



UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

**DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING**

Activities and Publications Report

PhD Student: **Luca Giamattei**

Student DR number: DR995855

PhD Cycle: XXXVII

PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01/11/2021

PhD program student's end date: 31/10/2024

Supervisor: Prof. Roberto Pietranuono

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PhD scholarship funding entity: Università Federico II

General information

Luca Giamattei received in year 2021 the Master Science degree in Computer Engineering from the University of Napoli Federico II. He attended a curriculum in AI-based Software Engineering within the PhD program in Information Technology and Electrical Engineering. He received a grant from University of Napoli Federico II.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1 st	Machine Learning	MSc course	6	Prof. Carlo Sansone	University Federico II
1 st	Statistical data analysis for science and engineering research	Ad hoc course	4	Prof. Roberto Pietrantuono	ITEE
1 st	Virtualization technologies and their applications	Ad hoc course	5	Prof. Luigi De Simone	ITEE
2 nd	IoT Data Analysis	Ad hoc course	4	Prof. Raffaele Della Corte	ITEE
3 rd	Fundamentals of programming and data management	MSc course	6	Prof. Roberto Pietrantuono	University Federico II

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1 st	International Winter School on Blockchain Technology and Applications – Hyperledger	Online	6	13-17/12/2021	Università di Camerino
1 st	Advanced Course on Data Science & Machine Learning	Online	8	22/08/2022 – 26/08/2022	Giuseppe Nicosia, Panos Pardalos

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1 st	Challenges towards Large-Scale Quantum Computers	0,2	Prof. Giovanni Miano	University Federico II	University Federico II
1 st	An Introduction to Deep Learning for Natural Language Processing - Explainable Natural	0,5	Prof. Francesco Cotugno	University Federico II	University Federico II

Activities and Publications – Final Report

UNINA PhD in Information Technology and Electrical Engineering – XXXVI Cycle

PhD candidate: **Luca Giamattei**

	Language Inference				
1 st	Privacy-Preserving Machine Learning	0,4	Prof. Simon Pietro Romano, Prof. Roberto Natella	University Federico II	University Federico II
2 nd	Privacy and Data Protection	0.4	Prof. Simon Pietro Romano	University Federico II	University Federico II
2 nd	AI for Software Dependability: How Far Can We Go?	0.2	Prof. Tao Xie	Peking University	International Conference on Software Quality, Reliability and Security
2 nd	Game Theory for Information Engineering	0.6	Prof. Marcello Caleffi, Prof. Leonardo Badia	Università di Padova	University Federico II
2 nd	MLOps: Achieving Operational Velocity with Faster Delivery and Collaboration	0.2	Prof. Tarry Singh, Prof. Carlo Sansone, Dr. Stefano Marrone	University Federico II	University Federico II
2 nd	Future Software for Life in Trusted Futures	0.2	Prof. Sarah Pink	RMIT University, Australia	International Conference on Software Engineering
2 nd	Software Engineering as the Linchpin of Responsible AI	0.2	Dr. Liming Zhu	University of New South Wales	International Conference on Software Engineering
2 nd	The Road Toward Dependable AI Based Systems	0.2	Prof. Paolo Tonella	Università della Svizzera Italiana	International Conference on Software Engineering
2 nd	What about Web APIs versioning?	0.2	Souhaila Serbout	Università della Svizzera Italiana	Università della Svizzera Italiana
2 nd	Research Code as Infrastructure (RCaI)	0.2	Marco Raglianti	Università della Svizzera Italiana	Università della Svizzera Italiana
2 nd	ByteBack: Deductive Functional Verification of Bytecode programs	0.2	Marco Paganoni	Università della Svizzera Italiana	Università della Svizzera Italiana
2 nd	Contribution-based Firing of Developers?	0.2	Vincenzo Orrei	Università della Svizzera Italiana	Università della Svizzera Italiana
2 nd	Ricerca e formazione nella società della transizione digitale	1	CINI	//	CINI
2 nd	Software Regression Testing Orchestration: Because so Many Techniques Need a Conductor (and not	0.2	Prof. Antonia Bertolino	CNR	International Symposium on Software Reliability Engineering

