Danilo Amitrano

Optimization and data science techniques supporting logistics problems

Supervisors: Prof. Maurizio Boccia
Prof. Adriano Masone

Cycle: XXXIX   **Year**: Second

Candidate's information

- **MSc degree:** Management Engineering

- **Research group/laboratory:** Optimization and Problem-Solving Laboratory (OPS-Lab), Unina.

- **PhD start date – end date:** 01/11/2023

- **Scholarship type:** PNRR – DM 117

- **Partner company:** Masifran S.r.l.

- **Period abroad:**
  FIRST VISIT: 14 October 2024 – 14 December 2024;
  SECOND VISIT: 8 Jenuary 2025 – 8 June 2025.
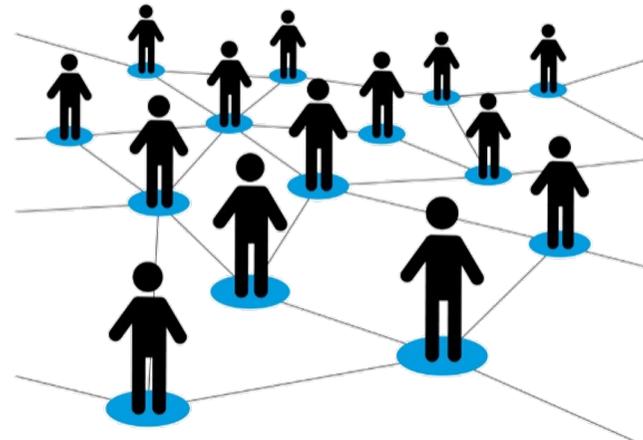
Summary of study activities

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	0.4	10	0	10.4
Bimonth 2	0	0.2	11	0	11.2
Bimonth 3	0	1.3	8	0	9.3
Bimonth 4	3	2	8	0	13
Bimonth 5	3	0.8	5	0	8.8
Bimonth 6	4	0.6	7	0	11.6
Total	10	5.3	49	0	64.3
Expected	30 – 70	10 – 30	80 - 140	0 – 4.8	

Ad hoc PhD cuorses

- I pilastri della trasformazione digitale
- Innovation and Entrepreneurship
- Deep Learning and Telecommunications

Conference

- *5th EUROYoung WORKSHOP*
    - Naples, Campania (IT); October 15-17, 2025
- *WORKSHOP* TFLT 2026
    - Naples, Campania (IT); Jenuary 16, 2026

Seminars (1)

Title	Hours	Credits	Dates	Organizer
Modelos Matemáticos para la Predicción de Tsunamis: Retos y Avance	1	**0.2**	11/11/2024	Prof. A. M. Rodriguez - Chia
Analisis de sistemas de transporte: datos y modelos	1	**0.2**	11/11/2024	Prof. A. M. Rodriguez - Chia
Explainable Scientific Machine Learning Theoretical and Practical Perspectives	1	**0.2**	20/02/2025	SSM – Scuola Superiore Meridionale
Dynamic Risk Assessment in Industrial Applications Leveraging Bayesian Inference for Enhanced Decision-Making	1	**0.2**	04/03/2025	Dr. Francesco Vitale
Numerical bifurcation analysis for delay equations	1	**0.2**	07/03/2025	Prof. Gabor Orosz and Prof. Wim Michiels
The Bi-objective Cable-Trench Problem	1	**0.2**	13/03/2025	Dpt. of Statistical Sciences Sapienza, University of Rome
Emergent dynamics of nonequilibrium systems with nonreciprocal couplings	1	**0.2**	27/03/2025	SSM – Scuola Superiore Meridionale
On the Security of Semantic Watermarking to Detect AI-Generated Content	1	**0.2**	29/04/2025	Prof. Luisa Verdoliva (DIETI, UniNA)
Trasporto ottimale: dalla teoria alla realtà	1.5	**0.3**	13/03/2025	Università di Catania – PRIN 2022, ACHILLES
Optimizing On Demand Warehousing Systems	1	**0.2**	07/05/2025	CIRRELT / MobilOpt
Multi-Neighborhood Search for Combinatorial Optimization	1	**0.2**	09/05/2025	Prof. Claudio Sterle, Prof. Maurizio Boccia, Prof. Adriano Masone (DIETI, UniNA)
Multi-Layer Network Design and Planning Consolidation-Based Transportation Systems	2	**0.4**	13/05/2025	Prof. Guido Perboli (Politecnico di Torino)
How complex is to schedule the Italian Serie A Problems and methods in sports timetabling	2	**0.4**	15/05/2025	Prof. Claudio Sterle, Prof. Maurizio Boccia, Prof. Adriano Masone (DIETI, UniNA)

