Mattia Fumagalli

Short Bio

I have a Master's Degree in *Philosophy* and a Ph.D. in *Computer Science*. My research concerns primarily *Artificial Intelligence*, with a particular focus on the automated support for *Knowledge Representation* and *Knowledge Discovery*. Other key research interests include *Logic* and *Philosophy of Mind*.

I am currently a *Postdoctoral Researcher/Fixed-term Assistant Professor (RTDa)*, member of the *KRDB* group at the *Free University of Bozen-Bolzano*, where I have been a lecturer for the *Information Systems Design* and *Research Methods* courses.

I am also having a strong collaboration with the *Services and Cybersecurity Group* at the *University of Twente*, with the *Laboratory for Applied Ontology (LOA) - CNR* and, occasionally, I am working with the *Knowdive Group* at the *Department of Information Engineering and Computer Science of the University of Trento*, where I got my Ph.D., and (from 2015 to 2020) I was teaching assistant for the *Computational Logics* and *Knowledge Graphs and Data Integration* courses.

Education

- **University of Trento** — Trento, Italy
  Doctor of Philosophy (PhD) in Information and Communication Technology — *December 2017*
- **Catholic University of the Sacred Heart** — Milano, Italy
  Master - Philosophy and Metaphysics; 110/110 cum laude — *April 2007*
- **Catholic University of the Sacred Heart** — Milano, Italy
  Bachelor - Philosophy; 110/110 cum laude — *December 2004*

Work Experience

- **Free University of Bozen-Bolzano** — Bolzano, Italy
  Postdoctoral Researcher/Fixed-term Assistant Professor (RTDa) — *January 2023*
- **Free University of Bozen-Bolzano** — Bolzano, Italy
  Postdoctoral Researcher (AR) — *June 2020 - June 2022*
- **University of Trento** — Trento, Italy
  Postdoctoral Researcher (AR) — *December 2017 - May 2020*
- **University of Trento** — Trento, Italy
  PhD Candidate, Research and Teaching Assistant — *October 2012 - December 2017*
- **GroupM - WPP Group** — Milano, Italy
  Web Analytics and Search Engine Optimization Consultant — *May 2009 - September 2012*
- **Logotel S.p.A & Mastra S.r.l.** — Milano, Italy
  Web Analytics and Web Marketing Junior Consultant — *2006 - 2009*
- **Self Employed** — Milano, Italy
  Web Developer and Web Marketing Specialist — *2003 - 2006*

Teaching Experience

- **Free University of Bozen-Bolzano** — Bolzano, Italy
  Research Methods (PhD Seminar) - Lecturer — *February 2023*
- **Free University of Bozen-Bolzano** — Bolzano, Italy
  Information Systems Design - Lecturer — *September 2022 - December 2022*
- **Free University of Bozen-Bolzano** — Bolzano, Italy
  Information Systems Design - Teaching Assistant — *September 2021 - June 2022*
- **Free University of Bozen-Bolzano** — Bolzano, Italy
  IT Management and Enterprise Modeling - Teaching Assistant — *September 2021 - June 2022*
- **University of Trento** — Trento, Italy
  Computational Logics - Teaching Assistant — *September 2016 - May 2020*
- **University of Trento** — Trento, Italy
  Knowledge Graphs and Data Integration - Teaching Assistant — *September 2017 - May 2020*

