

Intelligenza artificiale per la produzione e la gestione di energia nel teleriscaldamento

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ISLa

**Le Comunità e le Reti Energetiche
modelli di sviluppo sostenibile a confronto per la valorizzazione delle risorse termiche**

16 Marzo 2022

Radicondoli (SI) e online

Overview

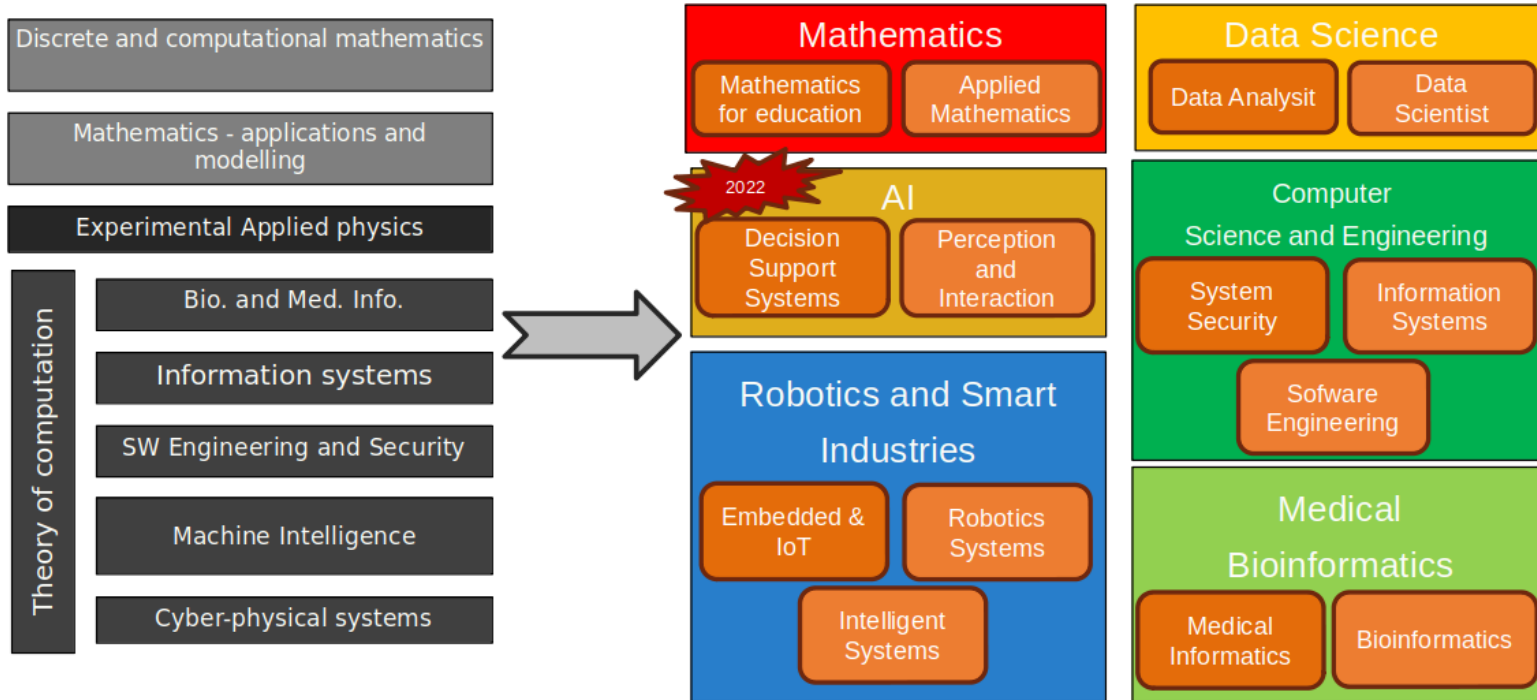
1. Introduction
2. The GHOTEM project
3. Heating load prediction in district heating networks
4. Our solution
5. Software XM_HeatForecast
6. Conclusions