Seminars (2)

Column generation applied to the estimation of non-parametric discrete-choice models	1	**0.2**	26/05/2025	Dpt. of Information Engineering (DEI), University of Padova
Analysis of a two-dimensional birth-death process for the dynamics of B cell antigen recptors	1	**0.2**	29/05/2025	Prof. Alfonso Suarez Llorens – Escuela de Doctorado de la Universidad de Cadiz
Variance comparison via the PMVT and the centered mean residual lifetime order	1	**0.2**	29/05/2025	Prof. Alfonso Suarez Llorens – Escuela de Doctorado de la Universidad de Cadiz
Superconducting Radio Frequency Cavities for Quantum Computing and Communication	1	**0.2**	24/06/2025	Prof. Edo Giusto (DIETI, UniNA)
A Gentle and Incomplete Introduction to Bilevel Optimization	1	**0.2**	15/10/2025	5th EUROYoung Workshop, Naples, Italy
Optimization in Transportation and Logistics	1	**0.2**	16/10/2025	5th EUROYoung Workshop, Naples, Italy
Local Explainability in Machine Learning	1	**0.2**	16/10/2025	5th EUROYoung Workshop, Naples, Italy
Exact and ML-guided Matheuristic approaches for a Truck-and Drone delivery problem	1	**0.2**	17/10/2025	5th EUROYoung Workshop, Naples, Italy
Verso nuovi paradigmi per la collaborazione uomo-macchina, orchestrazione, prototipazione e formazione per l'industria manifatturiera e il made in Italy	2	**0.4**	17/11/2025	Prof. Marcello Cinque
Bilevel optimization and reinforcement learning for last-mile delivery problems	1	**0.2**	16/01/2026	Workshop TFLT 2026

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Research area

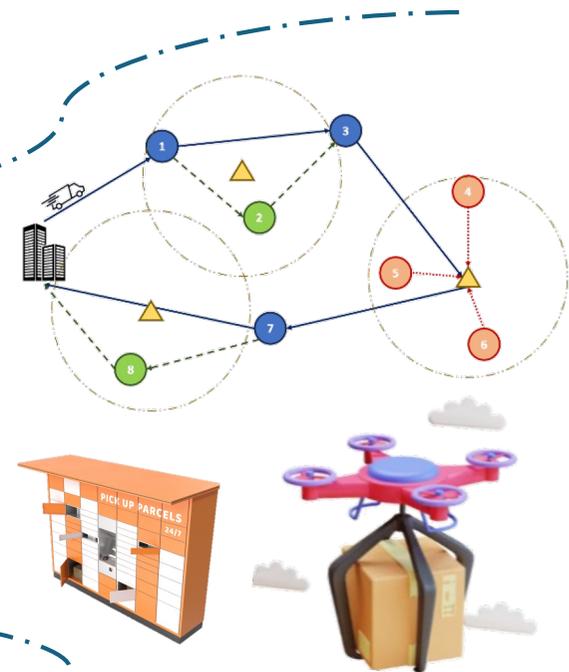**Main Topic** : "*Optimization and data science techniques supporting logistics problems*"

- **Application's field:**

Operations Research and Optimization Science

- **Class of interest:**

 - Optimization problems in the *last-mile logistics* (LML);

 - Involving the introduction of innovative / eco-friendly solutions (Green – LML).

- **Innovative approach:**

Evaluating the introduction and use of *Machine learning* and *Deep learning* techniques to develop innovative approaches for solving the problems addressed.

Research results
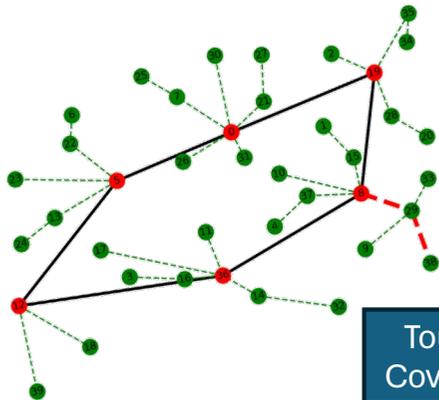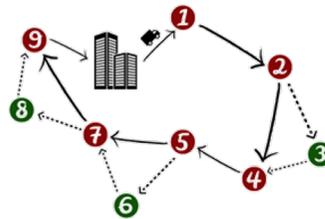
This year, I mainly focused on five problems, all of which can be formulated on a *graph*. In each feasible solution, every node can belong to only one of *two classes*.
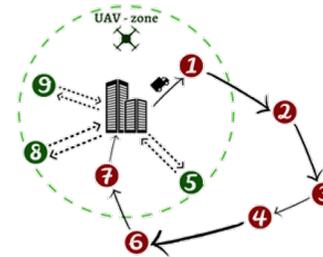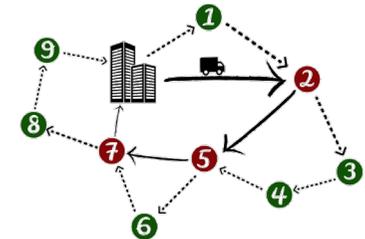
Covering Tour Problem with Path Upgrades (CTPPU)

