowledge.

My initial explorations of established fuzzy and probabilistic logics did not yield a straightforward solution. This led me to a methodological shift toward a design guided mainly by intuition. The result of this process was a simple heuristic: to satisfy a clause, increase the truth value of the most likely true literal. While empirically successful, the next crucial step was to ground this intuitive design in formal theory. This involved a deliberate "reverse-engineering" of the underlying properties that I was implicitly assuming. For instance, why did I choose to only increase the values of literals? I've soon realized that I was assuming the monotonicity property for the disjunction. Similarly, the fact that the operation's outcome depended only on the truth values, regardless of their order, was recognized as conforming to commutativity and associativity.

This revers-engineering process systematically revealed that my intuition-driven design choices had converged on the foundational properties of fuzzy logic t-conorms, and the analysis concluded that the heuristic was a practical implementation of the minimal change required to satisfy a formula under Gödel fuzzy logic. This unexpected connection raised a foundational question that would guide my subsequent research: Q1: considering that my conceptualization process was grounded entirely in classical, Boolean logic, why did the solution converged on this specific fuzzy logic semantics?

1.1.1 KENN Extension to relational domains

The KENN framework was subsequently generalized from propositional to relational domains—in a manner analogous to Graph Neural Networks—and its practical utility was validated in a collaborative project on semantic point cloud segmentation. By injecting simple spatial constraints, KENN significantly improved performance on rare object classes, demonstrating its ability to solve tangible, real-world challenges in machine learning.

1.2 From KENN to Iterative Local Refinement

A pivotal turn in my research trajectory came shortly after my PhD, through a collaboration with the VU University Amsterdam. The experience began when a doctoral researcher from their group contacted me with insightful questions about my paper on KENN. Our subsequent discussions evolved into a formal research proposal, which secured funding from the HumanE-AI-NET consortium for a three-month mobility project. This international collaboration was a profound opportunity for professional growth.

Our primary scientific goal was to rebuild the foundations of KENN into a more general framework. The strategy was to re-frame the reasoning layer as a formal optimization problem: finding a new set of fuzzy truth values that satisfies the logical constraints while minimizing the Lp-norm distance from the initial predictions of the neural network. We then aimed to derive analytical, closed-form solutions—which we termed Refinement Functions (RFs)—for each logical operator using Karush-Kuhn-Tucker (KKT) conditions.

This approach was effective for deriving RFs for both Gödel and Łukasiewicz t-norms across all Lp norms. However, the Product t-norm proved significantly more challenging, with a general closed-form solution appearing intractable. This analytical obstacle led us to investigate the specific case of the L1 norm. Here, we uncovered a remarkable convergence: the solution for the Łukasiewicz t-norm became almost identical to that of Gödel, and crucially, the previously intractable Product t-norm could now be solved, yielding the very same solution.

This discovery offered a new perspective on the initial question of Gödel logic's emergence into the KENN framework (see Q1). Indeed, the L1 norm metric is known to favor sparse solutions, which intuitively is more connected to "discrete-like" solution spaces. This provided a compelling insight: it serves as an intuitive confirmation that the strategy used by KENN, and by the RFs, is deeply connected to classical, discrete reasoning. It suggests that this connection, revealed under the sparsity-promoting L1 norm, is an intrinsic property of Gödel's logic, which other semantics only emulate under these specific, 'discrete-like' conditions. This intuition revealed to be fundamental for my current research.

The theoretical work of the collaboration culminated in the development of a novel algorithm, Iterative Local Refinement (ILR). ILR leverages the derived Refinement Functions as a propagation rule, creating an iterative update mechanism analogous to backpropagation but often exhibiting significantly faster convergence. The complete framework, including the theoretical analysis on t-norm convexity and the ILR algorithm, was published in the Machine Learning journal. This highly fruitful and ongoing collaboration, which has recently led to a further joint project, was also an invaluable formative experience, exposing me to a dynamic and diverse research environment.

2 Current Research Lines

2.1 Discrete vs Continuous

A turning point in my research philosophy emerged from a critical re-evaluation of the foundational goals of Neuro-Symbolic (NeSy) integration. The field has long aimed to create frameworks that combine the perceptual strengths of neural networks with the reasoning capabilities of symbolic methods. However, I observed that after decades of research, the community remained distant from this ultimate goal. Furthermore, many existing NeSy systems not only combine the strengths of both paradigms but also inherit their weaknesses. This led me to question the premise itself. Instead of asking how to best combine these two worlds, I began to ask a more fundamental question: why do they exhibit such diametrically opposed strengths and limitations in the first place?