Research Projects

- **Mining Interesting Patterns in Large-Scale Knowledge Graphs**: Applied and foundational research to mine frequent and actionable subgraph structures over datasets of large-scale knowledge graphs. For more info about this, you can contact Prof. Calvanese and Prof. Guizzardi. (Since June 2022)
- **RiskGraph Project - In collaboration with Accenture Israel Cybersecurity R&D Lab**: Development of an approach to support risk propagation techniques that leverages the semantics encoded by *ad-hoc* ontologies. The approach, starting from an application to the specific domain of cyber security, aims at being generalized to multiple risk scenarios, thus advancing the state of the art in the research of ontology-driven risk assessment and propagation (Since June 2020)
- **NEXON - Foundations of Next-Generation Ontology-Driven Conceptual Modeling**: This project is aimed at developing automatic techniques to support conceptual modelling. The first outcome of this project was an approach that can be used to learn constraints from conceptual model simulations, which leverages the combination of inductive logic programming and model validation. A second outcome was a highly automated interactive solution for the empirical discovery of conceptual modelling patterns from model data sets. A third outcome was the construction of a models catalogue for ontology-driven conceptual modelling research (June 2020 - September 2022)
- **LiveSchema - Adaptable and Reusable Knowledge Graphs**: Development of a research-oriented, open-source, ontologies catalogue (liveschema.eu) with a set of services that can be used to exploit resources in machine learning scenarios. The catalog leverages the gold mine of data collected by many of the already existing ontology catalogs. By implementing a continuously updating aggregation facility, which keeps track of the updates from selected existing catalogs, liveschema.eu offers a family of services to easily access, analyze, transform, and re-use data to set up a relational machine learning pipelines and address predictive tasks. (January 2016 - May 2020)

Languages

- **Italian**: Mother tongue
- **English**:
  - Listening: C1
  - Reading: C1
  - Spoken interaction: C1
  - Spoken production: C1
  - Writing: C2

Skills

- **Programming**: Python, JavaScript
- **Libraries**: Scikit, Pandas, Seaborn, Networkx, Rdflib, NodeJS, Gatsby, Graphviz
- **Tools**: Rapidminer, Visual Paradigm, Alloy, Git, MySQL WorkBench, Protege, Orange3, Neo4j, GraphDB, Archi, yED

Publications

- **Conference Article - ODGL: a Logic for Object-Oriented Disruption Graphs**: Stefano M. Nicoletti, E. Moritz Hahn, Mattia Fumagalli, Giancarlo Guizzardi, and Mariëlle Stoelinga; forthcoming (2025)
- **Journal Article - CMining Frequent Structures in Conceptual Models**: Mattia Fumagalli, Tiago Prince Sales, Pedro Paulo F Barcelos, Giovanni Micale, Vadim Zaytsev, Diego Calvanese, Giancarlo Guizzardi; International Journal on Software and Systems Modeling (SoSyM), (2025)
- **Journal Article - Computational Approaches to Concepts Representation: A Whirlwind Tour**: Mattia Fumagalli, Riccardo Baratella, Marcello Frixione, Daniele Porello; Acta Analytica, (2024)
- **Conference Article - Unpacking the semantics of risk in climate change discourses**: Greta Adamo, Anna Sperotto, Mattia Fumagalli, Alessandro Mosca, Tiago Prince Sales and Giancarlo Guizzardi; Formal Ontology in Information Systems Conference, 14th FOIS (2024)
- **Journal Article - A Teleological Approach to Information Systems Design**: Mattia Fumagalli, Roberta Ferrario, Giancarlo Guizzardi; Minds & Machines (2024)
- **Journal Article - Integrating 3D City Data through Knowledge Graphs**: Linfang Ding, Guohui Xiao, Albulen Pano, Mattia Fumagalli, Dongsheng Chen, Yu Feng, Diego Calvanese, Hongchao Fan, Liqiu Meng; Geo-spatial Information Science (2024)
- **Journal Article - Ontology-based security modeling in ArchiMate Models**: Ítalo Oliveira, Tiago Prince Sales, João Paulo A Almeida, Riccardo Baratella, Mattia Fumagalli, Giancarlo Guizzardi; Software and Systems Modeling (2024)
- **Journal Article - Computational Approaches to Concepts Representation**: Mattia Fumagalli, Riccardo Baratella, Marcello Frixione, Daniele Porello; under review (2024)
- **Journal Article - Mining Frequent Structures in Conceptual Models**: Mattia Fumagalli, Tiago Prince Sales, Pedro Paulo F Barcelos, Vadim Zaytsev, Diego Calvanese, Giancarlo Guizzardi; under review (2024)

