



**PhD in Information Technology and Electrical Engineering**  
Università degli Studi di Napoli Federico II

**PhD Student: Luca Giamattei**

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**Cycle: XXXVII**

**Training and Research Activities Report**

**Year: Second**

**Tutor: prof. Roberto Pietrantuono**

**Co-Tutor:**

**Date: October 25, 2023**

# Training and Research Activities Report

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Cycle:

Author:

## 1. Information:

- PhD student: Luca Giamattei
- DR number: DR995855
- Date of birth: 06/02/1996
- Master Science degree: Computer Engineering    University: Università degli Studi di Napoli Federico II
- Doctoral Cycle: XXXVII
- Scholarship type: UNINA
- Tutor: Roberto Pietrantuono
- Co-tutor:

## 2. Study and training activities:

Activity	Type <sup>1</sup>	Hours	Credits	Dates	Organizer	Certificate <sup>2</sup>
Privacy and Data Protection	Seminar	2	0.4	22/11/2022	Prof. Simon Pietro Romano	Y
AI for Software Dependability: How Far Can We Go?	Seminar	1	0.2	05/12/2022	Prof. Tao Xie	N
Game Theory for Information Engineering	Seminar	3	0.6	13/12/2022	Prof. Marcello Caleffi, Prof. Leonardo Badia	Y
IoT Data Analysis	Course		4	09/01/2023 - 27/01/2023	Dr. Raffaele Della Corte	Y
MLOps: Achieving Operational Velocity with Faster Delivery and Collaboration	Seminar	2	0.2	02/03/2023	Prof. Tarry Singh, Prof. Carlo Sansone, Dr. Stefano Marrone	Y
Future Software for Life in Trusted Futures	Seminar	1	0.2	17/05/2023	Prof. Sarah Pink	N
Software Engineering as the Linchpin of Responsible AI	Seminar	1	0.2	18/05/2023	Dr. Liming Zhu	N
The Road Toward Dependable AI Based Systems	Seminar	1	0.2	19/05/2023	Prof. Paolo Tonella	N
What about Web APIs versioning?	Seminar	1	0.2	1/05/2023	Università della Svizzera Italiana	N

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Research Code as Infrastructure (RCaI)	Seminar	1	0.2	4/05/2023	Università della Svizzera Italiana	N
ByteBack: Deductive Functional Verification of Bytecode programs	Seminar	1	0.2	11/05/2023	Università della Svizzera Italiana	N
Contribution-based Firing of Developers?	Seminar	1	0.2	25/05/2023	Università della Svizzera Italiana	N
Ricerca e formazione nella società della transizione digitale	Seminar		1	22/09/2023		
Software Regression Testing Orchestration: Because so Many Techniques Need a Conductor (and not Necessarily a Human One)	Seminar	1	0.2	10/10/2023	Prof. Antonia Bertolino	N
Trustworthy Intelligent Systems – A Daunting Challenge	Seminar	0.5	0.1	10/10/2023	Prof. Joseph Sifakis	N
Reliability and Testing of Reinforcement Learning Systems	Seminar	0.5	0.1	10/10/2023	Prof. Zheng Zheng	N
Unveiling the Veil: Towards the Trustworthiness of AI Code Generators	Seminar	0.5	0.1	10/10/2023	Prof. Domenico Cotroneo	N

1) Courses, Seminar, Doctoral School, Research, Tutorship

2) Choose: Y or N

## 2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	1.2	8.8	0	10
Bimonth 2	4	0	6	0	10
Bimonth 3	0	0.2	8.9	0.8	10
Bimonth 4	0	1.4	7.8	0.8	10
Bimonth 5	0	0	10	0	10
Bimonth 6	0	1.5	8.5	0	10
<b>Total</b>	<b>4</b>	<b>4.3</b>	<b>50</b>	<b>1.6</b>	<b>60</b>
<b>Expected</b>	<b>30 - 70</b>	<b>10 - 30</b>	<b>80 - 140</b>	<b>0 - 4.8</b>	

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## 3. Research activity:

The focus of my research activities was on the use of causal reasoning in software testing. Beginning with investigations in microservices and autonomous driving systems testing in the first year, we envisioned a framework that we later presented in a paper at the “45th International Conference on Software Engineering: New Ideas and Emerging Results”. This framework, called “Reasoning-based Software Testing” (RBST), reformulates the software testing process as a causal reasoning task, enabling more advanced reasoning beyond the mere search for patterns in past observations, as commonly done in intuition-based or state-of-the-art learning-based strategies.