The answer, I concluded, lies in a single, fundamental distinction: symbolic methods operate on discrete variables, while neural networks operate on continuous ones. I posited that nearly all the divergent properties of these two paradigms could be traced back to this core difference. This realization exposed a paradox at the heart of the dominant NeSy methodology: the common practice is to take discrete symbolic formalisms (e.g., logic) and create continuous, differentiable relaxations to make them compatible with gradient-based learning. However, if the power of symbolic reasoning—its robustness, abstraction, and generalizability—stems from its inherent discreteness, then the very act of continuous approximation is self-defeating, potentially erasing the essential properties we aim to preserve.

This insight has since become the cornerstone of my current research vision. My central hypothesis is that a definitive solution to the neuro-symbolic challenge must involve the direct integration of truly discrete variables and functions within end-to-end models, without resorting to continuous relaxations. I propose that such a framework would not only achieve a more genuine synthesis of perception and reasoning but could also enable the learning of symbolic knowledge directly from data through hybrid discrete/continuous latent representations. This vision directly addresses what is known in the broader AI community as the Symbol Grounding Problem, and tackling it has become the primary objective of my research.

This ambition, however, confronts a formidable technical barrier that is now the central focus of my work: the inherent incompatibility of non-differentiable discrete functions with the gradient-based backpropagation algorithm that powers modern deep learning.

To tackle this formidable barrier, I have formulated a multi-stage research plan designed to systematically build from foundational methods to complex, dynamic applications.

1. The first and most critical step is to solve the foundational methodological problem: developing novel optimization techniques that allow for the end-to-end integration of discrete variables within gradient-based pipelines, effectively enabling combinatorial optimization within deep learning.

2. With this core technology in place, the second phase will focus on applying it to solve static and simple instances of the Symbol Grounding Problem, demonstrating the ability to learn symbolic knowledge directly from data.

3. The third phase will address the crucial challenge of scalability, ensuring these methods can be applied to large-scale, real-world problems.

4. Subsequently, the fourth stage will extend this framework into dynamic environments. As systems evolve over time, the ability to represent and enforce

constraints on their behavior becomes paramount. This naturally leads to the integration of formalisms like Temporal Logic, which provides a rigorous language for specifying and reasoning about the properties of dynamic processes. My goal is to leverage the discrete reasoning capabilities developed earlier to learn or enforce temporal rules within complex systems.

5. Ultimately, these advances will converge towards the long-term vision of creating agents capable of continual learning and exhibiting robust, explainable behavior in complex, evolving environments.

2.2 Deep Symbolic Learning: A Proof of Concept for Learning Discrete Rules

My first concrete step towards realizing this vision was the development of Deep Symbolic Learning (DSL). Drawing inspiration from how discrete actions are handled in reinforcement learning, DSL is a framework that combines RL-derived policies with fuzzy logic to learn both discrete latent representations and simple logical formulas in an end-to-end fashion. To test its capabilities on the Symbol Grounding Problem, I modified standard NeSy benchmarks, such as MNIST addition. Crucially, instead of providing the rules of arithmetic a priori, the task was reformulated to require the model to learn these symbolic rules directly from raw perceptual data. DSL was the first method demonstrated to solve SGP instances of this complexity, successfully extracting perfectly correct logical rules. The resulting model exhibited not only superior explainability but also stronger generalization capabilities compared to purely neural approaches. This work, which served as a critical proof of concept for the feasibility of my research vision, was published at the International Joint Conference on Artificial Intelligence (IJCAI) and presented as a spotlight paper at the NeSy workshop.

Despite these promising results, this initial version of DSL faced significant scalability challenges. Its internal representation of logical formulas was combinatorially complex, and its performance was limited to relatively simple perceptual inputs. To address these limitations, I developed a subsequent approach based on a novel form of transfer learning. This method leverages the training efficiency of standard neural networks by first training a simple NN on the task, and then transferring its learned knowledge to a DSL model, which can refine this knowledge into an explainable and more generalizable symbolic form. Interestingly, this transfer learning strategy proved to be a general technique applicable to a wide range of neuro-symbolic systems. The paper detailing this contribution was published at the NeSy conference, where it received the Best Paper Award.

