UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

itee PhD information technology electrical engineering

DIETI. UNINA

Franca Rocco di Torrepadula

AI-Based Systems for Smart Cities: From Cloud down to Edge Systems

Tutor: Prof. Mazzocca

co-Tutor: Prof. Di Martino

Cycle: XXXVII

Year: Second

itee PhD information technology electrical engineering

My background

- MSc degree in Computer Engineering (October 2021)
- Research group: SECLAB
- PhD start date: 01/11/2021
- Scholarship type: UNINA

Summary of study activities

- **Ad hoc PhD courses / schools:**
  - IoT Data Analysis
  - Semantic artifacts and multimedia knowledge graphs for bio-data integration
  - 2023 Spring School in Transferable Skills
- **Conferences / events attended:**
  - International Symposium on Web and Wireless Geographical Information Systems (W2GIS2023). **Winner of the Best Presentation Award** for the presentation of the paper *Bus Journey Time Prediction with Machine Learning: An Empirical Experience in Two Cities.*

Research field of interest

- My research activity concerns the definition and the application of **AI-based systems** to **smart cities**.
- During this second year, I investigated how to deploy such intelligent systems at the edge, falling into the research field of **EdgeAI.**

From Cloud down to Edge Systems

- **Problem:** when Deep Neural Networks (DNNs) are deployed on cloud resources data must be moved from source locations to the cloud, introducing several challenges:

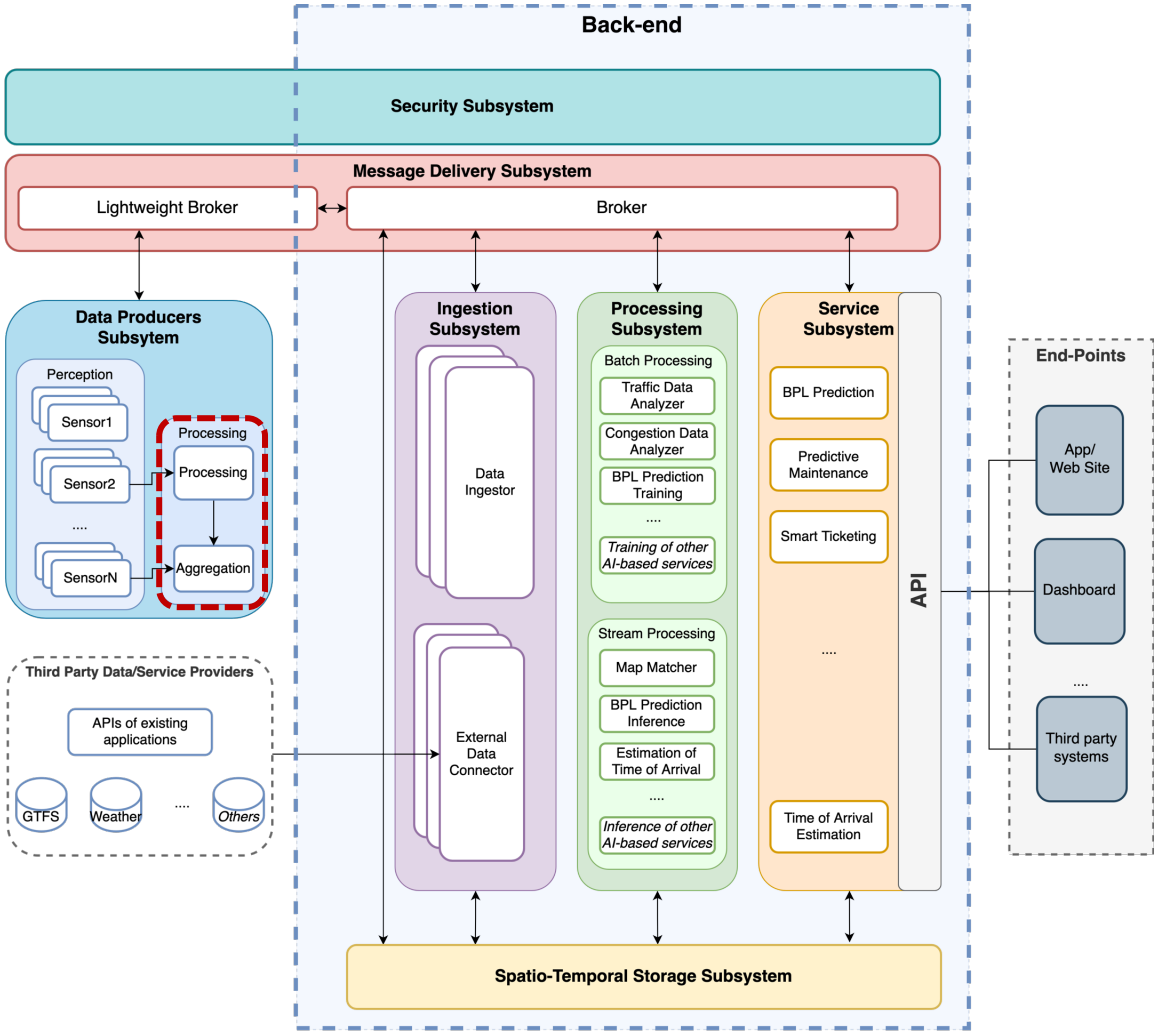
Latency

Scalability

Privacy

From Cloud down to Edge Systems

- **Objective:** move DNNs inference tasks down to edge systems
- **Challenge:** Edge devices are characterized by limited capabilities.