- **Journal Article - A FAIR catalog of ontology-driven conceptual models**: Tiago Prince Sales, Pedro Paulo F Barcelos, Claudenir M Fonseca, Isadora Valle Souza, Elena Romanenko, César Henrique Bernabé, Luiz Olavo Bonino da Silva Santos, Mattia Fumagalli, Joshua Kritz, João Paulo A Almeida, Giancarlo Guizzardi; Data & Knowledge Engineering DKE (2023)
- **Conference Article - Property Specification and Models for Risk: Towards Risk Propagation Graphs**: Stefano M. Nicoletti; Mattia Fumagalli; Milan Lopuhaä-Zwakenberg; E. Moritz Hahn; Giancarlo Guizzardi; Mariëlle Stoelinga. International Conference on Computer Safety, Reliability, and Security, SAFECOMP (2023)
- **Conference Article - On the Semantics of Risk Propagation**: Fumagalli, Mattia; Engelberg, Gal; Sales, Tiago Prince; Oliveira, Ítalo; Klein, Dan; Soffer, Pnina; Baratella, Riccardo; Guizzardi, Giancarlo. International Conference on Research Challenges in Information Science, RCIS (2023)
- **Conference Article - Boosting D3FEND: Ontological analysis and recommendations**: Oliveira, Italo; Engelberg, Gal; Sales, Tiago Prince; F Barcelos, Pedro Paulo; Fumagalli, Mattia; Bratella, Riccardo; Klein, Dan; Guizzardi, Giancarlo. 13th Formal Ontology in Information Systems Conference, FOIS (2023)
- **Journal Article - Conceptual Model Visual Simulation and the Inductive Learning of Missing Domain Constraints**: Fumagalli, Mattia; Sales, Tiago Princes; Baião, Fernanda; Guizzardi, Giancarlo. Data & Knowledge Engineering Journal, DKE (2022)
- **Conference Article - Ontological Analysis and Redesign of Security Modeling in ArchiMate**: Oliveira, Italo; Prince Sales, Tiago; Almeida, João Paulo A; Bratella, Riccardo; Fumagalli, Mattia; Guizzardi, Giancarlo. 5th Working Conference on the Practice of Enterprise Modelling, PoEM (2022)
- **Conference Article - An Ontology-Driven Approach for Process-Aware Risk Propagation**: Engelberg, Gal; Fumagalli, Mattia; Kuboszek, Adrian; Klein, Dan; Soffer, Pnina; Guizzardi, Giancarlo. The 38th ACM/SIGAPP Symposium On Applied Computing, SAC (2023)
- **Conference Article - Popularity Driven Data Integration**: Giunchiglia, Fausto; Bocca, Simone; Fumagalli, Mattia; Bagchi, Mayukh; Zamboni, Alessio. 4th Knowledge Graph and Semantic Web Conference, KGSWC (2022)
- **Conference Article - Pattern Discovery in Conceptual Models Using Frequent Itemset Mining**: Fumagalli, Mattia; Sales, Tiago Princes; Guizzardi, Giancarlo. 41st International Conference on Conceptual Modeling, ER (2022)
- **Conference Article - An Ontology of Security from a Risk Treatment Perspective**: Oliveira, Italo; Prince Sales, Tiago; Bratella, Riccardo; Fumagalli, Mattia; Guizzardi, Giancarlo. 41st International Conference on Conceptual Modeling, ER (2022)
- **Conference Article - A FAIR Model Catalog for Ontology-Driven Conceptual Modeling Research**: Favato Barcelo, Pedro; Prince Sales, Tiago; Fumagalli, Mattia; Fonseca, Claudenir; Guizzardi, Giancarlo. 41st International Conference on Conceptual Modeling, ER (2022)
- **Conference Article - Understanding and Modeling Prevention**: Baratella, Riccardo; Fumagalli, Mattia; Oliveira, Italo; Guizzardi, Giancarlo. The Sixteenth International Conference on Research Challenges in Information Science, RCIS (2022)
- **Conference Article - "Mind the Gap!": Learning Missing Constraints from Annotated Conceptual Model Simulations**: Fumagalli, Mattia; Sales, Tiago Princes; Guizzardi, Giancarlo. 14th Working Conference on the Practice of Enterprise Modelling, PoEM (2021)
- **Conference Proceedings - Proceedings of the International Workshop on Value Modelling and Business Ontologies**: Guizzardi, Giancarlo; Prince Sales, Tiago; Griffo, Cristine; Fumagalli, Mattia. CEUR Workshop Proceedings 2835 (2021)
- **Conference Article - Ranking Schemas by Focus: A Cognitively-Inspired Approach**: Fumagalli, Mattia; Shi, Daqian; Giunchiglia, Fausto. 26th International Conference on Conceptual Structures, ICCS (2021)
- **Conference Article - How FAIR are Security Core Ontologies? A Systematic Mapping Study**: Oliveira, Italo; Fumagalli, Mattia; Prince Sales, Tiago; Guizzardi, Giancarlo. The Fifteenth International Conference on Research Challenges in Information Science, RCIS (2021)
- **Conference Article - Ontology-Driven Cross-Domain Transfer Learning**: Fumagalli, Mattia; Bella, Gabor; Samuele Conti; Giunchiglia, Fausto. 11th International Conference on Formal Ontology in Information Systems, FOIS (2020)
- **Workshop Article - Towards Automated Support for Conceptual Model Diagnosis and Repair**: Fumagalli, Mattia; Sales, Tiago Princes; Guizzardi, Giancarlo. 1st Workshop on Conceptual Modeling Meets Artificial Intelligence and Data-Driven Decision Making, CMAI (2020)
- **Workshop Article - Assessing Ontologies Usage Likelihood via Search Trends**: Fumagalli, Mattia; Bailoni, Tania, Giunchiglia, Fausto. Proceedings of the 2020 Joint Ontology Workshops, SKALE (2020)
- **Conference Article - Entity Type Recognition – dealing with the Diversity of Knowledge**: Giunchiglia, Fausto; Fumagalli, Mattia. Principles of Knowledge Representation and Reasoning: Proceedings of the Seventeenth International Conference, KR (2020)
- **Conference Article - Towards Understanding Classification and Identification**: Fumagalli, Mattia; Bella, Gabor; Giunchiglia, Fausto. PRICAI 2019: Pacific Rim International Conference on Artificial Intelligence (2019)