In the RBST paper, we describe the framework for test case generation and provide preliminary results of an evaluation against adaptive random testing and an ML-driven search-based technique in the context of autonomous driving systems. Our results demonstrate the benefits of exploiting cause-effect relations to derive safety-violating tests, leading to a more efficient and effective exploration of the input space. RBST can be instantiated in various ways, with different strategies for model building, intervention variable/value selection, and effect estimation. We further explored these alternatives in the context of autonomous driving systems and conducted extensive experiments, which have been submitted (currently under revision) to “ACM Transactions on Software Engineering and Methodology” under the title “Causality-driven Testing of Autonomous Driving Systems.” This line of research has been extended through collaborations during my 3-month period abroad at the “Università della Svizzera Italiana” under the supervision of Prof. Paolo Tonella, focusing on Causal Reinforcement Learning techniques for online system-level testing of autonomous driving systems.

In addition to our work on autonomous driving systems, we also conducted investigations in the context of microservices testing. We began with the paper “Automated Grey-Box Testing of Microservice Architectures,” which was published at the “IEEE 22nd International Conference on Software Quality, Reliability, and Security.” In this paper, we introduced a grey-box framework, named “MacroHive,” for testing microservices from an internal perspective. We extended this work in another paper titled “Automated Functional and Robustness Testing of Microservice Architectures,” published in the “Journal of Systems & Software.” In this publication, we abstracted the testing process of Microservices Architecture (MSA), presented the MacroHive framework, introduced a new causal inference engine (implemented in a new microservice, named “uKnows”), compared it experimentally to state-of-the-art tools, and discussed its benefits in the MSA testing process. MacroHive provided unique advantages by offering insights about internal coverage and failures, as well as inferring causality in failure chains, thus helping improve the reliability of microservices within the MSA.

Our research on microservices testing and monitoring was complemented by collaborations during my period abroad as part of the European project “uDEVOPS.” We conducted a survey on monitoring tools for microservices architecture submitted (and currently under revision) to the “Journal of Systems & Software.” Additionally, we collaborated with the University of Amsterdam (Vrije Universiteit Amsterdam), particularly with Prof. Ivano Malavolta, on developing strategies to monitor and enhance the energy efficiency of containers in microservices architectures. This collaboration resulted in a paper titled “An Empirical Evaluation of the Energy and Performance Overhead of Monitoring Tools on Docker-based Systems,” which will be published in the proceedings of the “21st International Conference on Service-Oriented Computing.”

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As part of our future plans, we are currently conducting a survey with the goal of mapping the usage of causal reasoning in software quality assurance. Additionally, we intend to address open challenges in this context by applying RBST in various domains.

## 4. Research products:

- L. Giamattei, A. Guerriero, R. Pietrantuono and S. Russo, "Automated Grey-Box Testing of Microservice Architectures," 2022 IEEE 22nd International Conference on Software Quality, Reliability and Security (QRS), Guangzhou, China, 2022, pp. 640-650, doi: 10.1109/QRS57517.2022.00070.
- L. Giamattei, R. Pietrantuono and S. Russo, "Reasoning-Based Software Testing," 2023 IEEE/ACM 45th International Conference on Software Engineering: New Ideas and Emerging Results (ICSE-NIER), Melbourne, Australia, 2023, pp. 66-71, doi: 10.1109/ICSE-NIER58687.2023.00018.
- L. Giamattei, A. Guerriero, R. Pietrantuono, S. Russo, "Automated functional and robustness testing of microservice architectures", *Journal of Systems and Software*, Volume 207, 2024, 111857, ISSN 0164-1212
- 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

## 5. Conferences and seminars attended

- IEEE 22nd International Conference on Software Quality, Reliability and Security (QRS), Guangzhou, China, 2022 – the paper "Automated Grey-Box Testing of Microservice Architectures" was presented.
- 45th IEEE/ACM International Conference on Software Engineering (ICSE), Melbourne, Australia, 2023
- 34th IEEE International Symposium on Software Reliability Engineering (ISSRE), Florence, Italy, 2023

## 6. Activity abroad:

12/11/2022 - 24/11/2022 Panel Sistemas (Madrid, Spain)

01/12/2022 - 17/12/2022 Panel Sistemas (Madrid, Spain)

26/01/2023 - 08/02/2023 Panel Sistemas (Madrid, Spain)

14/04/2023 - 30/04/2023 Università della Svizzera Italiana (USI), Prof. Paolo Tonella (Lugano, Svizzera)

1/05/2023 - 14/05/2023 Università della Svizzera Italiana (USI), Prof. Paolo Tonella (Lugano, Svizzera)

23/05/2023 – 30/06/2023 Università della Svizzera Italiana (USI), Prof. Paolo Tonella (Lugano, Svizzera)

17/07/2023 - 01/08/2023 Panel Sistemas (Madrid, Spain)

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*The activities carried out during the abroad periods comprehend techniques for testing of microservices and autonomous driving systems, monitoring of microservices, energy consumption in microservices architectures.*

*Number of month spent abroad: 5*

## 7. Tutorship

- *“Software Engineering” course, support and tutorship on:*
  - *Java basic notions, exception handling, I/O*
  - *UML*
  - *Testing*
- *Support for BSc Thesis*