



**PhD in Information Technology and Electrical Engineering**

**Università degli Studi di Napoli Federico II**

**PhD Student: Vincenzo Riccio**

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**XXXI Cycle**

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

**Tutor: Anna Rita Fasolino**



### Information

I am Vincenzo Riccio, I obtained a Ms.Sc. Degree (Laurea Magistrale) cum laude in Computer Engineering (Ingegneria Informatica) at the Università degli Studi di Napoli Federico II in April 2015. I am a Third Year PhD Student attending the XXXI Cycle of the Information Technology and Electrical Engineering (ITEE) PhD program of Università degli Studi di Napoli Federico II. My fellowship is financed by a PhD student grant. I am carrying out my research activity within the ReVERSE research group of Software Engineering under the tutorship of Prof. Anna Rita Fasolino.

### Study and Training activities

In the third year of PhD program (1.11.2017-31.10.2018), I attended the seminars reported below. I also attended two International Workshops in Delft and Amsterdam, respectively.

### International Workshops

Name	Type	Located in	Credits
1st ACM Workshop on the Internet of Safe Things (SafeThings 2017)	International Workshop	Delft, The Netherlands	1
1st joint workshop of 4th International Workshop on User Interface Test Automation, and 8th Workshop on TESTing Techniques for event Based Software (INTUITESTBEDS 2018)	International Workshop	Amsterdam, The Netherlands	1

### Seminars

Name	Type	Speaker	Credits
Atoms of Confusion: Understanding source code misunderstanding	Seminar	D Porzio	0,3
Search-based Software Engineering for Testing Autonomous Cars	Seminar	A Gambi	0,4

### Research Activity

In my Ph.D., I chose Software Testing as my main research topic since it is an important practice that allows to evaluate and improve software quality. In competitive sectors where software is a key component of the product, there is a constant pressure to improve the software quality and to provide quantitative evidence of the improvement. Test automation tools and techniques can facilitate software testing activities since they save humans from routine, time-consuming and error-prone manual tasks. My research goal is to enhance the automation level of software testing activities in multiple domains including Automotive, Mobile and Internet of Things.

### Model Driven Engineering in the Automotive Domain

In Model Driven Engineering (MDE), models of software systems are automatically transformed into target code. MDE is emerging as a relevant research topic in the Industry as it shifts the focus of software development from writing code to modeling the behavior of the system [1]. In MDE approaches, models can be tested before the target code generation; this allows detecting software faults earlier and reducing the costs of software development. I gathered my first experiences in this research topic during an internship at FIAT Chrysler Automobiles (FCA) for my Master Thesis. Then, I enhanced my knowledge thanks to my involvement in the EU funded project APPS4SAFETY. This research has resulted in techniques and tools for supporting the Verification and Validation of embedded automotive software. I focused my efforts towards the automation of coverage evaluation of embedded code auto-generated from models. This topic is also relevant for the scientific community and I explored it in a research manuscript that provides a comparison between Model Coverage and Code Coverage in Model Driven Testing [C1].

### Model Driven Engineering in the IoT Domain

I applied the lessons learned in the automotive domain to the emerging domain of Internet of Things (IoT). Although there is an increasing interest among several research communities to IoT themes, there are still few contributions related to approaches for the Verification and Validation of IoT systems. This motivated me to collaborate on the preparation of a research paper [C2], which I presented this year at the 1st ACM Workshop on the Internet of Safe Things (SafeThings 2017), co-located with the ACM Conference on Embedded Networked Sensor Systems (SenSys 2017). This manuscript proposes a novel Verification and Validation approach for the IoT domain that inherits the advantages of the MDE approaches adopted in multiple embedded systems domains and tackles the main challenges of IoT.

### Automated GUI Exploration Techniques for Android Applications

The major research activity of my PhD concerns Mobile Software Engineering. This field is particularly relevant since the number of users of mobile technology and smartphones is large and is steadily growing. Thus, the demand for improving quality of mobile apps has grown together with their spread. Therefore, effective techniques and tools are being requested to support developers in mobile app quality engineering activities [2].

Automation tools can facilitate these activities since they can save humans from routine, time consuming and error prone manual tasks [3]. Automated GUI exploration techniques are widely adopted by researchers and practitioners in the context of mobile apps for supporting critical engineering tasks such as reverse engineering [4], testing [5], and network traffic signature generation [6]. These techniques iteratively exercise a running app by exploiting the information that the app exposes at runtime through its GUI to derive the set of input events to be fired [7].