Computer Science Department @UniVr

- **più di 260 persone**
 - 80 strutturati
 - 120 PhD, AdR
 - 5 admin
- **Competenze:** Matematica, Fisica, Informatica, Ingegneria Informatica
- **Dipartimenti di eccellenza 2018-2022 (MIUR)**
 - Computer engineering for industry 4.0
 - Finanziamento di 8 M€
- **Ricerca ed Innovazione (2014-2021)**
 - 4.1 M€ progetti di ricerca
 - 5.1 M€ contratti con imprese
 - 6 spin-off
 - Computer Science Park



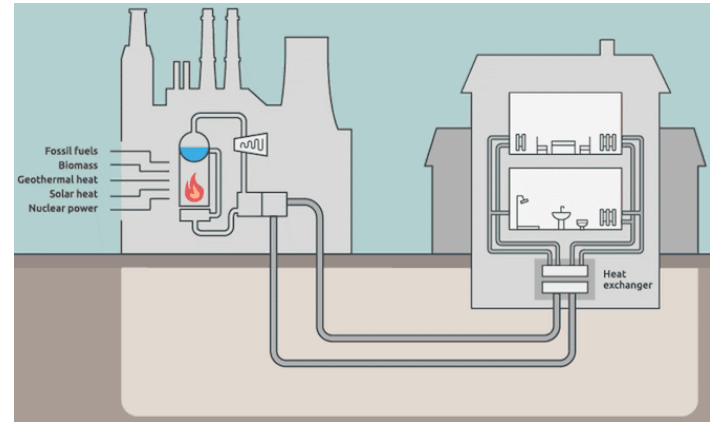
Research Areas and Master's Degrees



GHOTEM: Heating Load Prediction in District Heating Networks

GHOTEM

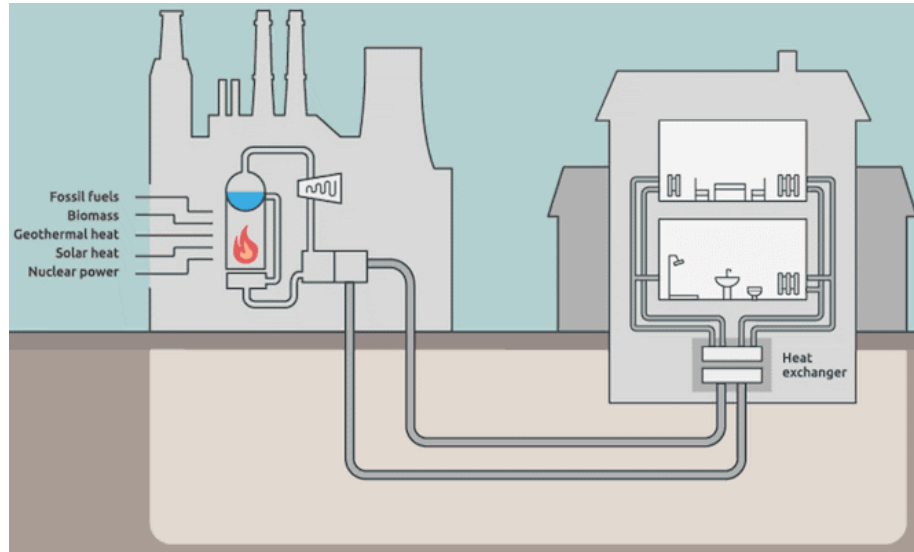
≈ 5.7M€ funding



Objectives:

