
UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II
DOTTORATO DI RICERCA / PhD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Activities and Publications Report

PhD Student: Idio Guarino

Student DR number: DR995139

PhD Cycle: XXXV

PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01/11/2020

PhD program student's end date: 30/11/2023

Supervisor:

e-mail: pescape@unina.it

PhD scholarship funding entity:

No scholarship

General information

Idio Guarino received in the year 2020 a Master's Science degree in Computer Engineering from the University of Napoli Federico II. He attended a curriculum in Networking Engineering within the PhD program in Information Technology and Electrical Engineering. He was enrolled in the ITEE PhD program without a grant.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1 st	Scientific Programming and Visualization with Python	Ad hoc course	2.0	DIST-Prof. A.Botta	ITEE
1 st	Data Science for Patient Records Analysis	MSc course	2.5	Prof. M.Cinque and Prof. C. Bavacchio	ITEE
1 st	Digital Forensics' methods, practices and tools	Ad hoc course	3.0	Dr. G. Cozzolino	ITEE
1 st	Statistical data analysis for science and engineering research	Ad hoc course	4.0	Prof. R. Pietrantuono	ITEE
1 st	Big Data and Business Intelligence	MSc course	6.0	Prof. G. Sperli	ITEE
1 st	Machine Learning - Neural networks and deep learning	MSc course	6.0	Prof. R. Prevete	ITEE
2 nd	Data Management	MSc course	6.0	Prof. F.Amato	ITEE
3 rd	Machine Learning for Science and Engineering Research	Ad hoc course	5.0	Proff. Anna Corazza, Francesco Isgrò, Roberto Prevete, and Carlo Sansone	ITEE

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
2 nd	TMA PhD Summer School	Napoli, Italy	3.2	27-28/06/2022	University of Twente, The Netherland
3 rd	TMA PhD Summer School	Napoli, Italy	2.0	26-27 June, 2023	University of Napoli Federico II

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
------	---------------	---------	----------	----------------------	--------------

Activities and Publications – Final Report

UNINA PhD in Information Technology and Electrical Engineering – XXXV Cycle

PhD candidate: **Idio Guarino**

1 st	#andràtuttobene: Images, Texts, Emojis and Geodata in a Sentiment Analy	0.3	Prof. Serena Pelosi	University of Salerno	University of Napoli Federico II
1 st	Patent searching best practices with IEEE Xplore	0.2	Eszter Lukacs	IEEE Europe	IEEE
1 st	How to get published with the IEEE	0.3	Paul Henriques	IEEE North America	IEEE
1 st	Exploiting Deep Learning and Probabilistic Modeling for Behavior Analytics	0.2	Prof. Giuseppe Manco	ICAR-CNR	University of Napoli Federico II
1 st	Data Driven Transformation in WINDTRE through Managers voice	0.4	Marcello Savarese, Erica Bertone, Amida Kudasheva	WINDTRE	University of Napoli Federico II
1 st	From Photometric Redshifts to Improved Weather Forecasts: an interdisciplinary view on machine learning	0.2	Kai Polsterer	Heidelberg Institute for Theoretical Studies	University of Napoli Federico II
1 st	Cybercrime and e-evidence: the criminal justice response	0.2	Matteo Lucchetti	Cybercrime Council of Europe	University of Napoli Federico II
1 st	Advances in Machine Learning for Modelling	0.3	Prof. Gustau		
1 st	AI LEGAL: Artificial Intelligence for notary's sector - a case study	0.2	Salvatore Palange	FLUEL (Innovation for Business)	University of Napoli Federico II
1 st	The era of Industry 4.0: new frontiers in business model innovation	0.2	Marco Balzano	University Ca' Foscari	University of Napoli Federico II
1 st	Machine learning: Causality lost in translation	0.3	Edwin A.Valentijn	Kapteyn Astronomical Institute, University of Groningen The Netherlands	University of Napoli Federico II
1 st	Robo Ludens: A game design taxonomy for human-robot interaction	0.2	Dr. John Edison Muñoz Cardona	University of Waterloo	University of Waterloo
1 st	Big data and Computational Linguistics	0.4	Francesco Cutugno	University of Naples Federico II	University of Napoli Federico II
1 st	Machine Learning and Security	0.4	Dott. Fabio de Gaspari	University of Rome La Sapienza	University of Rome La Sapienza