Although several automated GUI exploration techniques have been proposed in the literature, they suffer from some limitations that may hinder them from a thorough app exploration. I proposed two novel solutions that contribute to the literature in Software Engineering towards improving existing automated GUI exploration techniques for mobile software applications.

The former is a fully automated GUI exploration technique that aims to detect issues tied to the app instances lifecycle, a mobile-specific feature that allows users to smoothly navigate through an app and switch between apps. This technique is novel since it is the first dynamic testing technique that addresses the issue of GUI failures, that consists in the manifestation of unexpected GUI states [8]. This year, I presented this technique at the 1st joint workshop of 4th International Workshop on User Interface Test Automation, and 8th Workshop on TESTING Techniques for event Based Software (INTUITESTBEDS 2018) [C3].

I carried out two exploratory studies that prove that GUI failures are a widespread problem in the context of mobile apps. These studies have been described in collaboration with D. Amalfitano, A. R. Fasolino, and A. Paiva in the paper “Why does the orientation change mess up my Android application? From GUI failures to code faults” in the Software Testing, Verification and Reliability (STVR) journal, published by Wiley [J1].

The latter solution is a hybrid exploration technique that combines automated GUI exploration with capture and replay through machine learning. It exploits app-specific knowledge that only human users can provide in order to explore relevant parts of the application that can be reached only by firing complex sequences of input events on specific GUIs and by choosing specific input values. This solution is described in the paper “Combining Automated GUI Exploration of Android apps with Capture and Replay through Machine Learning” published by Elsevier in the Information and Software Technology journal [J2].

Both the techniques have been implemented in tools that target the Android Operating System, that is today the world’s most popular mobile operating system. The effectiveness of the proposed techniques is demonstrated through experimental evaluations performed on real mobile apps.

During my visiting period at the University of Passau, I worked with Prof. Gordon Fraser on evolutionary search for testing mobile applications [C5].

## Products

### Conference Papers

- [C1] D. Amalfitano, V. De Simone, AR. Fasolino and V. Riccio, **Comparing Model Coverage and Code Coverage in Model Driven Testing: An Exploratory Study**, 2015 30th IEEE/ACM International Conference on Automated Software Engineering Workshop (ASEW), Lincoln, NE, 2015, pp. 70-73. doi: 10.1109/ASEW.2015.1830.
- [C2] D. Amalfitano, N. Amatucci, V. De Simone, V. Riccio, and AR. Fasolino, **Towards a Thing-in-the-Loop approach for Verification and Validation of IoT systems**, 1st ACM Workshop on the Internet of Safe Things (SafeThings 2017), Delft, The Netherlands, 2017.
- [C3] V. Riccio, D. Amalfitano, AR. Fasolino, **Is This the Lifecycle We Really Want? An Automated Black-Box Testing Approach for Android Activities**, 1st joint workshop of 4th International Workshop on User Interface Test Automation, and 8th Workshop on TESTing Techniques for event BasED Software (INTUITESTBEDS 2018), Amsterdam, The Netherlands, 2018.
- [C4] V. Riccio, D. Amalfitano, P. Tramontana, AR. Fasolino, **Do Memories Haunt You? An Automated Black-Box Testing Approach for Detecting Memory Leaks in Android Apps** (in preparation)
- [C5] V. Riccio, G. Fraser, **Beyond Traditional Fitness Functions** (in preparation)

### Journal Papers

- [J1] D. Amalfitano, V. Riccio, ACR. Paiva, AR. Fasolino (2018) **Why does the orientation change mess up my Android application? From GUI failures to code faults**. Softw Test Verif Reliab Journal. Wiley. doi: [10.1002/stvr.1654](https://doi.org/10.1002/stvr.1654)
- [J2] D. Amalfitano, V. Riccio, N. Amatucci, V. De Simone, and AR. Fasolino (2018) **Combining Automated GUI Exploration of Android apps with Capture and Replay through Machine Learning**. Information and Software Technology. Elsevier. doi:10.1016/j.infsof.2018.08.007