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	Necessarily a Human One)				
2 nd	Trustworthy Intelligent Systems – A Daunting Challenge	0.1	Prof. Joseph Sifakis	Verimag laboratory, Grenoble	International Symposium on Software Reliability Engineering
2 nd	Reliability and Testing of Reinforcement Learning Systems	0.1	Prof. Zheng Zheng	Università di Aeronautica e Astronautica di Pechino	International Symposium on Software Reliability Engineering
2 nd	Unveiling the Veil: Towards the Trustworthiness of AI Code Generators	0.1	Prof. Domenico Cotroneo	University Federico II	International Symposium on Software Reliability Engineering
3 rd	IoTility: Unleashing the Utility of Internet of Things through Microservices Architectural Extensions	0.2	Prof. Abdelsalam (Sumi) Helal	University of Florida	International Conference on Service Oriented Computing
3 rd	Service Governance in a Transforming World – Challenges Ahead	0.2	Prof. Pablo Fernandez	University of Sevilla	International Conference on Service Oriented Computing
3 rd	Logic, Automata, and Games in Service Composition	0.2	Prof. Giuseppe De Giacomo	Sapienza Università di Roma	International Conference on Service Oriented Computing
3 rd	Exploring the landscape: Software Testing in the AI Era	0.3	Ina Schieferdecker	Technische Universität	International Conference on Software Engineering
3 rd	The future of testing: Unleashing creativity with power of AI	0.3	Marko Ivanković	Google	International Conference on Software Engineering
3 rd	Challenges and Opportunities in Model Checking Large-scale Distributed Systems	0.15	Rupak Majumdar	Max Planck Institute	International Conference on Software Engineering
3 rd	Software Engineering in a World with Generative AI	0.15	Martin Rinard	Massachusetts Institute of Technology	International Conference on Software Engineering
3 rd	AI is making us rethink everything, including software development	0.15	Soumith Chintala	Meta	International Conference on Software Engineering
3 rd	Trustworthy by Design	0.15	Carol Smith	Carnegie Mellon University	International Conference on Software Engineering
3 rd	Intelligenza Artificiale tra valutazione del rischio e certificazione accreditata	0.4	Accredia	CINI, Accredia	CINI, Accredia
3 rd	Una vera riforma fiscale e l'AI per il rilancio della	0.8	Associazione Nazionale	Associazione Nazionale	Associazione Nazionale Commercialisti

Professione: realtà?	sogno	o	Commercialisti	Commercialisti
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Research activities

Luca Giamattei's research focused on advancing software testing methodologies, particularly in microservices architectures (MSA) and autonomous driving systems (ADS). He developed uTest, a tool for automated test generation in MSAs, which efficiently improved fault detection compared to state-of-the-art methods. Recognizing the limitations of black-box testing in complex microservice environments, he created MacroHive, a grey-box testing tool that enabled better insights into internal behaviors and failure detection. His research significantly enhanced microservice reliability and robustness, complemented by collaborations within the European uDevOps project to improve container energy efficiency.

In parallel, he explored the use of causal reasoning in ADS testing, proposing the Reasoning-Based Software Testing (RBST) framework. RBST redefined test generation by utilizing cause-effect relationships, outperforming traditional machine-learning-based methods. He further investigated Causal Reinforcement Learning for system-level ADS testing, publishing several impactful papers on the topic.

His work also extended to collaborations with the University of Amsterdam on optimizing energy efficiency in microservices, resulting in notable publications. His ongoing research continues to bridge causal reasoning and software testing, with a focus on expanding its applications across diverse software engineering domains, including a recent comprehensive survey on causal reasoning in software quality assurance.

Tutoring and supplementary teaching activities

Luca Giamattei provided support and tutorship for the “Software Engineering” BSc course over three years. He specifically focused on basic Java concepts, exception handling, I/O operations, UML modeling, and software testing. He also supported numerous BSc theses on topics such as aspect-oriented programming, microservices monitoring with Prometheus, a systematic mapping study on microservices monitoring, autonomous driving systems testing using the CARLA simulator, the conversion of microservices API specifications from OpenAPI to Protobuf, and a study on Nagios for microservices monitoring. Additionally, he provided support for two MSc theses: one on automated performance testing of microservices architectures through causal reasoning, and another on the joint assessment of accuracy, fairness, and privacy in machine learning systems.