Flying Sidekick TSP (FSTSP)

Parallel Drone Scehduling TSP (PDSTSP)

Truck-Drone Team Logistics (TDTL)

Tour or Covered?

NATURE

Truck or Drone?

As a result of the conducted **research**, the following **results** have been achieved:

1) A new heuristic approach based on machine learning techniques for the **CTPPU**.
   [Project abroad developed at University of Cadiz (ES)]

2) A Local Search Metaheuristic for the: **PDSTSP, FSTSP, TDTL**.

Research products

[P1]	Danilo Amitrano*, Maurizio Boccia, Adriano Masone, Claudio Sterle, *«A new formulation for the Traveling Salesman Problem with Drone and Lockers»* <u>JOURNAL:</u> **Networks**, published by WILEY <u>STATUS:</u> Published 26 April 2025 <u>PRESENTED AT</u>: 8th AIROYoung WORKSHOP, University of Calabria, Arcavacata di Rende, Calabria (IT), February 14 – 16, 2024
[P2]	Danilo Amitrano*, Maurizio Boccia, Adriano Masone, Claudio Sterle, *«A classification-based metaheuristic approach for the Flying Sidekick TSP»* <u>STATUS:</u> Published 29 April 2025; IFAC – PapersOnLine, Elsevier <u>PRESENTED AT</u>: ODS 2024 – International Conference on Optimization and Decision Science, Badesi, Sardinia (IT), September 8 – 12, 2024
[P3]	Danilo Amitrano*, Maurizio Boccia, Adriano Masone, Claudio Sterle, *«An exact approach for a Local Container Drayage Problem with Truck Platooning Mode»* <u>STATUS:</u> Published 29 April 2025; IFAC – PapersOnLine, Elsevier
[P4]	Danilo Amitrano*, Maurizio Boccia, Gabriella Colajanni, Laura Scrimali, *«Truck-Drone Delivery in Practice: A Local Search Metaheuristic with a Real-World Pharmaceutical Case Study»* <u>STATUS:</u> Submitted 22 December 2025; to Volume AIRO Springer Series "Transforming Freight Logistics and Transportation by Optimization and Data-Driven Methods" (Editors: F. Carrabs, R. Cerulli, F. Guerriero, M. Samà, C. Sterle).
[P5]	Danilo Amitrano*, Maurizio Boccia, Gabriella Colajanni, Laura Scrimali, *«A classification-based heuristic approach for the CTPPU»* <u>STATUS:</u> Ongoing work

