

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

**DOTTORATO DI RICERCA / PhD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING**

Activities and Publications Report

PhD Student: **Oumaima Achour**

Student DR number: DR996998

PhD Cycle: XXXVIII

PhD Chairman: Prof. Stefano Russo

PhD program student's start date: 01/11/2022

PhD program student's end date: 31/12/2025

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**PhD scholarship funding entity: Incoming student in co-tutorship with ISITCom,
University of Sousse, Tunisia.**

Co-tutorship Incoming from Institut Supérieur d'Informatique et des Techniques de Communication (ISITCom) – University of Sousse, Tunisia

General information

Oumaima Achour received in 2020 the Master Science degree in Distributed Computer Sciences from the University of Sousse, Tunisia. She attended a curriculum in computer science within the PhD program in Information Technology and Electrical Engineering as a co-tutorship incoming from Institut Supérieur d'Informatique et des Techniques de Communication (ISITCom) – University of Sousse, Tunisia. She enrolled into the ITEE PhD program without a grant.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1 st	Big Data Architecture and Analytics course	Ad hoc course	5	Pr. Giancarlo Sperli	ITEE
2 nd	1. Strategic Orientation for STEM Research & Writing 2. Research methodology	Ad hoc course	5 2	1. CHIE SHIN FRASER 2. Pr. Rafik Brahim	1. ITEE 2. University of Sousse, Tunisia.

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1 st	Data engineering and artificial intelligence: big data & cloud	Sousse, Tunisia	1.5	16-21 August, 2023	University of Sousse, Tunisia

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1 st	AI, Robots and Society: Challenges and Opportunities for Social Innovation	0.2	Dr. Amit Kumar Pandey	University of Frederico II	ITEE
1 st	Traffic Engineering with Segment Routing: optimally dealing with most popular use-cases	0.2	Pr. Pascal Mérindol	University of Strasbourg, France	ITEE
1 st	Symbiotic Control of Wearable Soft Suits for human motion assistance and augmentation	0.4	Pr. Lorenzo Masia	Technical University of Munich, Germany	IEEE
1 st	BGP & Hot-Potato Routing: graceful and optimal convergence in case of IGP events	0.2	Pr. Pascal Merindol	University of Strasbourg, France	ITEE

2 nd	On the Single Allocation hub location problems: New Formulations and Solving Methods	0.2	Pr. A.M. Rodríguez-Chía	University of Cadiz, Spain	ITEE
2 nd	Using support vector machines for feature selection and outlier detection	0.2	Pr. Marta Baldomero-Naranjo	University of Cadiz, Spain	ITEE
3 rd	Robotica per la salute: il futuro che stiamo sperimentando	0.4	Pr. Bruno Siciliano	University of Federico II	ITEE

Research activities

Oumaima Achour participated in several research activities during her PhD thesis. Particularly, she investigated how to identify influential nodes in complex, multilayer social networks. The research activities during this PhD thesis are distributed across three years:

- **Year 1:** She studied the influence maximization problem within its traditional form. Next, she surveyed the theory of multiplex networks and the influence maximization (IM) problem, then mapped single-layer IM methods to the multiplex setting. In addition, she analyzed state-of-the-art strategies for influential node detection in both traditional and multiplex graphs, identifying limits related to inter-layer redundancy and computational cost.
- **Year 2:** She addressed the first challenge—how to reason over multiple layers—by proposing two fusion models that aggregate a multiplex into a single, information-preserving network while reducing noise and redundancy. These fusions were rigorously evaluated (e.g., link prediction/AUC and community structure consistency) against standard aggregations, showing improved predictive power and interpretability.
- **Year 3:** She targeted scalability on large-scale networks and the second/third challenges—efficient computation and accurate influence detection. I designed a fast workflow combining hop-bounded shortest paths and sampling-based reduction to keep computation local, and I introduced complementary centrality criteria to detect influential nodes without heavy greedy search. Extensive experiments on real and synthetic multiplex datasets demonstrated competitive or superior accuracy with significant runtime and memory savings, together with formal complexity analyses and ablations that clarify when each component is most effective.

Tutoring and supplementary teaching activities**Credits summary**

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1 st	5	1	54	0
2 nd	7	0.4	52.6	0
3 rd	0	0.4	59.6	0

As an incoming doctoral student under a co-tutorship agreement, I joined the host university after completing most of my coursework at my home institution. During my PhD program, I took courses in both universities to investigate my research task from different perspectives, also following seminars to broaden my skills, and continued sustained research work.