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1 st	29	1.1	28.3	1.6
2 nd	4	4.3	50.1	1.6
3 rd	6	3	49,4	1.6

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
1 st	Panel Sistemas Informaticos (Madrid, Spain)	Dr. Javier Lopez Camacho	(05/02/22 – 26/02/22), (10/06/22 – 24/06/22), (03/07/22 – 24/07/22)	- Research on Testing of Microservices
2 nd	Panel Sistemas Informaticos (Madrid, Spain)	Dr. Javier Lopez Camacho	(12/11/22 – 24/11/22), (01/12/22 – 17/12/22), (26/01/23 – 08/02/23), (17/07/23 – 01/08/23)	- Research on Monitoring tools for Microservices - Research on Energy consumption evaluation in Microservices
2 nd	Università della Svizzera Italiana	Prof. Paolo Tonella	14/04/23 – 14/07/23	- Research on Reinforcement Learning for Online Testing of Autonomous Driving Systems
3 rd	Silensec	Dr. Almerindo Graziano	(19/01/24 – 26/01/24), (09/02/24 – 16/02/24)	- Research on Reinforcement Learning for security testing

PhD Thesis

In the PhD Thesis, Luca Giamattei addresses the limitations of current software testing methodologies by advocating for a shift from traditional data-driven approaches to a more advanced causality-driven framework, referred to as Reasoning-Based Software Testing (RBST). Software engineering, particularly software quality assurance (SQA), involves complex tasks such as fault detection, debugging, and prediction, which have increasingly relied on machine learning (ML) to automate test generation, selection, and execution. However, ML-based techniques focus on pattern recognition and correlations, failing to capture deeper cause-effect relationships in system behavior. This reliance on past data creates a conceptual gap, as ML-driven methods assume that future system behavior mirrors past observations, which is often not the case, especially in evolving systems. As a result, traditional testing strategies may fail to generalize, missing critical failure scenarios in new contexts.

The thesis begins by examining the foundational role of causal reasoning (CR) in addressing these shortcomings. CR enables engineers to move beyond data associations and reason about the cause-effect relationships that underpin system failures. This approach has long been applied in domains such as epidemiology, economics, and social sciences, and its introduction into software engineering holds significant promise. By integrating CR, software testing can evolve from identifying correlations to identifying the actual causes of failures, enabling testers to predict system behavior under different conditions and simulate interventions to avoid potential failures.

In response to these challenges, the thesis proposes RBST, a novel framework that leverages causal inference techniques to enhance software testing. RBST enables testers to systematically explore the impact of different inputs and conditions on system behavior by simulating interventions. It provides a more robust method for identifying failure-causing inputs and designing effective test cases, even in complex and dynamic systems. Unlike traditional methods, which are limited to correlational data, RBST empowers testers to ask “what-if” questions and explore system responses beyond observed data. This is particularly relevant in scenarios where test inputs and system behaviors evolve over time.

A key contribution of the thesis is the application of RBST to autonomous driving systems (ADS), a domain characterized by high complexity and stringent safety requirements. The results demonstrate that RBST significantly outperforms state-of-the-art ML-based testing techniques in identifying safety-violating test cases. By integrating causal reasoning into testing strategies, RBST allows for more accurate failure prediction and better-informed decision-making in software engineering.

Ultimately, the thesis argues that automated causal reasoning represents the next frontier in software testing, providing a powerful tool for enhancing software quality assurance. RBST bridges the gap between pattern recognition and causal understanding, offering a more proactive and comprehensive approach to testing. By shifting the focus from merely identifying correlations to uncovering the underlying causes of failures, this framework holds the potential to improve the reliability, robustness, and safety of modern software systems.

Research products

Research results appear in 5 papers published in international journals, 6 contributions to international conferences.

List of scientific publications

International journal papers

L. Giamattei, A. Guerriero, R. Pietrantuono, S. Russo,
Causality-driven Testing of Autonomous Driving Systems,
ACM Transactions on Software Engineering and Methodology,
Vol 33, 3, 2024, DOI: 10.1145/3635709.