2.3 A Breakthrough in Discrete Optimization within deep Learning: The Gödel Trick and Logic of Hypotheses

While scalability remains a key challenge for future work, my latest work produced an additional improvement on this behalf, culminating also in a theoretical breakthrough that finally provides a formal answer to the foundational question (Q1) that has guided my research. By defining classical and Gödel logic as algebraic structures, I proved the existence of a homomorphism between them. This establishes Gödel logic not as a mere continuous relaxation, but as a valid proxy for classical Boolean logic in a continuous domain. The most significant consequence of this is the finding that backpropagation applied to formulas under Gödel semantics is mathematically equivalent to a combinatorial optimizer operating on discrete variables. This discovery provides a concrete realization of my core research vision: using the standard deep learning machinery for true discrete optimization. It reframes the infamous sparse gradients of

Gödel logic from a limitation into the very property that enables this behavior. Moreover, the work shows the true practical challenge of Gödel logic, which is the presence of local optima. To solve the issue, I proposed the "Gödel Trick"—a stochastic variant of Gödel logic implemented with a reparameterization trick to efficiently escape the local optima. The empirical results on SAT solving confirms the theoretical findings and provide an additional contribution of the work. The resulting paper, which also establishes a novel connection between the Gödel Trick and Weighted Model Counting, is currently under review at NeurIPS.

Building directly on this theoretical foundation, my second recent contribution tackles more complex Symbol Grounding Problems. This research introduces the Logic of Hypotheses (LoH), a novel logical formalism designed to define a structured hypothesis space of logical rules. An LoH formula can be compiled into a differentiable architecture that learns within this predefined symbolic space using the Gödel Trick. This approach allows for the end-to-end learning of complex, discrete logical rules from perceptual data, while also granting an unprecedented level of control over the model's inductive biases through the injection of partial or complete prior knowledge. This second contribution, which demonstrates a flexible solution to the SGP, is also currently under review at NeurIPS.

2.4 Future Directions: Integrating Temporal Reasoning

While scalability remains an ongoing research effort, the maturity of my current methods allows me to begin addressing the fourth stage of my research plan: the integration of temporal dynamics. My initial encounter with this area has been a highly successful collaboration with researchers at FBK and, notably, with two professors from the University of Bolzano (Chiara Ghidini and Marco Montali). This joint work extends my Iterative Local Refinement (ILR) algorithm to accommodate Fuzzy Linear Temporal Logic on Finite Traces (LTLf), connecting my past work directly with the domain of temporal reasoning. Our initial results, which demonstrate state-of-the-art performance on relevant benchmarks, have been accepted for publication at the upcoming NeSy 2025 conference. We are currently actively extending this work in an ongoing collaboration.

My future plans in this domain are twofold. In the short term, I aim to explore broader temporal formalisms, such as Allen's interval algebra. In the long term, my central goal is to achieve a grand synthesis: integrating these temporal reasoning capabilities with the Gödel Trick and the Logic of Hypotheses. This will pave the way for models that can not only enforce complex, discrete temporal knowledge but can also learn it directly from sequential data, fully realizing my research vision in the temporal domain.

Prizes and Awards

2024 **Best Paper Award** for the paper "Simple and Effective Transfer Learning for Neuro-Symbolic Integration", received at the *International Conference on Neural-Symbolic Learning and Reasoning*.
Authors: A. Daniele, T. Campari, S. Malhotra, L. Serafini

2018 **Best Doctoral Consortium Paper Award** for the paper "Scenarios Interpretation with Prior Knowledge", received at the *International Conference of the Italian Association for Artificial Intelligence*.
Author: A. Daniele

Publications

Journal Articles

⋆ [Ale+23b] *Alessandro Daniele*, Emile van Krieken, Luciano Serafini **and** Frank van Harmelen. "Refining neural network predictions using background knowledge". **in***Mach. Learn.*: 112.9 (2023), **pages** 3293–3331. DOI: 10.1007/S10994-023-06310-3. URL: https://doi.org/10.1007/s10994-023-06310-3.