-- Forecasting heating load of power stations from weather and social factors

Heating load generation in district heating networks

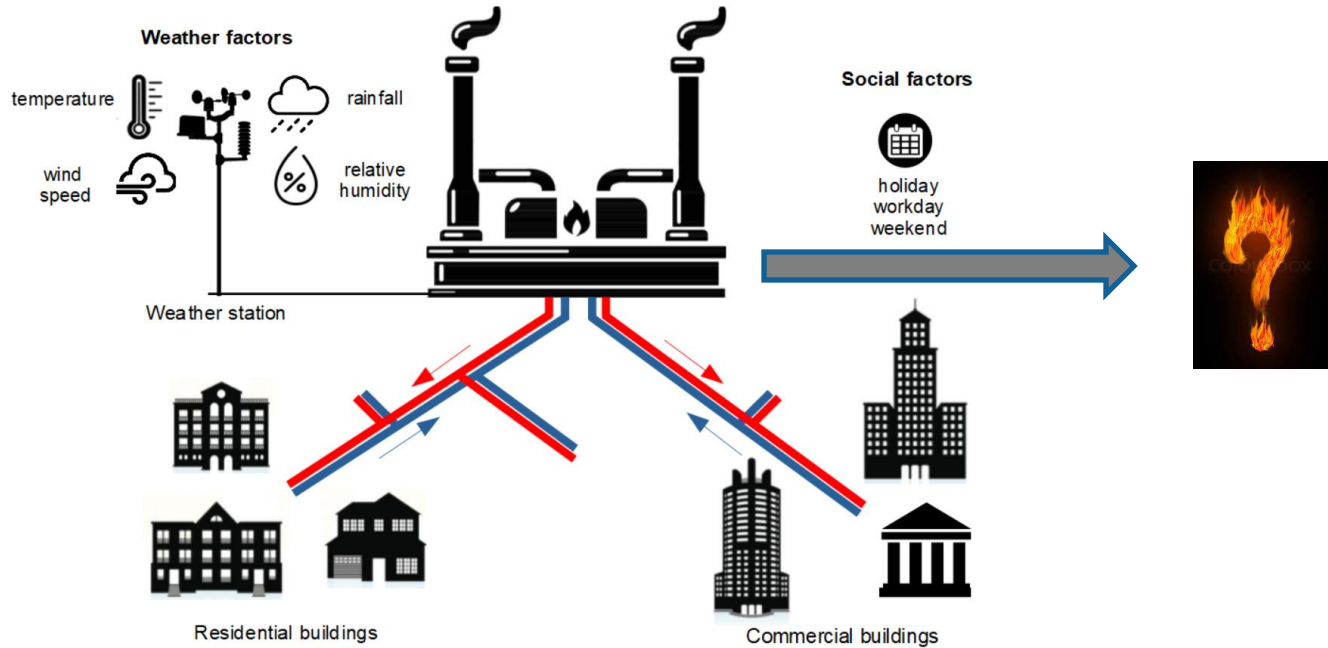


Operating principle of a district heating network

The AGSM district heating network in Verona

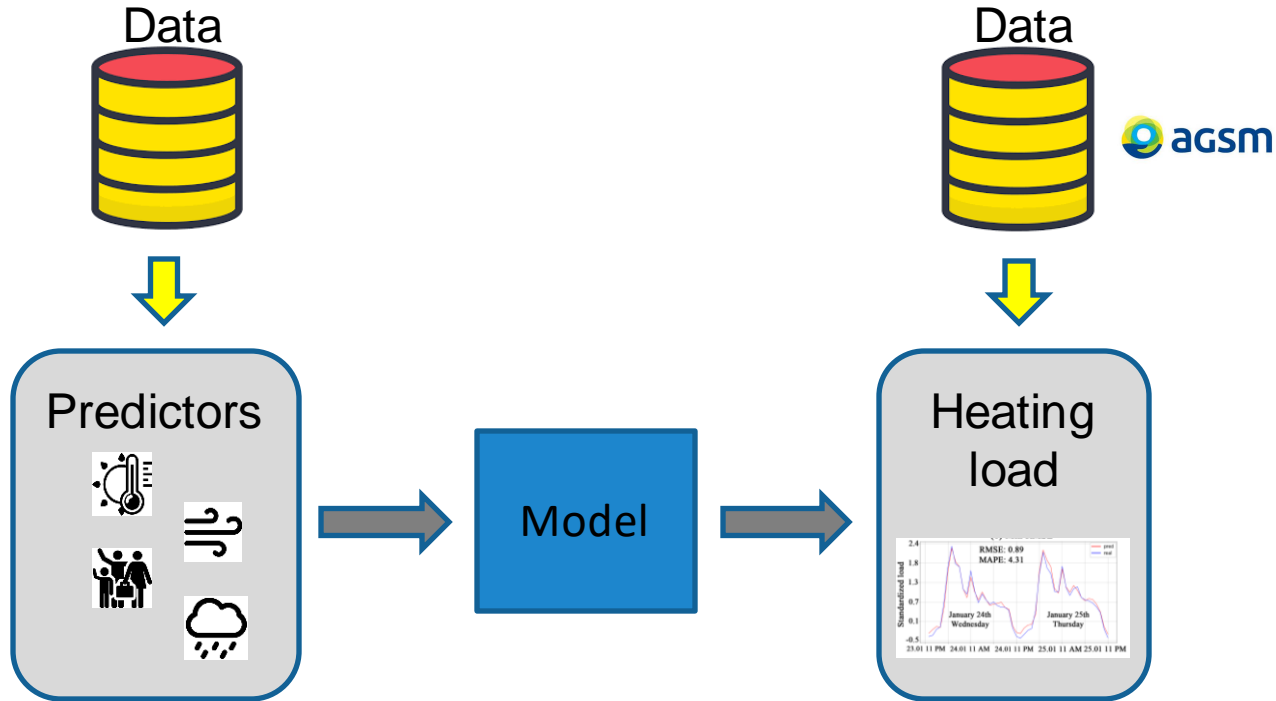
- Power generation split in 3 stations: CCC, CRV and CSD
- CCC (main station)
 - cogeneration engines fueled by natural gas (base load)
 - gas-fired boilers (peak load)
 - high temperature heat pumps
- CRV: foundry waste heat
- CSD: gas-fired boilers