Activities and Publications – Final Report

UNINA PhD in Information Technology and Electrical Engineering – XXXV Cycle

PhD candidate: **Idio Guarino**

1 st	Distributional Semantics Methods: How Linguistic features can improve the semantic representation	0.3	Alessandro Maisto	University of Salerno	University of Napoli Federico II
1 st	Ethics of quantification	0.4	Andrea Saltelli	Open University of Catalonia	University of Napoli Federico II
1 st	End-to-End Optimization of Augmented Experience Services over Cloud-Integrated 5G Networks	0.8	Prof. A.M. Tulino	University of Naples Federico II	University of Napoli Federico II
1 st	5G: Esposizione ai Campi Elettromagnetici e Metodologie di Misura	0.8	Prof. N. Pasquino	University of Naples Federico II	University of Napoli Federico II
2 nd	Cyber security in Akka Technologies	0.3	Dr. Luigi Guida - Luigi Villa	Akka Technologies	University of Napoli Federico II
2 nd	Vehicular Hacking in Akka Technologies	0.4	Dr. Luigi Villa- Sara Belluccini -Matteo Pracchia	Akka Technologies	University of Napoli Federico II
2 nd	Single cell omics leverage Machine Learning to dissect tumor microenvironment and cancer immuno editing	0.4	Dr. Raoul J.P. Bonnal	IFOM	University of Napoli Federico II
2 nd	Threat Hunting Use-Cases	0.4	Group-IB	Group-IB	University of Napoli Federico II
2 nd	The quest of quantum advantage with a photonics platform	0.3	Prof. Fabio Sciarrino	University of Rome La Sapienza	University of Napoli Federico II
2 nd	RAILS MID-TERM WORKSHOP	1.0	Prof. Valeria Vittorini	University of Naples Federico II	University of Napoli Federico II
2 nd	Project Vāc: Can a Text-to-Speech Engine Generate Human Sentiments? (Picariello Lecture)	0.2	Prof. Vijay K. Gurbani	Illinos Tech	University of Napoli Federico II
2 nd	Ethics and Politics of A.I.	0.4	Mark Coeckelbergh	University of Vienna	University of Napoli Federico II
2 nd	Explainable Natural Language Inference	0.3	Dr. Marco Valentino	Idiap Research Institute	University of Napoli Federico II
2 nd	Accelerated Deep Learning via Efficient, Compressed and Managed Communication	0.2	Prof. M. Canini	King Abdullah University of Science and Technology (KAUST)	University of Napoli Federico II

3 rd	MLOps: Achieving Operational Velocity with Faster Delivery and Collaboration	0.2	Prof. Tarry Singh	DeepKapha.ai, Amsterdam, Paesi Bassi	University of Napoli Federico II
3 rd	BGP & Hot Potato Routing: graceful and optimal convergence in case of IGP events	0.2	Prof. P. Merindol	Università di Strasburgo	University of Napoli Federico II
3 rd	Traffic Engineering with segmented routing: optimally addressing popular use cases	0.2	Prof. P. Merindol	Università di Strasburgo	University of Napoli Federico II

Research activities

The research activities of Idio Guarino focused on the analysis of mobile internet traffic, particularly from communication and collaboration apps (CC apps) whose usage surged during and after the COVID-19 pandemic, causing significant network traffic changes. He designed, implemented, and evaluated Deep-Learning approaches to support traffic classification and prediction. To support his activities, he collected real human-generated traffic data from popular CC apps, publicly releasing the dataset (MIRAGE-COVID-CCMA-2022). He characterized and modeled such traffic based on activities the user can perform with CC apps and evaluated existing approaches for traffic classification, noting their limitations in classifying user activity. Then, he defined a novel set of inputs (Context Input) to address this issue, designing a deep-learning architecture (MIMETIC-ALL) that combines them with that commonly used in literature. Results showed that MIMETIC-ALL outperforms other state-of-the-art approaches to classify user activities.

Additionally, he explored multi-task learning approaches for packet-level traffic prediction. He found that training a shared model for all apps or one for each transport layer protocol provides comparable performance w.r.t. a dedicated model for each app. He also proposed a first approach to capitalize on packet-level predictions to obtain coarse-grained traffic predictions (e.g., volume).

Finally, he applied eXplainable Artificial Intelligence (XAI) techniques for model interpretability and reliability of resulting deep-learning classifiers and predictors to cope with their black-box nature.

Other explored research areas in the context of traffic classification: (i) the evaluation of ML classification methods for Intrusion Detection; (ii) addressing the need for large datasets by deep learning algorithms through the application of meta-learning, transfer-learning, and contrastive-learning methods.

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1 st	23.5	6.1	30.4	60.0
2 nd	6.0	7.1	46.9	60.0
3 rd	5.0	2.6	52.6	60.2

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
2 nd 3 rd	Huawei R&D Centre, Paris, France	Alessandro Finamore, Principal Engineer		Study and research activity concerns the design, implementation, and evaluation of few-shot learning techniques—typically employed in the field of computer vision—for the classification of the traffic generated by mobile apps.

PhD Thesis

The advent of new lifestyles has significantly reshaped the Internet, leading to significant changes in the volume of Internet traffic and the types of apps used. The global COVID pandemic has also contributed to the increased use of communication and collaboration apps, which has significantly impacted network infrastructure and traffic management. These apps are characterized by their multi-activity nature, allowing users to engage in chat and interactive audio/video sessions in a single usage session.