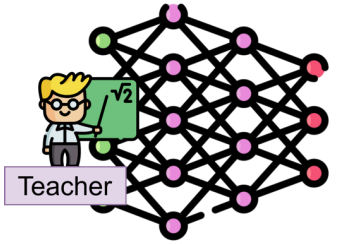


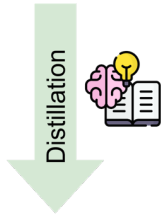
Hardware-Software Codesign

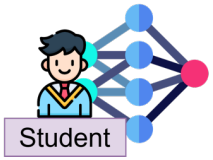
- Software side:
  - Techniques for compressing DNNs or defining novel network, efficient by design.
  - Trade-off between network accuracy and computational/storage costs.
- Hardware side:
  - Avoiding GPUs and designing ad hoc neural network accelerators *(e.g.* RISC-V based, FPGA-based, etc*).*
  - Trade-off between flexibility w.r.t network structure and performances.

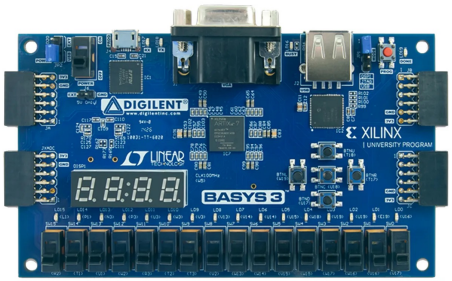
Knowledge Distillation

- **Knowledge Distillation** as a model compression technique, to obtain a good **trade-off** between the accuracy of the results and the performance at the edge.
  - A deep model (the ***teacher***) is trained without strict requirements.
  - A smaller model (the ***student***) is designed to be more suitable for the deployment at the edge.
  - The student is trained by exploiting (***distilling***) the knowledge acquired from the teacher.