Heating load prediction



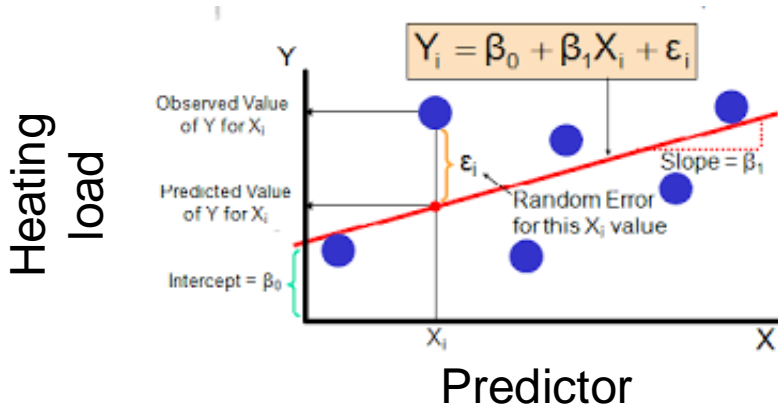
Weather and social factors used to predict the amount of heat to produce

Predictive model generation



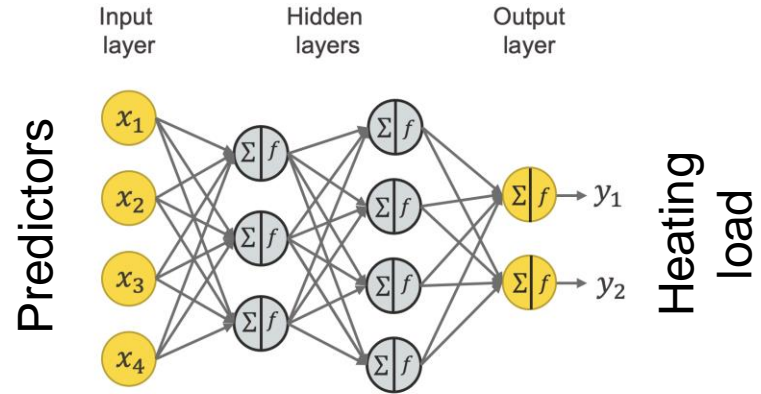
How a predictive model is made (examples)