[Gri+23] Eleonora Grilli, *Alessandro Daniele*, Maarten Bassier, Fabio Remondino **and** Luciano Serafini. "Knowledge Enhanced Neural Networks for Point Cloud Semantic Segmentation". **in***Remote. Sens.*: 15.10 (2023), **page** 2590. DOI: 10.3390/RS15102590. URL: https://doi.org/10.3390/rs15102590.

Book Chapters

[AS25] *Alessandro Daniele* **and** Luciano Serafini. "Knowledge Enhanced Neural Networks". **in***Handbook on Neurosymbolic AI and Knowledge Graphs*: **byeditor**Pascal Hitzler, Miriam K. Bergman **and** Krzysztof Janowicz. IOS Press, 2025. URL: https://ebooks.iospress.nl/volumearticle/72316.

Conference Papers

[Zil+26] Filippo Ziliotto, Jelin Raphael Akkara, Alessandro Daniele, Lamberto Ballan, Luciano Serafini **and** Tommaso Campari. "PersONAL: Towards a Comprehensive Benchmark for Personalized Embodied Agents". **in***Proceedings of the 2026 IEEE International Conference on Robotics and Automation (ICRA)*: to appear. Preprint available at arXiv:2509.19843. IEEE, 2026.

[And+25] Riccardo Andreoni, Andrei Buliga, *Alessandro Daniele*, Chiara Ghidini, Marco Montali **and** Massimiliano Ronzani. "T-ILR: a Neurosymbolic Integration for LTLf". **in***Conference on Neurosymbolic Learning and Reasoning*: PMLR. 2025, **pages** 252–265.

⋆ [Ale+24] *Alessandro Daniele*, Tommaso Campari, Sagar Malhotra **and** Luciano Serafini. "Simple and Effective Transfer Learning for Neuro-Symbolic Integration". **in***Neural-Symbolic Learning and Reasoning - 18th International Conference, NeSy 2024, Barcelona, Spain, September 9-12, 2024, Proceedings, Part I*: **byeditor**Tarek R. Besold, Artur d'Avila Garcez, Ernesto Jiménez-Ruiz, Roberto Confalonieri, Pranava Madhyastha **and** Benedikt Wagner. **volume** 14979. Lecture Notes in Computer Science. Springer, 2024, **pages** 166–179. DOI: 10.1007/978-3-031-71167-1_9. URL: https://doi.org/10.1007/978-3-031-71167-1%5C_9.

[Car+24] Tommaso Carraro, *Alessandro Daniele*, Fabio Aiolli **and** Luciano Serafini. "Mitigating Data Sparsity via Neuro-Symbolic Knowledge Transfer". **in***Advances in Information Retrieval - 46th European Conference on Information Retrieval, ECIR 2024, Glasgow, UK, March 24-28, 2024, Proceedings, Part III*: **byeditor**Nazli Goharian, Nicola Tonellotto, Yulan He, Aldo Lipani, Graham McDonald, Craig Macdonald **and** Iadh Ounis. **volume** 14610. Lecture Notes in Computer Science. Springer, 2024, **pages** 226–242. DOI: 10.1007/978-3-031-56063-7_15. URL: https://doi.org/10.1007/978-3-031-56063-7%5C_15.

⋆ [Ale+23a] *Alessandro Daniele*, Tommaso Campari, Sagar Malhotra **and** Luciano Serafini. "Deep Symbolic Learning: Discovering Symbols and Rules from Perceptions". **in***Proceedings of the Thirty-Second International Joint Conference on Artificial Intelligence, IJCAI 2023, 19th-25th August 2023, Macao, SAR, China*: ijcai.org, 2023, **pages** 3597–3605. DOI: 10.24963/IJCAI.2023/400. URL: https://doi.org/10.24963/ijcai.2023/400.

[AS22] *Alessandro Daniele* **and** Luciano Serafini. "Knowledge Enhanced Neural Networks for Relational Domains". **in***AIxIA 2022 - Advances in Artificial Intelligence - XXIst International Conference of the Italian Association for Artificial Intelligence, AIxIA 2022, Udine, Italy, November 28 - December 2, 2022, Proceedings*: **byeditor**Agostino Dovier, Angelo Montanari **and** Andrea Orlandini. **volume** 13796. Lecture Notes in Computer Science. Springer, 2022, **pages** 91–109. DOI: 10.1007/978-3-031-27181-6_7. URL: https://doi.org/10.1007/978-3-031-27181-6%5C_7.

