



**PhD in Information Technology and Electrical Engineering**

**Università degli Studi di Napoli Federico II**

**PhD Student: Antonio Guerriero**

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**XXXIV Cycle**

**Training and Research Activities Report - Third Year**

**Tutor: Stefano Russo - co-Tutor: Roberto Pietrantuono**



### 1. Information

**PhD candidate:** Antonio Guerriero (mat. DR993614)  
**Date of birth:** 06/08/1992  
**Master Science title:** Master's degree in Computer Engineering (cum laude) on 25/05/2018, Università di Napoli Federico II  
**Doctoral Cycle:** XXXIV  
**Fellowship type:** UNINA  
**Tutor:** Prof. Stefano Russo  
**Co-tutor:** Prof. Roberto Pietrantuono  
**Year:** Third  
**Publications:** A. Guerriero, R. Pietrantuono and S. Russo, Operation is the Hardest Teacher: Estimating DNN Accuracy Looking for Mispredictions, 2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE), doi: 10.1109/ICSE43902.2021.00042.

A. Guerriero, Reliability Evaluation of ML systems, the oracle problem, 2020 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW), doi: 10.1109/ISSREW51248.2020.00050.

A. Bertolino, G. De Angelis, A. Guerriero, B. Miranda, R. Pietrantuono, S. Russo, DevOpRET: Continuous reliability testing in DevOps. Journal of Software: Evolution and Process, e2298, doi: 10.1002/smr.2298.

A. Bertolino, A. Guerriero, B. Miranda, R. Pietrantuono, and S. Russo, Learning-to-rank vs ranking-to-learn: strategies for regression testing in continuous integration, In Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering (ICSE '20), 2020, Association for Computing Machinery, New York, NY, USA, 1–12, doi: 10.1145/3377811.3380369.

R. Pietrantuono, S. Russo, A. Guerriero, Testing microservice architectures for operational reliability. Software Testing, Verification and Reliability, 30(2), e1725, doi: 10.1002/stvr.1725.

A. Guerriero, R. Mirandola, R. Pietrantuono and S. Russo, A Hybrid Framework for Web Services Reliability and Performance Assessment, 2019 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW), doi: 10.1109/ISSREW.2019.00070.

R. Pietrantuono, S. Russo, A. Guerriero, Run-time Reliability Estimation of Microservice Architectures, Proc. of the 2018 IEEE International Symposium on Software Reliability Engineering (ISSRE), Memphis, TN, USA, Oct. 15-18, IEEE, 2018 Winner of "Best Research Paper Award", doi: 10.1109/ISSRE.2018.00014.

# Training and Research Activities Report – Third Year

PhD in Information Technology and Electrical Engineering – XXXIV Cycle

Antonio Guerriero

## 2. Study and Training activities

In my third year I attended several Modules, Seminars, a PhD school, and an advanced course.

Lecture/Activity	Type	Hours	Credits	Dates	Organizer	Certificate
Testing Web Enabled Simulation at Scale Using Metamorphic Testing	Seminar	1	0,2	1/12/2020	Facebook	Yes*
Reinforcement Learning Virtual School	Virtual School	32	6,4	25-26/03/2021, 1-2/04/202, and 8-9/04/2021	Université Fédérale	Yes**
2021 Spring School on Transferable Skills	Doctoral School	10	2,0	4th & 5th May 2021	UNINA	Yes

\*Autoproduced

\*\*The certification provided by ANITI reports the amount of hours spent during the doctoral school. The credits are therefore calculated as 0.2 \* hours.

Year 1	Year 2	Year 3											
Summary	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	7 bimonth	8 bimonth	Summary	Total	
25.9	16.6	0	0	0	0	2	0	0	0	0	2	44,5	
12.8	0.8	0	0,2	0	6,4	0	0	0	0	0	6,6	20,2	
37.0	44.0	50	7,4	8	1,6	5	8	8	8	4	50,0	131,0	
75.7	61.4	50	7,6	8	8	7	8	8	8	4	58,6	195,7#	

# The maximum amount of credits (180) has been increased by 5 credits for each additional month (15) due to the extension of 3 months.

## 3. Research activity

During the third year, I deepened the research activity started in the previous two years. In the following sections, I describe the new contribution.

### 1.1 Reliability and Performance Assessment of Microservices Architectures

With the research group of Barbara Russo, associate professor at Libera Università di Bolzano, we are working on a unified framework for the performance and reliability assessment of microservice applications. Continuous quality assurance for extra-functional properties of modern software systems is today a big challenge as their complexity is constantly increasing to satisfy market demands. This is the case of microservice systems [Fowler14]. They provide high control on the scale of operation by means of fine-

grained service decomposition, but this demands careful consideration of the relations between the performance of individual microservices and service failures.