Linear regression model



High interpretability

Neural network



High prediction accuracy

Our solution

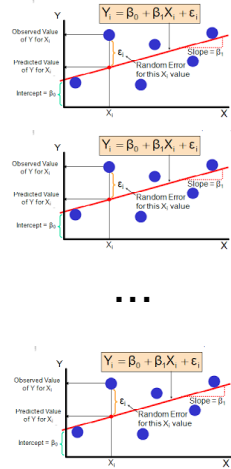
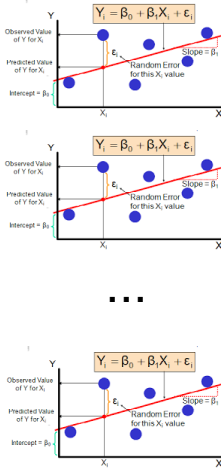
To keep both **interpretability** and **predictive ability** we used a **multiequation multivariate linear regression model**

Day of the week

Mon

Tue

Sun

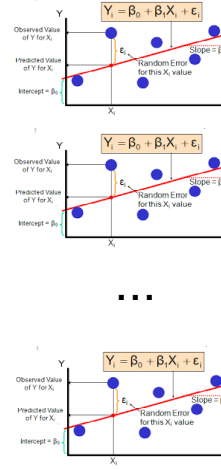


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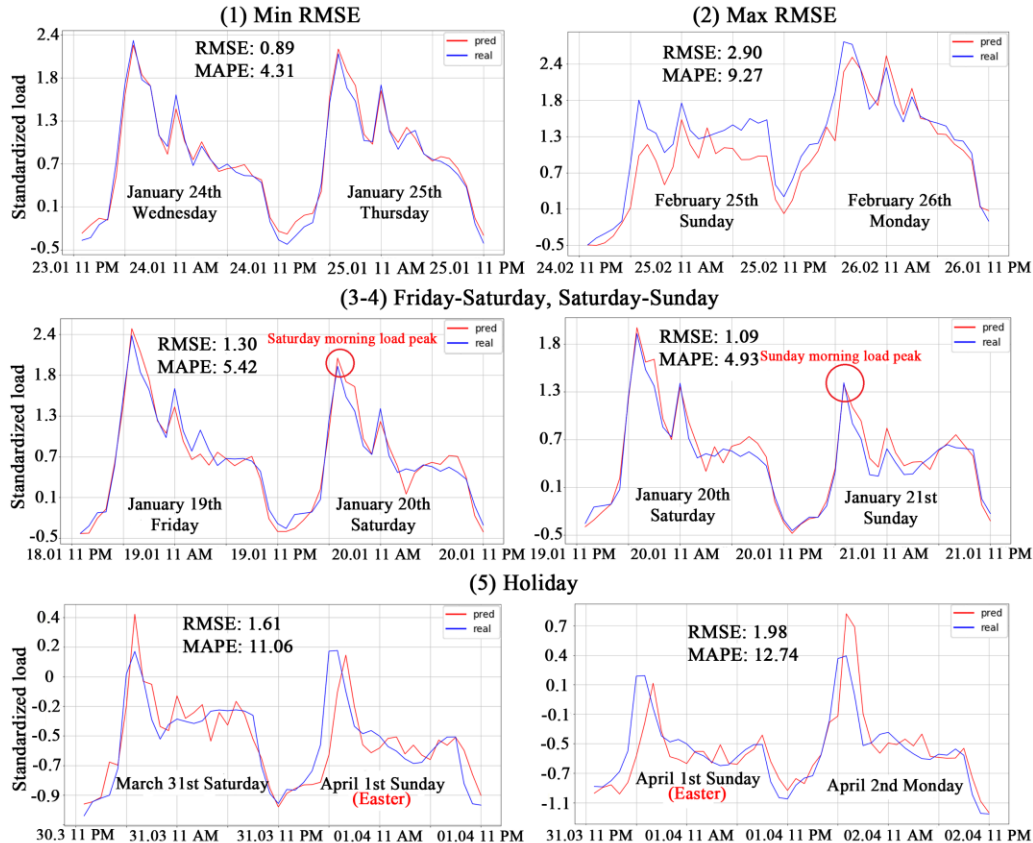
00.00