[Car+22] Tommaso Carraro, *Alessandro Daniele*, Fabio Aiolli **and** Luciano Serafini. "Logic Tensor Networks for Top-N Recommendation". **in***AIxIA 2022 - Advances in Artificial Intelligence - XXIst International Conference of the Italian Association for Artificial Intelligence, AIxIA 2022, Udine, Italy, November 28 - December 2, 2022, Proceedings*: **byeditor**Agostino Dovier, Angelo Montanari **and** Andrea Orlandini. **volume** 13796. Lecture Notes in Computer Science. Springer, 2022, **pages** 110–123. DOI: 10.1007/978-3-031-27181-6_8. URL: https://doi.org/10.1007/978-3-031-27181-6%5C_8.

[AS19] *Alessandro Daniele* **and** Luciano Serafini. "Knowledge Enhanced Neural Networks". **in***PRICAI 2019: Trends in Artificial Intelligence - 16th Pacific Rim International Conference on Artificial Intelligence, Cuvu, Yanuca Island, Fiji, August 26-30, 2019, Proceedings, Part I*: **byeditor**Abhaya C. Nayak **and** Alok Sharma. **volume** 11670. Lecture Notes in Computer Science. Springer, 2019, **pages** 542–554. DOI: 10.1007/978-3-030-29908-8_43. URL: https://doi.org/10.1007/978-3-030-29908-8%5C_43.

[Ale18] *Alessandro Daniele*. "Scenarios Interpretation with Prior Knowledge". **in***Proceedings of the AI*IA Doctoral Consortium (DC) co-located with the 17th Conference of the Italian Association for Artificial Intelligence (AI*IA 2018), Trento, Italy, November 20-23, 2018*: **byeditor**Marco Rospocher, Luciano Serafini **and** Sara Tonelli. **volume** 2249. CEUR Workshop Proceedings. CEUR-WS.org, 2018, **pages** 39–42. URL: https://ceur-ws.org/Vol-2249/AIIA-DC2018%5C_paper%5C_8.pdf.

Statement of Interest

I am writing to express my enthusiastic interest in the RTD-A position focused on Temporal Logic. My application is motivated by a deep alignment between this research area and the trajectory of my own work, which has been steadily converging on the challenges of reasoning in dynamic systems. My connection to the University of Bozen-Bolzano is already established through a highly successful collaboration with Professors Ghidini and Montali on a project involving Fuzzy Temporal Logic. This partnership has resulted in a joint publication accepted at the upcoming NeSy 2025 conference and demonstrates a strong scientific alignment with the broader research excellence at the university. I am therefore confident that I could rapidly integrate and become a productive member of the research community, and I am particularly eager to build new

synergies.

My research is driven by a central vision: that a true neuro-symbolic synthesis requires the direct integration of discrete variables and combinatorial reasoning within deep learning models. Through my work on the "Gödel Trick" and the "Logic of Hypotheses," I have developed a novel theoretical and practical framework for achieving this goal in static domains. Having established these foundational methods, the next logical and most exciting frontier is to apply them to systems that evolve over time. Temporal Logic provides the rigorous, formal language necessary to reason about such systems, and I believe my unique approach—focusing on learning and enforcing discrete temporal rules without continuous relaxation—can bring a new and powerful perspective to this field of research.

My objective as an RTD-A would be to pursue a clear and ambitious research plan. I will naturally continue the productive collaboration already underway, while actively seeking to establish new joint projects where my expertise can be of value. My primary research goal is to pursue the "grand synthesis" I have outlined: integrating my Gödel Trick and Logic of Hypotheses frameworks with temporal formalisms. The aim is to create models capable of not only verifying given temporal properties but also of learning complex, discrete temporal dependencies directly from data streams. I am convinced that my research program would complement the existing strengths in computer science at the University of Bolzano, and I am eager to contribute to the vibrant research environment through collaboration, teaching, and student supervision.

Language Competence

Italian: *Native speaker*
English: *Full professional proficiency. Primary language for all research activities, including publications, presentations, and international collaborations.*

Trento, February 6, 2026

Alessandro Daniele