POLITECNICO DI TORINO

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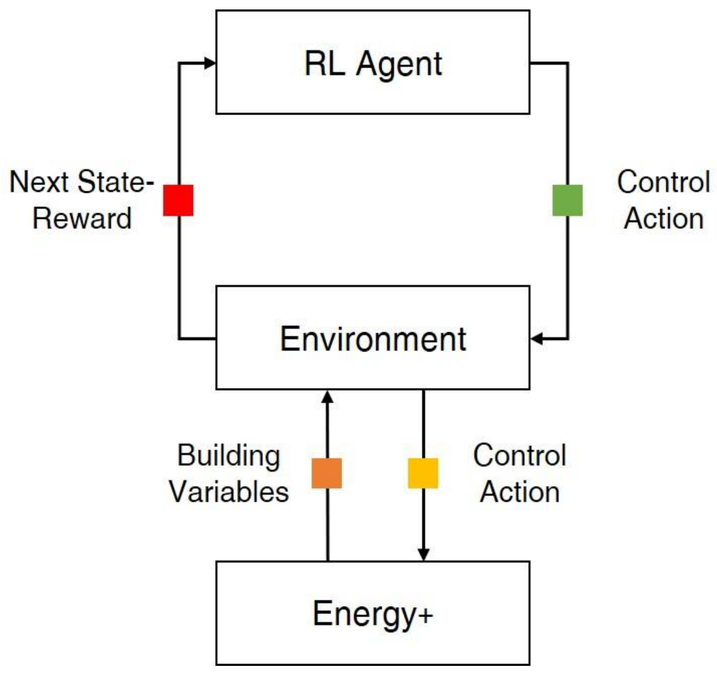
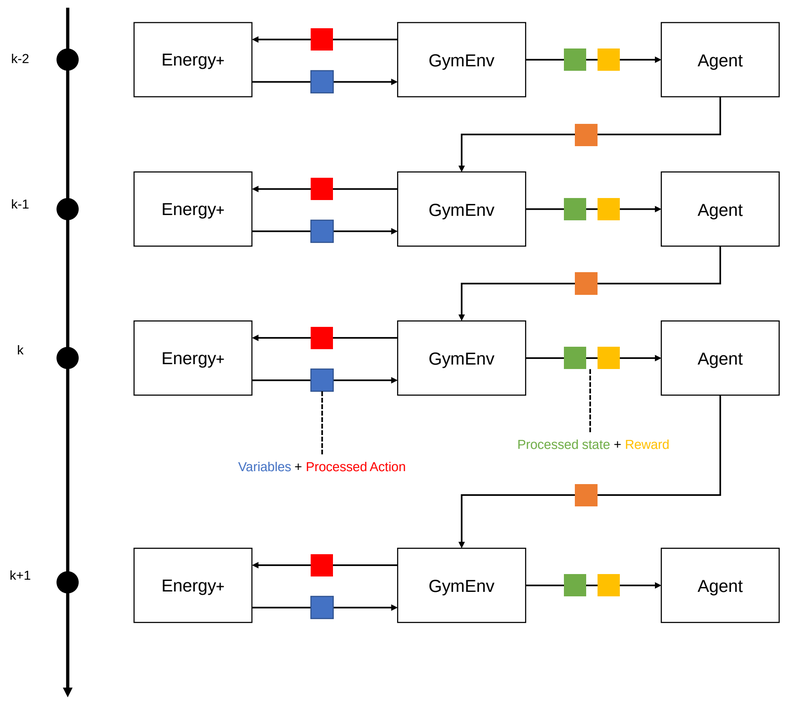
Adaptive Control Strategies for improving energy flexibility in buildings

Adaptive Control & Energy Flexibility

Energy flexibility, defined as the property of a building to be optimally operated according to forcing external variables, occupant comfort and grid needs, is becoming an emerging requirement. Adaptive and predictive optimal control (e.g. Reinforcement Learning) provides powerful opportunities for leveraging building properties, storage systems and renewable energy sources to enhance energy flexibility during operation.