We propose a novel methodology and platform to automatically test microservice operations for performance and reliability in combination. The proposed platform can be integrated into a DevOps cycle to support continuous testing and monitoring by the automatic (1) generation and execution of performance-reliability ex-vivo testing sessions, (2) collection of monitoring data, (3) computation of performance and reliability metrics, and (4) integrated visualization of the results.

This collaboration results in a paper submitted to the International Conference on Automation of Software Test (AST 2022).

With my research group, we developed a framework to automatically generate and execute specification-based test cases for functional and robustness testing of microservices. The framework generates tests based on a microservices' specification (e.g., in a format like OpenAPI/Swagger) via a combinatorial strategy, and prioritizes them according to predefined criteria.

### *1.2 Operational Accuracy assessment of CNN-based image classifiers*

The *operational accuracy assessment* of Machine Learning systems is the main topic addressed in the last year of my PhD. In particular, this topic has been addressed in the Image Classification domain, where Convolutional Neural Networks (CNN) represent the state of the art ML models, they can even outperform human beings.

Companies like Google are envisioning life cycles (MLOps [Alla21]) specific for ML systems, where development and operational stages are linked in a loop [Ashmore2021] aiming to assess and improve the accuracy of the ML system according to the operational environment.

Due to various phenomena in the operational environment (*distribution shift* and *label shift*), the accuracy estimated before the release of the ML systems can be very different compared to the one provided in operation.

In line with the emerging life cycle for ML systems, my thesis targets the *operational accuracy assessment* problem from two perspectives: *online* assessment, directly in the operational environment, and *offline* assessment, in the development environment.

My thesis presents two solutions for the online operational accuracy assessment of CNN (ICOS and PAOC) and one solution for the *offline assessment* (DeepEST [P1]).

### 4. Products

During the third year I co-authored the following paper and submission along with my research group as well as with external researchers.

[P1]	A. Guerriero, R. Pietrantuono and S. Russo, "Operation is the Hardest Teacher: Estimating DNN Accuracy Looking for Mispredictions," 2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE), 2021, pp. 348-358, doi: 10.1109/ICSE43902.2021.00042.
[P2]	M. Camilli, A. Guerriero, A. Janes, B. Russo and S. Russo, "Microservices systems, reliability testing, performance testing," Submitted to 3rd ACM/IEEE International Conference on Automation of Software Test (AST 2022), Pennsylvania, United States.

### 5. Activity abroad

From 1st to 31st January 2021, I stayed in smart working at Chinese University of Hong Kong, as a member of prof. Michael R. Lyu's research group to study the "testing of machine learning systems".

From the 21st of October 2021 to the 20th of November 2021, I went to Panel Sistemas (Madrid, Spain) for the UE Marie Curie "uDevOps" project. The research activity was about Machine Learning techniques for reliable Microservice Architectures.

### 6. Conferences and Seminars

I participated to the following conference:

Conference name	Place	Dates	Number of papers
2021 IEEE/ACM 43rd International Conference on Software Engineering (ICSE)	Madrid, Spain	May 25-28, 2021	168

As the author, I **presented** the paper [P1] at 2021 IEEE/ACM 43rd International Conference on Software Engineering.

### 7. Tutorship

In this third year, I have been a teaching assistant for the courses of Software Engineering a.a. 2020/2021, Distributed Systems a.a. 2021/2022, and Data Visualization a.a. 2020/2021 and 2021/2022.

### 8. References

[Fowler14] J. Lewis and M. Fowler. Microservices - a definition of this new architectural term. Available at: <http://martinfowler.com/articles/microservices.html>, 2014

[Alla21] Sridhar Alla and Suman Kalyan Adari. "What Is MLOps?", pages 79–124. Apress, Berkeley, CA, 2021

[Ashmore21] Rob Ashmore, Radu Calinescu, and Colin Paterson. "Assuring the machine learning lifecycle: Desiderata, methods, and challenges". ACM Comput. Surv., 54(5), may 2021

[Li19] Z. Li, X. Ma, C. Xu, C. Cao, J. Xu, and J. Lü. “*Boosting Operational DNN Testing Efficiency through Conditioning*”. In Proc. 27th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE), pages 499–509. ACM, 2019

[Guerriero 21] A. Guerriero, R. Pietrantuono, and S. Russo. “*Operation is the Hardest Teacher: Estimating DNN Accuracy Looking for Mispredictions*”. In IEEE/ACM 43rd International Conference on Software Engineering (ICSE), pages 348–358. IEEE, 2021