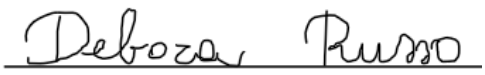
PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Debora Russo

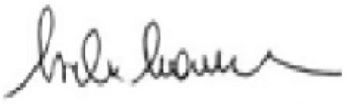
Cycle: XXXIX

Training and Research Activities Report

Year: First



Tutor: prof. Nicola Mazzocca *tutor signature*



Date: October 31, 2024

1. Information:

- **PhD student: Debora Russo**
- **DR number: DR997211**
- **Date of birth: 01/07/1993**
- **Master Science degree: Computer Engineering University: Università degli Studi di Napoli Federico II**
- **Doctoral Cycle: XXXIX**
- **Scholarship type: PNRR - Partenariato Esteso PE14 - RESTART**
- **Tutor: Nicola Mazzocca**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Economic Fitness: Concepts, Methods and Applications	Seminar	1	0.2	09/11/2023	Dr. Alessandro Della Pia, Dr. Davide Salzano, Dr. Giacomo Ascione, Dr. Francesco Bajardi	Y
Roadmaps for AI integration in the Rail Sector (RAILS)	Seminar	1.5	0.3	27/11/2023	Prof. Valeria Vittorini	Y
Energy-Efficient Data Science	Seminar	1	0.2	13/12/2023	Prof. Elio Masciari	Y
Multi-agent autonomous flight at Leonardo Labs	Seminar	1	0.2	21/12/2023	Prof. Vincenzo Lippiello	N
HOMINIS	Seminar	5	1	21/02/2024	Prof. Carlo Sansone, Prof. Stefano Marrone	Y
Edoardo Giusto Research, past, present and future	Seminar	1	0.2	26/02/2024	Prof. Nicola Mazzocca	Y
Analytic center selection of optimization-based controllers for robot ecology	Seminar	1	0.2	09/04/2024	Prof. Roberto Siciliano	Y

Exploring the Frontiers of Modern Cryptography	Seminar	1	0.2	12/04/2024	Prof. Simon Pietro Romano	Y
IEEE Authorship and Open Access Symposium: Tips and best Practices to Get Published from IEEE Editors	Seminar	2	0.4	07/05/2024	IEEE	Y
Machine Deception	Seminar	1	0.2	23/05/2024	Prof. Alessandra Rossi	Y
Sustainable IT: Strategies and Best practices for A green engineering future	Seminar	5	1	27/05/2024	5G Academy	Y
Generative AI for Software Engineering: Strategies, Impacts, and practical applications	Seminar	5	1	29/05/2024	5G Academy	Y
Social Network Analysis: Methods and Applications	Seminar	2	0.4	07/06/2024	Giancarlo Sperlì	Y
On the Single Allocation hub location problems: New formulations and Solving Methods	Seminar	1	0.2	26/06/2024	Claudio Sterle, Maurizio Boccia, Adriano Masone	Y
Real-time Resource Management for Adaptive Embedded Systems and Applications	Seminar	1	0.2	26/06/2024	Marcello Cinque	Y
Virtualization Technologies and Their Applications	Course	20	5	Jan. 08, 10, 15, 19, 24, 25, 29, 31 – Feb. 07, 26 2024	Prof. Luigi De Simone	Y
Strategic Orientation for STEM Research and Writing	Course	20	5	Dec. 07, 15 2023 – Jan. 12, 19 – Feb. 09, 23 2024	Dr. Chie Shin Fraser	Y
IoT Data Analysis	Course	12	4	Feb. 15, 19, 21, 23, 27, 29 2024	Prof. Raffaele Della Corte	Y

Using Deep Learning Properly	Course	12	4	Jan. 23, 25, 30 2024 – Feb. 01, 06, 08 2024	Prof. Andrea Apicella	Y
Innovation and Entrepreneurship	Course	12	4	Jun. 12, 14, 19, 21, 26 2024	Prof. Pierluigi Rippa	Y
ACDL 2024 - 7th Advanced Course on Data Science & Machine Learning	Doctoral School	35	8	Jun. 10, 11, 12, 13, 14 2024	Prof Giuseppe Nicosia, Prof. Panos Pardalos	Y

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		**0.9**	**9.1**		**10**
Bimonth 2	**10**	**1.2**			**11.2**
Bimonth 3	**4**	**0.5**	**5.5**		**10**
Bimonth 4	**12**	**3.4**			**15.4**
Bimonth 5	**4**		**6**		**10**
Bimonth 6			**10**		**10**
Total	**30**	**6**	**30.6**		**66.6**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