L. Giamattei, A. Guerriero, R. Pietrantuono, S. Russo, I. Malavolta, T. Islam, M. Dînga, A. Koziólek, S. Singh,
M. Armbruster, J.M. Gutierrez-Martinez, S. Caro-Alvaro, D. Rodriguez, S. Weber, J. Henss, E. Fernandez
Vogelin, F. Simon Panojo,
Monitoring tools for DevOps and microservices: A systematic grey literature review,
Journal of Systems and Software,
Vol 208, 2024, 111906, ISSN 0164-1212, DOI: 10.1016/j.jss.2023.111906

L. Giamattei, A. Guerriero, R. Pietrantuono, S. Russo,
Automated functional and robustness testing of microservice architectures,
Journal of Systems and Software,
Vol 207, 2024, 111857, ISSN 0164-1212, DOI: 10.1016/j.jss.2023.111857.

L. Giamattei, M. Biagiola, R. Pietrantuono, S. Russo, P. Tonella,
Reinforcement Learning for Online Testing of Autonomous Driving Systems: a Replication and Extension
Study,
Empirical Software Engineering,
Accepted, to appear.

L. Giamattei, A. Guerriero, R. Pietrantuono, S. Russo,
Causal Reasoning in Software Quality Assurance: A Systematic Review,
Information and Software Technology,
Accepted, to appear.

International conference papers

L. Giamattei, A. Guerriero, R. Pietrantuono and S. Russo,
Assessing Black-box Test Case Generation Techniques for Microservices,
15th International Conference on the Quality of Information and Communications Technology,
Talavera de la Reina, Spain, Sep. 12-14, 2022, pp. 46-60, Springer, DOI: 10.1007/978-3-031-14179-9_4

L. Giamattei, A. Guerriero, R. Pietrantuono and S. Russo,
Automated Grey-Box Testing of Microservice Architectures,
22nd International Conference on Software Quality, Reliability and Security,
Guangzhou, China, 2022, pp. 640-650, IEEE, DOI: 10.1109/QRS57517.2022.00070.

L. Giamattei, R. Pietrantuono and S. Russo,
Reasoning-Based Software Testing,
45th International Conference on Software Engineering: New Ideas and Emerging Results,
Melbourne, Australia, May 14-20, 2023, pp. 66-71, IEEE, DOI: 10.1109/ICSE-NIER58687.2023.00018.

M. Dinga, I. Malavolta, L. Giamattei, A. Guerriero, R. Pietrantuono,
An Empirical Evaluation of the Energy and Performance Overhead of Monitoring Tools on Docker-Based
Systems,
21st International Conference on Service-Oriented Computing,
Rome, Italy, Nov. 28 – Dec. 1, 2023, pp. 181-196, Springer, DOI: 10.1007/978-3-031-48421-6_13

L. Giamattei, A. Guerriero, I. Malavolta, C. Mascia, R. Pietrantuono, S. Russo,
Identifying Performance Issues in Microservice Architectures through Causal Reasoning,
5th International Conference on Automation of Software Test,
Lisbon, Portugal, Apr. 15-16, 2024, pp. 149–153, ACM, DOI: 10.1145/3644032.3644460

M. S. Floroiu, S. Russo, L. Giamattei, A. Guerriero, I. Malavolta, R. Pietrantuono,
Anomaly Detection and Root Cause Analysis of Microservices Energy Consumption,
International Conference on Web Services,
Shenzhen, China, Jul. 7-13, 2024, IEEE, to appear.

Patents and/or spin offs

Luca Giamattei founded ai.res s.r.l. in July 2024 with R. Pietrantuono, A. Guerriero, S. Russo, and P. Sciaudone. They are currently waiting for spin off recognition by the University Federico II. The company offers trustworthy AI and AI governance solutions, particularly in high-risk domains and use cases. Its offerings consists in scalable products for risk assessment, risk management, reporting and compliance, inventory, and monitoring of AI systems.

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Date 15/10/2024

PhD student signature



Supervisor signature