- **Workshop Article - On Knowledge Diversity**: Fumagalli, Mattia; Bella, Gabor; Giunchiglia, Fausto. Proceedings of the 2019 Joint Ontology Workshops, WOMoCoE, CEUR (2019)
- **Workshop Article - Representation of Concepts in AI: Towards a Teleological Explanation**: Fumagalli, Mattia; Ferrario, Roberta. Proceedings of the 2019 Joint Ontology Workshops, CAOS, CEUR (2019)
- **Conference Article - Teleologies: Objects, actions and functions**: Giunchiglia, Fausto; Fumagalli, Mattia. International conference on conceptual modeling, 520-534, "Springer, Cham" (2017)
- **Conference Article - Concepts as (Recognition) Abilities**: Giunchiglia, Fausto; Fumagalli, Mattia. The 9th International Conference on Formal Ontology in Information Systems, FOIS, 153-166 (2016)
- **Workshop Article - An Ontological Foundation for ER Models**: Giunchiglia, Fausto; Fumagalli, Mattia. 3rd International ESSENCE Workshop (2015)
- **Conference Article - From ER models to the entity model**: Giunchiglia, Fausto; Fumagalli, Mattia. International Conference on Knowledge Engineering and Knowledge Management, 116-119, "Springer, Cham" (2014)
- **Journal Issue - Philosophical Readings II/1**: Colombo, Chiara; Eva, Del Soldato; Di Martino, Francesco; Fumagalli, Mattia; Pozzi, Mattia Luigi; Sgarbi, Marco; Verde, Francesco. January-April, ISSN 2036-4989 (2010)
- **Journal Issue - Philosophical Readings I/1**: Colombo, Chiara; Eva, Del Soldato; Di Martino, Francesco; Fumagalli, Mattia; Pozzi, Mattia Luigi; Sgarbi, Marco; Verde, Francesco. September-December, ISSN 2036-4989 (2009)