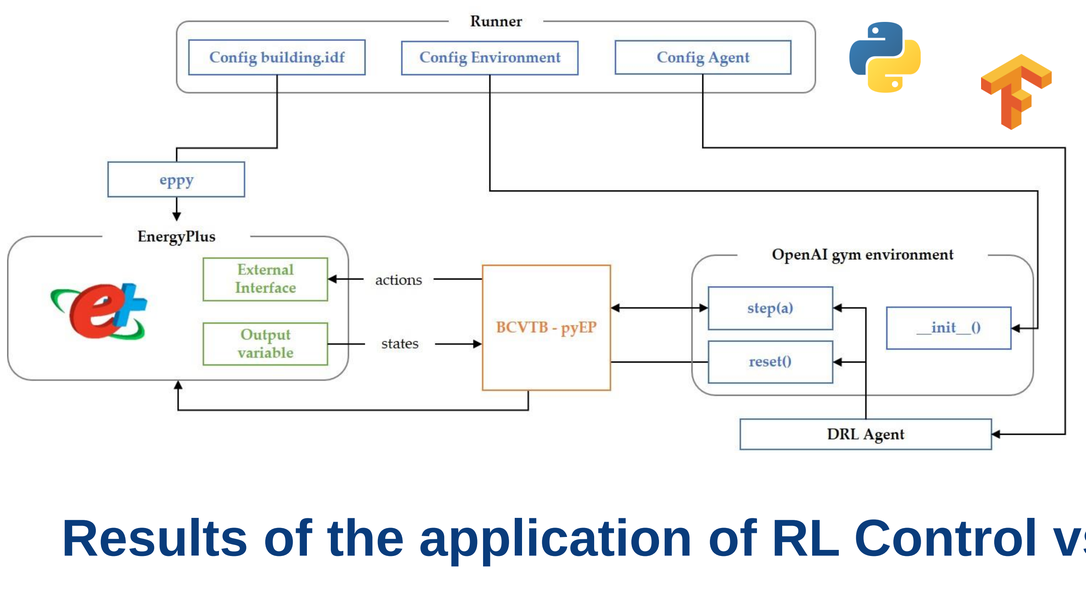


In the RL framework applied to HVAC control an agent (e.g. a control module linked to building management system running in the cloud) performs an action (e.g. turning on the heating system) when the environment (e.g. a building thermal zone) is in a state (e.g. the building is occupied, and the indoor temperature is below the desired setpoint) and receives a reward (e.g. the consumption of the heating system) which represents how much the agent is performing well by taking that action in that state with respect to the control objective.

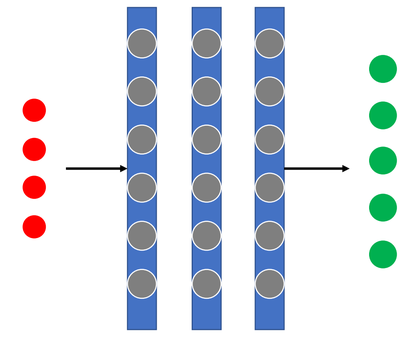


Integrated Environment for simulating RL controllers in HVAC systems

The entire process was developed in an integrated simulation environment combining EnergyPlus and Python. Through this environment is possible to overcame EnergyPlus limitations in simulating advanced control logics.



Deep Neural Network Architecture



Input: States — Hidden Layers — Output: Action-Value

Results of the application of RL Control vs Rule-Based Control

A Deep-RL agent was implemented in a simulated office building located in Turin. The main challenge is to design a robust agent capable to adapt to flexible indoor conditions such as variable occupancy patterns and indoor temperature setpoint requirements.

Control Action

Supply Water Temperature Setpoint to terminal units.

States

Ambient
- Air Temperature
- Direct Solar Radiation

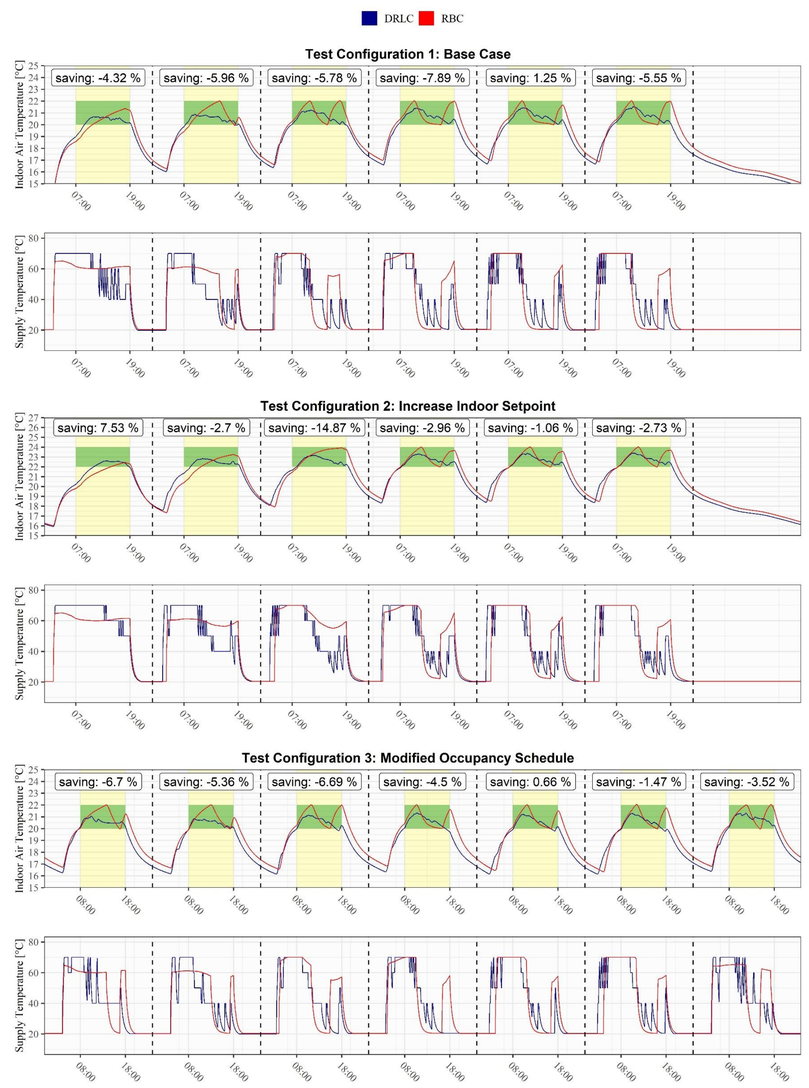
Building
- Distance between actual temperature and setpoint
- Occupancy Flag
- Time To Occupancy