Research Topic

The central focus of my research is the generation of synthetic datasets for 3D object localization and property identification in smart city applications, emphasizing the development of digital twin systems. In the first year, my research started with two-dimensions data, concentrating on analyzing the state of the art and developing methodologies for synthetic data generation specifically aimed at multi-object localization and identification. This approach was applied to urban mobility and Intelligent Transportation Systems (ITS), where the availability of annotated datasets for anomalous scenarios—such as strikes, road closures, and sudden spikes in demand during events—is often limited. This lack of accessible, annotated urban mobility data restricts the capability of researchers and urban planners to model and simulate the impacts of disruptive events accurately. My work addresses this gap by creating synthetic data solutions that mirror these complex scenarios, thereby enhancing the analytical and predictive power of smart city models.

Methodology

The methodology for generating synthetic datasets is designed to overcome common limitations in real-world data, which often lacks detailed anomaly annotations, fine-grained mobility traces, and variability across scenarios due to privacy constraints and proprietary data restrictions. My approach involves three key stages:

1. **Data Collection and Preparation**:
    - Aggregated diverse real-world data sources, including General Transit Feed Specification (GTFS) files and Origin-Destination (OD) matrices, to construct a foundation for realistic simulations.
    - Integrated GTFS data to represent public transport dynamics within the urban mobility model, ensuring that the simulation accurately reflects real-world behaviors and schedules.
2. **Simulation and Model Building**:
    - Developed a simulation model using SUMO (Simulation of Urban Mobility), an open-source, highly portable, microscopic, and continuous multi-modal traffic simulation tool capable of handling extensive networks.
    - Designed scenarios to incorporate both private vehicles and public transit data, simulating disruptive events (e.g., road closures, public transport strikes) to test system resilience under various conditions.
    - Created a user-friendly Graphical User Interface (GUI) to allow urban planners, decision-makers, and non-technical users to simulate and customize scenario-specific datasets, enhancing accessibility and usability of the tool.
3. **Data Analysis and Validation**:
    - Validated the simulation results by comparing synthetic datasets with real-world data from sources such as the City of Genova.
    - Evaluated model effectiveness using Key Performance Indicators (KPIs), including bus passenger loads, congestion levels, and route deviations, which demonstrated that the synthetic data closely aligned with observed urban mobility patterns and provided a high degree of accuracy and reliability.

Results

The research yielded several significant findings:

- **Generalized Methodology for Synthetic Data Creation**:
    - Developed a scalable, replicable methodology for generating synthetic datasets using urban traffic simulation tools like SUMO, offering a robust framework that can be adapted to various cities and urban environments.

- **Controlled Exploration of Anomalous Scenarios**:
    - The synthetic datasets generated, enable researchers to explore a diverse range of anomalous scenarios, such as public transport strikes or sudden traffic surges, that may not be present in real-world datasets. This enhances the robustness and adaptability of transportation models, allowing for better preparedness in handling unexpected disruptions.
- **Accurate Simulation of Real-World Urban Mobility**:
    - The synthetic datasets proved effective in simulating real-world urban conditions, making it possible to predict the impacts of disruptive events, such as increased bus occupancy during metro strikes or rerouting due to road closures.
- **Development of a Synthetic Data Generation Tool**:
    - I have developed a synthetic data generation tool specifically tailored for ITS research. This tool facilitates the creation of detailed, anomaly-rich urban mobility datasets, offering a streamlined approach to modeling complex urban dynamics and improving the accessibility of high-quality synthetic data for transportation researchers and city planners.

4. Research products:

Franca Rocco Di Torrepadula, Debora Russo, Sergio Di Martino, Nicola Mazzocca, Paolo Sannino, Using SUMO towards Proactive Public Mobility: Some Lessons Learned,
SuMob '23: Proceedings of the 1st ACM SIGSPATIAL International Workshop on Sustainable Mobility, *Pages 51 – 58. (Published)*

Debora Russo, Nicola Mazzocca,
Synthetic Data Generation for Smart City Applications: a SUMO Approach,
7th Advanced Course on Data Science & Machine Learning,
Tuscany, Italy, 10-14 June. 2024. (Presented)

5. Conferences and seminars attended

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6. Activity abroad:

-

7. Activity in partner companies:

-

8. Tutorship

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