Invited Talks

- **CNR Webinar 2024 - Spiegabilità e intelligenza artificiale** — Online, Italy
  Invited Speaker — *May 2024*
- **ForMoRe Workshop - Formalization and Representation of Social Pattern Analyses** — Trento, Italy
  Invited Speaker — *November 2023*
- **Festival dell'Economia 2023 - AI: rischi e vantaggi in nuovi scenari di vita** — Trento, Italy
  Invited Speaker — *Maggio 2023*
- **SCS Seminar - Mining Frequent Structures in Conceptual Models** — Enschede, The Netherlands
  Invited Speaker — *February 2023*

Contribution to International Research Events

- **CAISE'25 - 37th International Conferences on Advanced ISs Engineering** — Vienna, Austria
  PC Chair — *November 2024*
- **AIxIA'24 - International Conference of the Italian Association for AI** — Bolzano, Italy
  PC Member — *November 2024*
- **EDOC'24 - International Conference on Enterprise Design and Computing** — Vienna, Austria
  PC Member — *September 2024*
- **EKAW'24 - 24th Int. Conf. on Knowledge Engineering and Management** — Amsterdam, Netherlands
  PC Member — *November 2024*
- **CAISE'24 - 36th International Conference on Advanced ISs Engineering** — Limassol, Cyprus
  PC Member — *June 2024*
- **RCIS'24 - 18th Research Challenges in Information Science** — Guimarães, Portugal
  PC Member — *May 2024*
- **ER'24 - The 43rd International Conference on Conceptual Modeling** — Pittsburgh, USA
  PC Member — *October 2024*
- **FOIS'24 - 14th International Conference on Formal Ontology in ISs** — Enschede, The Netherlands
  PC Member — *July 2024*
- **MDE Intelligence'24 - 6th Workshop on AI and Model-driven Engineering** — Linz, Austria
  PC Member — *September 2024*
- **BEWARE'23 - 2nd Workshop on Bias, Risk, Explainability and the Role of Logic** — Roma, Italy
  PC Member — *November 2023*
- **SWODCH'23 - 3nd Workshop on Semantic Web and Ontology for Cultural Heritage** — Athens, Greece
  PC Member — *November 2023*

- **ER'23 - 42nd International Conference On Conceptual Modeling** — Lisbon, Portugal
  PC Member — *Novemeber 2023*
- **EDOC'23 - 27th conference in Enterprise Computing** — Groningen, The Netherlands
  PC Member — *July 2021*
- **MDE Intelligence'23 - 5th Workshop on AI and Model-driven Engineering** — Groningen, The Netherlands
  PC Member — *October 2023*
- **FOUST'23 - 7th Workshop on Foundational Ontology** — Québec, Canada
  PC Member — *July 2021*
- **EDOC'22 - 26th conference in Enterprise Computing** — Bolzano, Italy
  PC Chair — *October 2022*
- **BEWARE'22 - Joint Workshop - AIxIA 2022** — Udine, Italy
  PC Member — *December, 2022*
- **VORTE'22 - 11th International Workshop on Ontologies for the Enterprise** — Amsterdam, Netherlands
  Workshop Chair — *June 2022*
- **JOWO'22 – 8th Joint Ontology Workshops** — Jönköping, Sweeden
  PC Member — *August 2022*
- **JOWO'21 – 7th Joint Ontology Workshops** — Bolzano, Italy
  PC Member — *September 2021*
- **VMBO'21 - 15th International Workshop on Value Modelling and Business Ontologies** — Bolzano, Italy
  PC Member — *March 2021*
- **CBI'21 - 23rd IEEE International Conference on Business Informatics** — Bolzano, Italy
  PC Member — *September 2021*
- **EDOC'21 - 25th conference in Enterprise Computing** — Gold Coast, Australia
  PC Member — *October 2021*
- **IJCAI-PRICAI'20 - International Joint Conference on Artificial Intelligence** — Yokohama, Japan
  PC Member — *January 2020*
- **JOWO'20 - 6th Joint Ontology Workshops** — Bolzano, Italy
  PC Member — *October 2020*
- **Context'19 - 11th International Conference on Modeling and Using Context** — Trento, Italy
  Workshop Chair — *November 2019*