HVAC
- Supply Water Temperature
- Return Water Temperature
- Thermal Energy for Heating

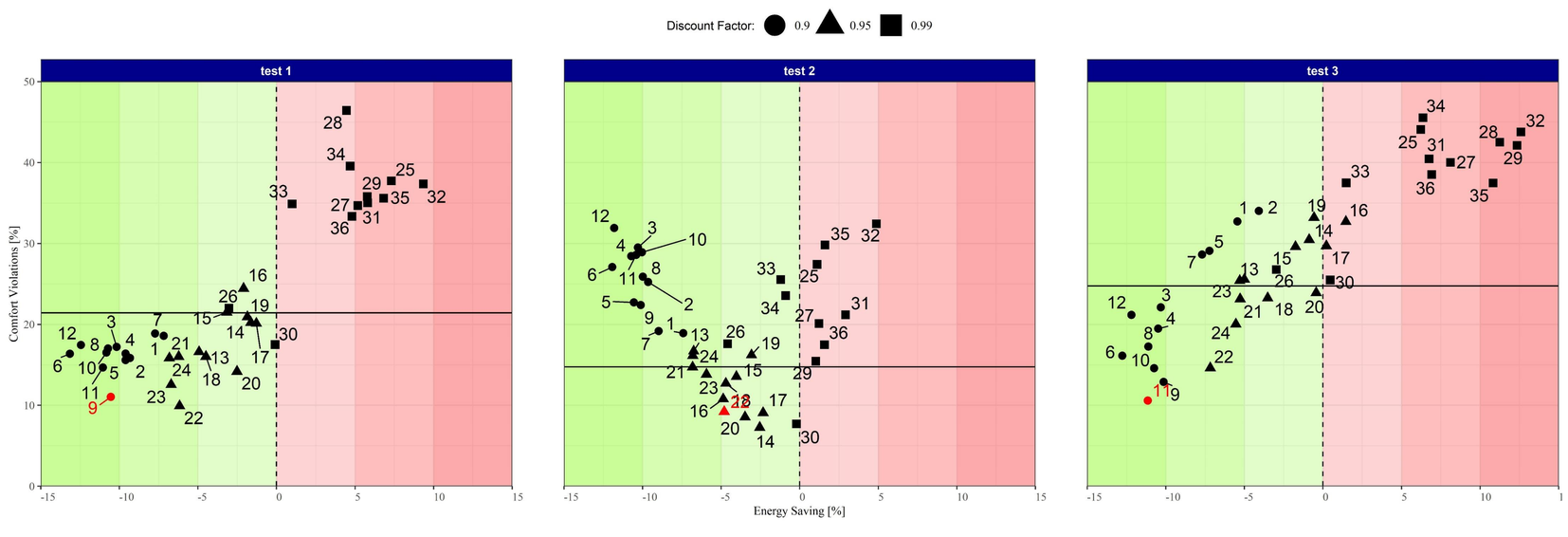
Rewards

Minimize Energy Consumption

Maximize Occupant Comfort



Summary of adaptability tests results as a function of different hyperparameter configurations.



Base Case — Increased Indoor Setpoint — Modified Occupancy Schedule

Energetics PhD XXXIV Cycle

PhD Day
Energy Center Auditorium
December 16th 2019

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Sponsored by:

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Publications

Piscitelli M S, **Brandi S**, Gennaro G, Capozzoli A, Favoino F, Serra V. **Advanced control strategies for the modulation of solar radiation in buildings: MPC-Enhanced rule-based control**. International conference Building Simulation-19, 2-4 September 2019 Rome (Italy)
Capozzoli A, Piscitelli M S, **Brandi S**., Grassi D., Chicco G. ***Automated load pattern learning and anomaly detection for enhancing energy management in smart buildings***. Energy 2018; 157: 336-352
Capozzoli A, Piscitelli M S, **Brandi S**. ***Mining typical load profiles in buildings to support energy management in the smart city context***. Energy Procedia 2017; 134: 865–874.

TEBE — Technology Energy Building Environment

BAEDA Lab — Building Automation Energy Data Analytics

External Collaborations:

TEXAS — The University of Texas at Austin

SCAN ME