Research periods in the co-tutela Institution

PhD Year	Institution / Company	Hosting tutor	Period	Activities
1 st	University of Naples Federico II	Giancarlo Sperli,	20/04/2023-19/07/2023	During my three-month research period at PICUS Lab, I focused on understanding how to handle the multilayer structure of social networks and on selecting suitable datasets for my thesis. I began by constructing a custom multiplex dataset from Scopus; however, after assessing coverage, noise, and reproducibility, I concluded it was not ideal for my aims. I then surveyed existing public multiplex datasets from social platforms and related benchmarks, which offered richer layer diversity and clearer ground-truth for evaluation. In parallel, I analyzed the structural characteristics of these datasets (layer densities, overlap, degree/assortativity profiles) to identify modeling requirements. This led me to investigate alternative representations of multilayer influence and to prototype several aggregation strategies. Our findings indicate that fusion, carefully combining layers into an information-preserving representation, provides a more robust and tractable solution than treating layers independently, and it became the basis for

				my subsequent experiments. In addition, I attended some courses and seminars that were held during that period.
2 st	University of Naples Federico II	Giancarlo Sperli	10/06/2024 to 09/12/2024	During my second period at Frederic II, I spent six months, during which I concentrated on the scalability challenge posed by large-scale networks. I surveyed algorithmic and systems-level approaches (indexing, parallelization, graph sparsification, sketching) and, after empirical tests on our datasets, identified sampling as the most effective and robust strategy for preserving influence-relevant structure under tight time/memory budgets. Building on these findings, we designed and evaluated our second solution , a sampling-based workflow that accelerates diffusion evaluation and seed selection while maintaining competitive accuracy. In parallel, I continued the line of work on multilayer (multiplex) modeling and developed a new fusion method that integrates complementary information across layers without inflating computation; this method has been published in Information Sciences and now serves as the backbone representation for our multiplex experiments. Overall, this period advanced both the scalability and multilayer modeling threads of my thesis, providing practical tools and a solid experimental foundation for the final results.

PhD Thesis

In the PhD Thesis, Oumaima Achour conducted a rigorous study on influence maximization within multiplex social networks. Indeed, this study is motivated by the fact that current social networks (OSNs) hold huge volumes of data, creating fertile ground for research. Influence Maximization (IM) is recognized as one of the most actively studied research topics due to its wide range of applications, such as viral marketing, public health, recommendation systems, etc. It is known as the problem of selecting a small set of users with size $\leq k$, known as seed users, from a social network that can maximize the spread of information, influence, or behavior within it. While IM has been extensively studied in traditional single-layer networks, the increasing trend of users engaging in multiple OSNs simultaneously has created a new, complex setting, known as multiplex networks. This has led to the emerging research area of Multiplex Influence Maximization (MxIM), which

focuses on the spread of influence across various social networks with a shared set of users. Studying MxIM is more challenging and intriguing than its single-layer counterpart due to several key factors, including the inherent multilayer structure of these networks, their massive scale, and the computational complexity of the problem itself. Like traditional IM, MxIM remains an NP-hard problem, presenting a significant obstacle that researchers are actively working to overcome. Therefore, to address these challenges, this PhD thesis presents a novel model for influence maximization in multiplex social networks that leverages network fusion and graph sampling. It first tackles the multilayer structure by transforming the multiplex network into a single-layer representative network, ensuring original structural properties and interlayer dependencies are maintained while avoiding redundancy. Next, to improve scalability for large-scale data, it incorporates a graph sampling strategy into this fused network, retaining structurally important nodes and edges. Subsequently, to identify the most potent influencers, the thesis introduces HCKLP, a new centrality measure that capitalizes on the complementary nature of K-Shell, PageRank, and Laplacian centralities. Finally, a series of experiments on real-world networks validates the efficiency of each developed phase.

Research products

Research results appear in 2 papers published in international journals, one conference, and the other two publications are under review.

List of scientific publications

International journal papers

Achour, O., & Romdhane, L. B.

A theoretical review on multiplex influence maximization models: Theories, methods, challenges, and future directions.

Expert Systems with Applications

DOI: <https://doi.org/10.1016/j.eswa.2024.125990>

Hafsi, A., Achour, O., & Romdhane, L. B.

Community Detection-Based Approach for Web Services Discovery Using User's Importance.

In International Conference on Intelligent Systems Design and Applications (pp. 376-383). Cham: Springer Nature Switzerland.

DOI: https://doi.org/10.1007/978-3-031-64650-8_37

O.Achour, L. Ben Romdhane, G. Sperli

A novel multiplex network fusion method based on edge relevance,

Information Sciences

DOI: [10.1016/j.ins.2025.122757](https://doi.org/10.1016/j.ins.2025.122757)

O.Achour, L. Ben Romdhane, G. Sperli,

FFMNet: Fuzzy Fusion multiplex network model for complex network analysis tasks,

Knowledge-based systems

Submitted

O.Achour, L. Ben Romdhane, G. Sperli,
A novel node sampling method for large-scale networks based on an improved gravity centrality,
Online Social Networks and Media
Submitted

Date 23-10-2025

PhD student signature



Supervisor signature



Co-Supervisor signature