Volunteer Experience

- **C.E.Re.S – Non-profit organization** — Milano, Italy
  Caregiver (taking care of persons with disabilities), mini-bus driver, management activities support — *2000 - 2002*

References

- *Giancarlo Guizzardi*, University of Twente
- *Diego Calvanese*, University of Bozen-Bolzano
- *Fausto Giunchiglia*, University of Trento
- *Roberta Ferrario*, Laboratory for Applied Ontology (LOA) - CNR

Links

- *Personal Website*, https://www.mattspace.net/
- *UniBz Webpage*, https://www.unibz.it/it/faculties/engineering/academic-staff/person/44264-mattia-fumagalli
- *Google Scholar*, https://scholar.google.com/citations?user=dRtzslcAAAA
- *LinkedIn*, https://www.linkedin.com/in/mattiafumagalli/
- *GitHub*, https://github.com/Matt-81

Research Statement

So far, my research interest has been in contributing to a deeper understanding of how to best represent knowledge in both human and machine-readable formats. The task of modelling knowledge is often characterized by a diversity of approaches and is influenced by numerous factors, depending on the application scenario and related purpose. I engage in theoretical and applied research, explore the combination of symbolic and sub-symbolic AI, and where possible, take cues from interdisciplinary scientific findings, such as cognitive sciences and the philosophy of mind, to design methods and tools for knowledge representation, conceptual modelling, knowledge discovery, and data integration.

The majority of my current research leverages state-of-the-art techniques, such as frequent subgraph mining (FSM), inductive logic programming (ILP), and Bayesian networks to provide semi-automated support for practitioners in creating knowledge graphs, discovering insightful patterns and enhancing reasoning capabilities.

Concerning the task of discovering insightful knowledge patterns, I am going through applied and foundational research to mine frequent and actionable subgraph structures over datasets of large-scale knowledge graphs. In this setting, the main research activities consist of: 1) applying consolidated technology to graphs representing specific domains (e.g., risk/attack graphs, behaviour graphs, or spatial/event graphs), to find recurring structures that can provide useful insights into domain experts (e.g., attack patterns or recurrent behaviours); 2) enhancing available technology to facilitate users in accessing and analyzing the discovered patterns (e.g., filtering out redundant or spurious patterns, and offering a service to organize and visualize the output patterns); 3) defining the notion of *interestingness* for a frequent subgraph structure and provide metrics to rank these structures accordingly.

Concerning the semi-automated creation of knowledge graphs, I am focusing on novel approaches to model validation and automated constraint learning that combines, on the one hand, *Model Finding* via the visual simulation of that model's valid instances and, on the other hand, *Inductive Logic Programming* techniques. The current effort is mainly dedicated to understanding how to properly channel the results produced by the application of a visual model-finding technique as input to a learning process. The main goal of this line of research is to foster semi-automated approaches to support knowledge engineers in creating knowledge representations that better capture their intended worldview (by excluding unintended models), and by also considering their reusability as a key feature.

Concerning the enhancement of reasoning capabilities, I am exploring how to combine Bayesian networks and ontologies to enhance the expressivity and accuracy of risk assessment models. My current work is focused on developing a framework where an "ontological" component and a "probabilistic" component can interact with each other and can be exploited to address a set of functional requirements that existing approaches are not able to handle. As a use case, I am focusing on the challenges raised by risk-propagation scenarios, starting from an application to the specific domain of cybersecurity, with the main goal of advancing the state of the art in the research of ontology-driven risk assessment and propagation.