Research activity

From a theoretical point of view, the *main objective of my thesis* is to show how classical approaches in Operations Research can be enhanced through the application of Machine Learning techniques.
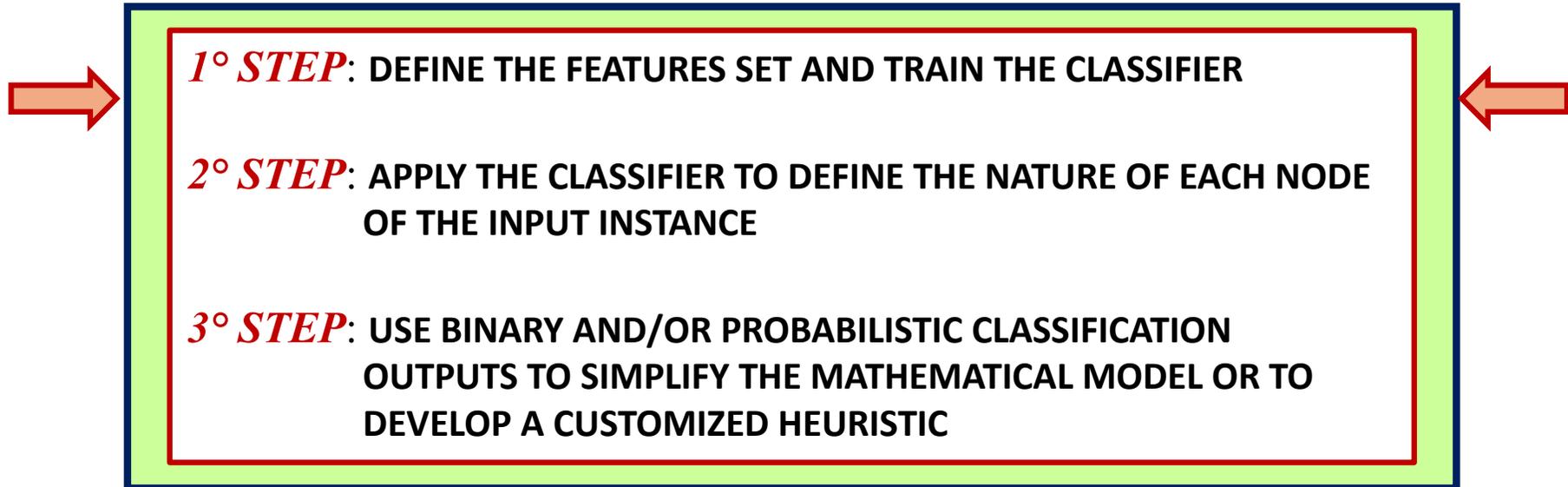
A *classification-based framework* for addressing last-mile logistics (*LML*) problems have been developed.
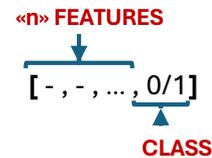
The **CORE IDEA** is to use machine learning techniques to reduce the complexity of the optimization problem by identifying a promising set of feasible solution.
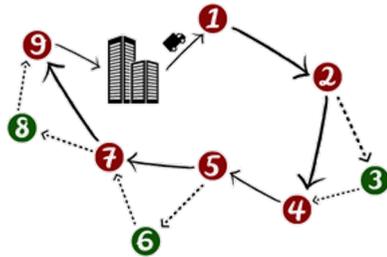
Research activity: Approach Architecture

1° STEP: **DEFINE THE FEATURES SET AND TRAIN THE CLASSIFIER**

2° STEP: **APPLY THE CLASSIFIER TO DEFINE THE NATURE OF EACH NODE OF THE INPUT INSTANCE**

3° STEP: **USE BINARY AND/OR PROBABILISTIC CLASSIFICATION OUTPUTS TO SIMPLIFY THE MATHEMATICAL MODEL OR TO DEVELOP A CUSTOMIZED HEURISTIC**

TRAIN THE CLASSIFIER

«n» FEATURES

$[- , - , \dots , 0/1]$

CLASS

– **DEFINE A FEATURE SET BASED ON THE SINGLE NODE**
– **CONSTRUCTION OF THE TRAINING DATASET**
  - **Generate "small" artificial instances**
  - **Solve the problem model**
  - **Calculate the set of features on each node**
  - **Construct the dataset**

FEATURES

OBSERV.   **CLASS**

– **SELECTION OF THE CLASSIFIER**
– **TRAINING AND EVALUATION OF PERFORMANCE**

- *PROBABILISTIC*
- *LINEAR*
- *INSTANCE BACED*
- *TREES*
- *NEURAL NETWORKS*
- *ENSEMBLE*

scikit *learn*

itee PhD
information technology
electrical engineering

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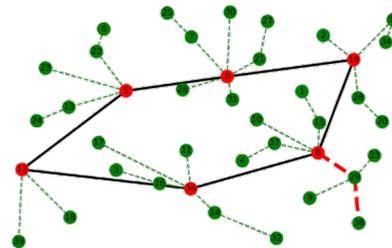# Research activity: Problem approach differences

Flying Sidekick TSP (FSTSP)

- 14 features

We used the *binary prediction* to fix some variables in the model
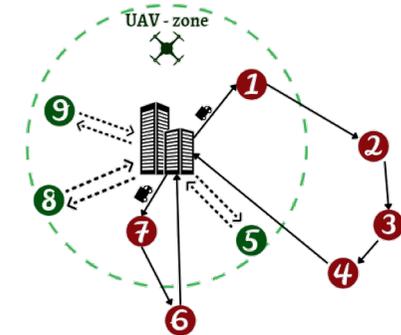
Covering Tour Problem with Path Upgrades (CTPPU)

- 26 features

We used the *probabilistic prediction* to guide and develop a customized heuristic approach.

Parallel Drone Scheduling Vehicle Routing Problem (PDSVRP)

- 15 features

- **Obtained results:**

Very good in terms of *execution time* and *solution quality* ⟶

FSTSP work: Published as *conference paper*

CTPPU work: Will be submitted to a *scientific journal* soon