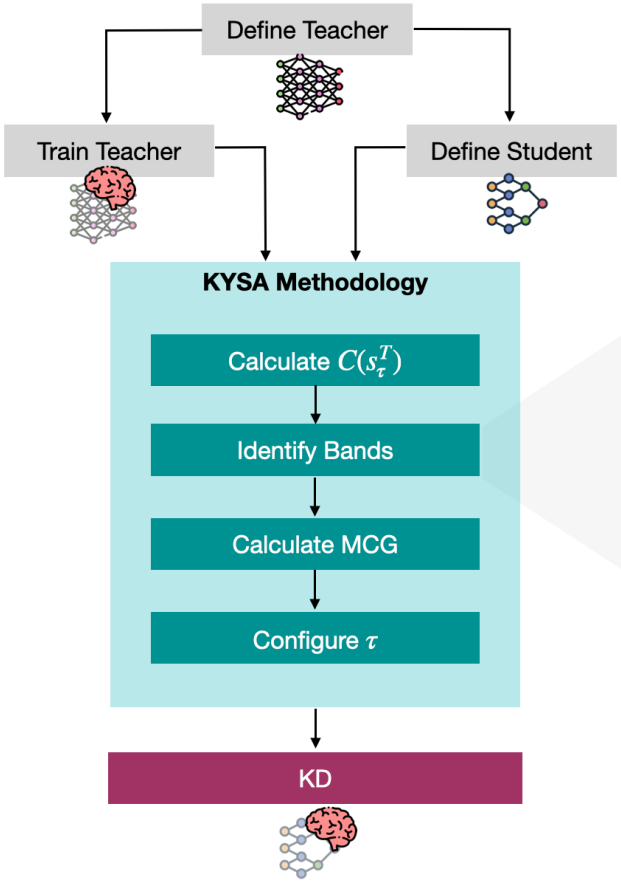


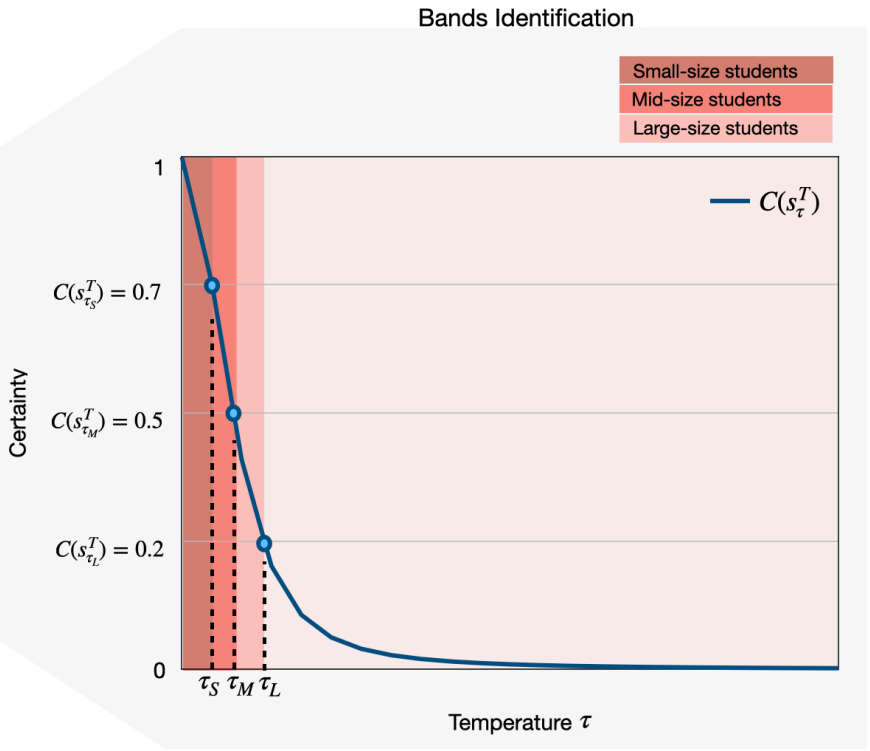


My Contribution

- Among not fully explored aspects, the proper configuration of the temperature hyper-parameter is a crucial point, referred to as the ***temperature dilemma.***
- We demonstrate that the temperature depends on two main factors:
  - The ability of the teacher w.r.t the task at hand
  - The model capacity gap between the teacher and the student, related to the capability of the student in following the teacher.

The KYSA Methodology





Next Year

- ***Toward Online Learning:***
  - KD and Online Learning (with *ETH Zürich* and *Università di Bologna*)
  - Federated Learning (with *Leibniz Universität*)

Products

[J1]	Di Martino, S., Landolfi, E., Mazzocca, N., **Rocco di Torrepadula, F.,** & Starace, L. L. L. (2023). *A visual-based toolkit to support mobility data analytics.* Published on *Expert Systems with Applications (ESWA)*.
[J2]	Cilardo, A., Maisto, V., Mazzocca, N., **Rocco Di Torrepadula, F.** (2023). An approach to the systematic characterization of multitask accelerated CNN inference in edge MPSoCs. Published on *ACM Transactions on Embedded Computing Systems (ACM TECS).*
[J3]	**Rocco Di Torrepadula, F.,** Napolitano E. V., Di Martino S., Mazzocca N., *Data-Driven Public Transportation Demand Prediction: A Systematic Mapping Study.* Submitted to the *IEEE Transactions on Intelligent Transportation Systems (T-ITS).* Under the second round of review.
[J4]	**Rocco Di Torrepadula, F.,** Cilardo, A., Mazzocca N. *Keep Your Student's Attention: A Methodological Approach for Configuring the Temperature in Knowledge Distillation.* Submitted to the *IEEE Transactions on Pattern Analysis and Machine Intelligence (T-PAMI).*

Products

[J5]	**Rocco Di Torrepadula, F.,** Maisto, V., Cilardo, A., Mazzocca. *Energy-Efficient DNNs via Knowledge Distillation and FPGA technologies.* Submitted to the *IEEE Transactions on Sustainable Computing (T-SUSC)*
[C1]	Dunne, L., **Rocco Di Torrepadula, F**., Di Martino, S., McArdle, G., & Nardone, D. (2023, June). *Bus Journey Time Prediction with Machine Learning: An Empirical Experience in Two Cities*. In *International Symposium on Web and Wireless Geographical Information Systems (W2GIS2023).* **Best Presentation Award.**
[C2]	Di Martino, S., Mazzocca, N., **Rocco Di Torrepadula, F**., & Starace, L. L. L. (2023, June). *Mobility Data Analytics with KNOT: The KNime mObility Toolkit.*In *International Symposium on Web and Wireless Geographical Information Systems (W2GIS2023)*
[C3]	**Rocco Di Torrepadula, F.,** Russo, D., Di Martino S., Mazzocca N., Sannino, P. *Using SUMO towards Proactive Public Mobility: Some Lessons Learned.* Accepted for the *1st ACM SIGSPATIAL Workshop on Sustainable Mobility (SuMob 2023)*

Tutorship

- ***Computer System Design*** course: support and tutorship on:
  - Motorola 6800 programming and simulation on ASIM/ASIM Tool 10/03/23 (3 hours) and 17/03/23 (3 hours);
  - Intel 82C59A Priority Interrupt Controller programming;
  - Intel 8237A DMA controller programming 28/04/23 (2 hours)
- ***Architettura dei Sistemi Digitali*** course: support and tutorship on:
  - Design of the Robertson's Multiplier on FPGA-based boards 13/12/22 (1 hour)
- ***Risk Assessment*** course: support and tutorship on:
  - Fault Tree Analysis 19/04/23 (2 hours) and 20/04/23 (2 hours).

Thank you for your attention

Contact:
franca.roccoditorrepadula@unina.it
Room 4.03 – building 3/A – via Claudio 21