01.00

23.00

Hour of the day

Predictions: some results

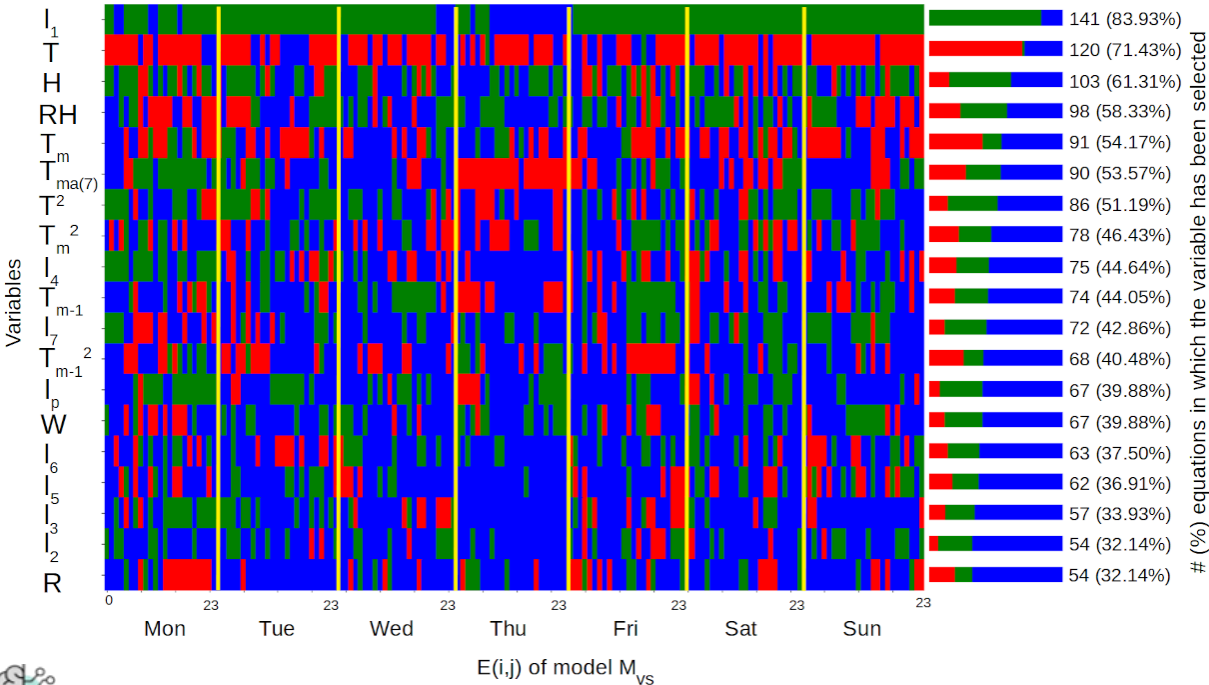


Advanced analysis: model parameters

a) Variables selected in each equation of model M_{vs}

Values of parameters

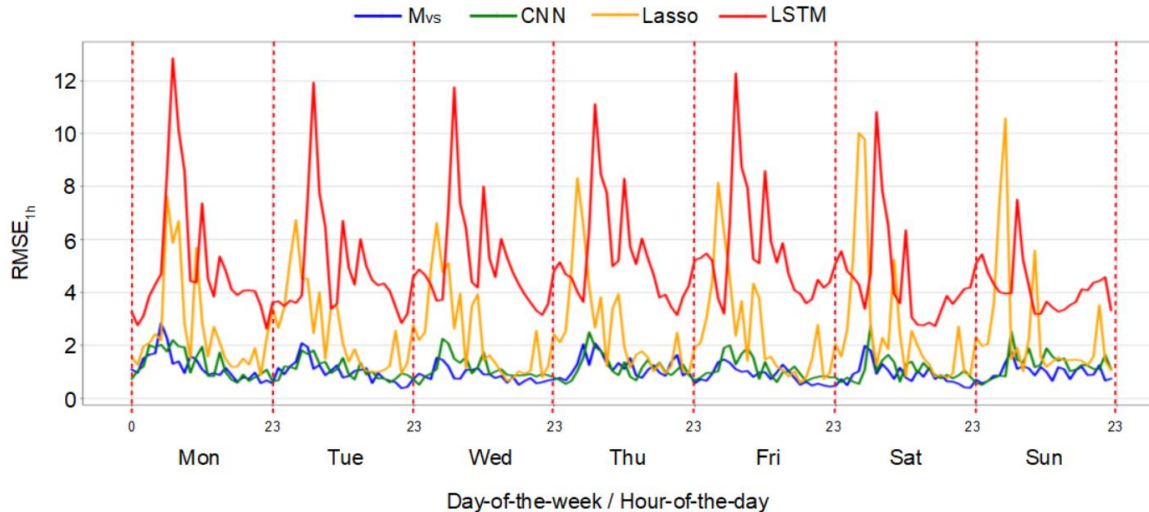
Selected and Negative Selected and Positive Not selected