### Conferences and Seminars

- [S1] V. Riccio, “Java Programming”, Seminars for the “Ingegneria del Software I” course of Prof. AR Fasolino [8 hours]
- [S2] V. Riccio, “Is This The Lifecycle We Really Want?” organized by Prof. Gordon Fraser and held at the University of Passau, Germany [1.5 hours].
- [P1] Presentation of the work “Towards a Thing-in-the-Loop approach for Verification and Validation of IoT systems” at the 1st ACM Workshop on the Internet of Safe Things (SafeThings 2017), Delft, The Netherlands, 05.11.2017.
- [P2] Presentation of the work “Is This the Lifecycle We Really Want? An Automated Black-Box Testing Approach for Android Activities” at the 1st joint workshop of 4th International Workshop on User Interface Test Automation, and 8th Workshop on TESTing Techniques for event BasED Software (INTUITESTBEDS 2018), Amsterdam, The Netherlands, 19.07.2017

### Activity abroad

This year, I have been a visiting Ph.D. student from April 14 to August 7 at the University of Passau, working with Prof. Gordon Fraser on evolutionary search for testing mobile applications.

### Tutorship

[T1] Co-tutorship of the student Raffaele Sellitto (Università di Napoli Federico II) during his Master Thesis work.

[T2] Presentazione dei Corsi di Studio e dei Laboratori agli studenti delle scuole superiori nell'ambito dell'Evento "Porte Aperte 2018", 4 ore

[T3] Co-tutorship of the student Fabio Caramiello (Università di Napoli Federico II) during his Master Thesis work.

[T4] Co-tutorship of the student Tanshi Pradhan (Università of Passau) during her Master Thesis work.

### Credits Summary

Student: Vincenzo Riccio <a href="mailto:vincenzo.riccio@unina.it">vincenzo.riccio@unina.it</a>									Tutor: Anna Rita Fasolino <a href="mailto:annarita.fasolino@unina.it">annarita.fasolino@unina.it</a>									Cycle XXXI								
	Credits year 1								Credits year 2								Credits year 3						Total	Check		
	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5			6	Summary
<b>Modules</b>	<b>20</b>	0	6	3	8	0	0	<b>17</b>	<b>15</b>	0	2,5	4	3	0	9	<b>19</b>	<b>0</b>							<b>0</b>	<b>35,5</b>	<b>30-70</b>
<b>Seminars</b>	<b>10</b>	6,8	1,4	0,7	0,8	0	0,5	<b>10,2</b>	<b>5</b>	0,4	0,8	0,6	3,4	0	0	<b>5,2</b>	<b>0</b>	1			0,3	1,4		<b>2,7</b>	<b>18,1</b>	<b>10-30</b>
<b>Research</b>	<b>30</b>	4	4	5	3	8	10	<b>34</b>	<b>45</b>	8	7	8	8	5	10	<b>46</b>	<b>60</b>	10	10	10	11	7	10	<b>58</b>	<b>138</b>	<b>80-140</b>
	<b>60</b>	10,8	11,4	8,7	11,8	8	10,5	<b>61,2</b>	<b>65</b>	8,4	10	13	14	5	19	<b>70</b>	<b>60</b>	11	10	10	11	8,4	10	<b>61</b>	<b>191,6</b>	<b>180</b>

### References

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- [2] Muccini H, di Francesco A, Esposito P. Software testing of mobile applications: Challenges and future research directions. *Automation of Software Test (AST)*, 2012 7th International Workshop on, IEEE: Zurich, Switzerland, 2012; 29–35, doi:10.1109/IWAST.2012.6228987.
- [3] S. R. Choudhary, A. Gorla, and A. Orso. “Automated Test Input Generation for Android: Are We There Yet? (E)”. In: 30th IEEE/ACM International Conference on Automated Software Engineering, ASE 2015, Lincoln, NE, USA, November 9-13, 2015. 2015, pp. 429–440. DOI: 10.1109/ASE.2015.89.
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- [5] A. Machiry, R. Tahiliani, and M. Naik. “Dynodroid: An Input Generation System for Android Apps”. In: *Proceedings of the 2013 9th Joint Meeting on Foundations of Software Engineering. ESEC/FSE 2013*. Saint Petersburg, Russia: ACM, 2013, pp. 224–234. ISBN: 978-1-4503-2237-9. DOI: 10.1145/2491411.2491450.
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