However, classifying, predicting, and managing the traffic generated by these apps is challenging. In this study, we focus on real data from popular apps whose traffic has experienced sudden growth since the outbreak of the COVID-19 pandemic. First, we collect human-generated traffic data from nine apps, reliably label it with the app and the specific user activity, and publicly release it as the MIRAGE-COVID-CCMA-2022 dataset.

Second, we provide the characterization at trace and flow levels and the modeling employing Multimodal Markov Chains for both apps and related activities. The results reveal that activities of the same app have different peculiar characteristics, which emerge especially when looking at their aggregate traffic. Third, we assess the effectiveness of state-of-the-art single-modal and multimodal Deep Learning-based classifiers in telling the specific app, the activity performed by the user, or both. While these solutions show excellent performance in app classification, they face significant challenges in activity classification when using transport-layer payload or per-packet information from biflows. To overcome this, we design a novel set of inputs (Context Inputs) providing clues about the nature of a biflow by observing the biflows coexisting simultaneously. Then, this work proposes Mimetic-All, a novel early traffic classification multimodal solution that leverages Context Inputs as an additional modality, achieving 82% F-measure in activity classification.

Fourth, we design data-driven models to predict this traffic at the finest granularity (i.e., at the packet level). To achieve this, we employ four multitask deep learning architectures and investigate three different training strategies. We also explore the trade-off between performance and complexity for four of the most popular apps in this category. Results suggest that designing one model for each transport layer protocol provides comparable, or even better, performance than using dedicated models for each application. Furthermore, we define a novel method for performing aggregate prediction on different time scales using the packet-level prediction approach. Fifth, we perform the trustworthiness analysis of deep-learning models used for classification and, for the first time, also for fine-grained prediction via the application of XAI. This helps us interpret the results and evaluate their reliability, providing insights into the significance of different parts of observed traffic for future analyses and applications. The findings of this study have significant implications for managing networks. Traffic classification provides visibility into the type of traffic that flows through the network, enabling efficient network management based on the content being carried. Traffic prediction enables the anticipation of the characteristics of incoming traffic, which allows for better resource provisioning and the application of new techniques and services to optimize network performance.

Research products

Research results appear in 1 paper published in international journals (1 further additional paper is currently under review) and 6 contributions to international conferences.

List of scientific publications

International journal papers

I. Guarino, G. Aceto, D. Ciunzo, A. Montieri, V. Persico, and A. Pescapè, Contextual counters and multimodal Deep Learning for activity-level traffic classification of mobile communication apps during COVID-19 pandemic, Elsevier Computer Networks, Special issue on Machine Learning empowered Computer Networks 219, 2022, 109452, doi: <https://doi.org/10.1016/j.comnet.2022.109452>.

International conference papers

I. Guarino, A. Nascita, G. Aceto and A. Pescapè, "Mobile Network Traffic Prediction Using High Order Markov Chains Trained At Multiple Granularity," 2021 IEEE 6th International Forum on Research and Technology for Society and Industry (RTSI), Naples, Italy, 2021, pp. 394-399, doi: 10.1109/RTSI50628.2021.9597313.

I. Guarino, G. Aceto, D. Ciunzo, A. Montieri, V. Persico and A. Pescapè, "Characterizing and Modeling Traffic of Communication and Collaboration Apps Bloomed With COVID-19 Outbreak," 2021 IEEE 6th International Forum on Research and Technology for Society and Industry (RTSI), Naples, Italy, 2021, pp. 400-405, doi: 10.1109/RTSI50628.2021.9597263.

I. Guarino, G. Aceto, D. Ciuonzo, A. Montieri, V. Persico and A. Pescapé, "Classification of Communication and Collaboration Apps via Advanced Deep-Learning Approaches," 2021 IEEE 26th International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD), Porto, Portugal, 2021, pp. 1-6, doi: 10.1109/CAMAD52502.2021.9617789.

I. Guarino, G. Bovenzi, D. Di Monda, G. Aceto, D. Ciuonzo and A. Pescapé, "On the use of Machine Learning Approaches for the Early Classification in Network Intrusion Detection," 2022 IEEE International Symposium on Measurements & Networking (M&N), Padua, Italy, 2022, pp. 1-6, doi: 10.1109/MN55117.2022.9887775.

I. Guarino, G. Aceto, D. Ciuonzo, A. Montieri, V. Persico and A. Pescapé, "Fine-Grained Traffic Prediction of Communication-and-Collaboration Apps Via Deep-Learning: A First Look at Explainability," ICC 2023 - IEEE International Conference on Communications, Rome, Italy, 2023, pp. 1609-1615, doi: 10.1109/ICC45041.2023.10278874.

I. Guarino, C. Wang, A. Finamore, A. Pescapè and D. Rossi, "Many or Few Samples?: Comparing Transfer, Contrastive and Meta-Learning in Encrypted Traffic Classification," 2023 7th Network Traffic Measurement and Analysis Conference (TMA), Naples, Italy, 2023, pp. 1-10, doi: 10.23919/TMA58422.2023.10198965.

Date 15/11/2023

PhD student signature



Supervisor signature