- Some **predictors** are **selected** only in some models
- Some predictors have a **positive effect** on the heating load
- Other predictors have a **negative effect**

Advanced analysis: comparison with other models

Average error of four types of models: comparison



The **proposed model** obtained the **lowest average error** of all four models compared

XM_HeatForecast: **Heating Load Forecasting in Smart District Heating Networks**

The Sixth International Conference on Machine Learning, Optimization and Data Science
July 19-23, 2020



Scientific publications

- A. Castellini, F. Bianchi and A. Farinelli. Generation and interpretation of parsimonious predictive models for load forecasting in smart heating networks. Applied Intelligence, Springer Nature, 2022
- F. Bianchi, F. Masillo, A. Castellini, A. Farinelli. XM HeatForecast: Heating Load Forecasting in Smart District Heating Networks. In LOD 2020 - The Fifth International Conference on Machine Learning, Optimization, and Data Science, Lecture Notes in Computer Science, volume 12514, pages 601-612, Springer-Verlag, 2020
- F. Bianchi, P. Tarocco, A. Castellini, A. Farinelli. Convolutional Neural Network and Stochastic Variational Gaussian Process for Heating Load Forecasting. In LOD 2020 - The Fifth International Conference on Machine Learning, Optimization, and Data Science, Lecture Notes in Computer Science, volume 12514, pages 244-256, Springer-Verlag, 2020
- A. Castellini, F. Bianchi, A. Farinelli. Predictive model generation for load forecasting in district heating networks. IEEE Intelligent Systems, 36(4):86-95, 2021
- F. Bianchi, A. Castellini, P. Tarocco, A. Farinelli. Load Forecasting in District Heating Networks: Model Comparison on a Real-World Case Study. In LOD 2019 - The Fifth International Conference on Machine Learning, Optimization, and Data Science, Lecture Notes in Computer Science, volume 11943, pages 553-565, Springer-Verlag, 2020

Acknowledgments



Prof. Alessandro Farinelli

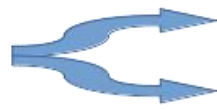


Dott. Federico Bianchi



Intelligent Systems LAb

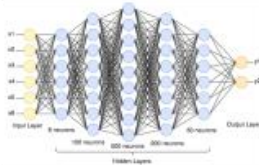
Laurea Magistrale in AI @UniVr



Symbolic methods

Probabilistic methods

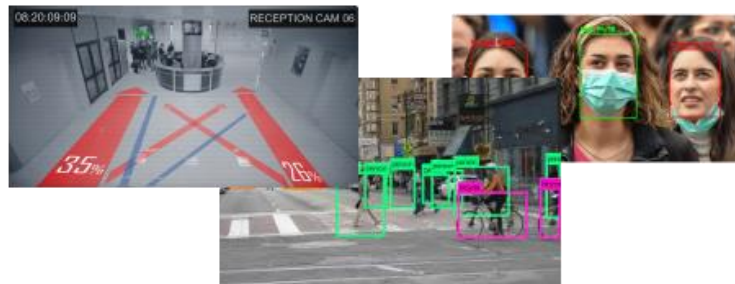
eXplainable Artificial Intelligence



Decision support systems



Perception and interaction



Thank you!