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Design Phases for Reinforcement Learning-based System Control Development

J. Montoya[1], R. Brandl[1,2]

Contact: Juan Montoya | Fraunhofer IEE | +49 160 96749682 | juan.montoya@iee.fraunhofer.de

[1]Fraunhofer IEE
[2]DERlab e.V.

Supporting Control Engineering Approach Using Deep Reinforcement Learning

Challenges of DRL development in control engineering

- Training of deep reinforcement learning (DRL)-Agents in pure simulation environments ignores the realistic behavior and phenomena that cannot be depicted or implemented due to its complex nature
  - More complex models of a power system increase simulation time, leading to slower training speed
- Putting non-trained DRL-Agents into real power systems can disturb power system security. Online learning is not practical for security-critical energy operation.

Design Phases for close-to-real DRL Agent Training and Validation

To form a stable and well-trained DRL-Agent as a supervised-level controller for distributed energy resources (DER) grid components, the design phases to develop a DRL-Agent are proposed. Each step transfers its outcomes to the next one, giving robustness to the process and increasing gradually the quality of the training. This ensures not just a development from implementation to application with a higher degree of realistic behavior, but also a better representation of the environment.

1. Offline Implementation and Pre-Training
   - Pure DRL implementation in a simulation environment
   - Pre-Training in simplified simulation environment
   - ➢ Determination of: type of agent, ANN sizes, hyper-parameters, …
2. Advanced Rapid Control Prototyping Training
   - Pre-trained agent implemented in real hardware (HW) controller
   - Training and inference in simplified simulation environment
   - ➢ Evaluation of HW performance and virtual interfaces
3. Hardware-in-the-Loop Training and Validation
   - Pre-trained HW-agent in detailed emulated real-time environment
   - Online training and inference with real-time feedback
   - ➢ Validation of agent in a close-to-real environment and physical interfaces
4. Laboratory and Field application
   - Integration of HW-agent in real environment
   - Additional training possibility in a real field
   - ➢ Validation of the real application

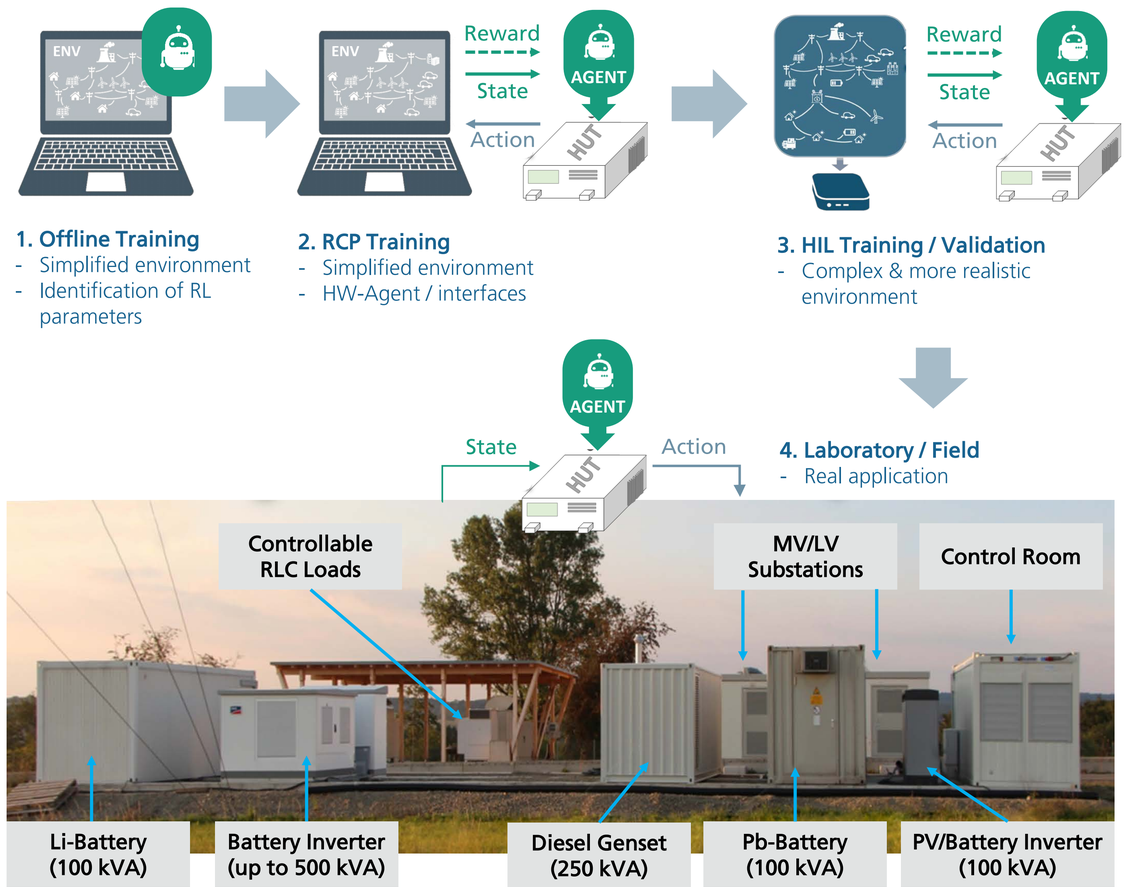


Figure 1: Systematical Approach of DRL-Agent Integration into the Field

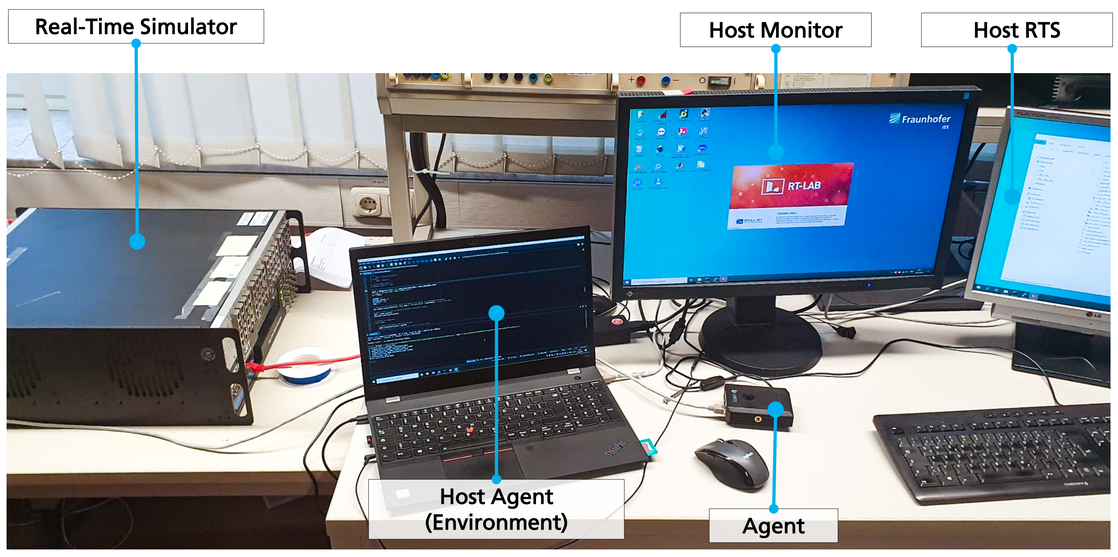
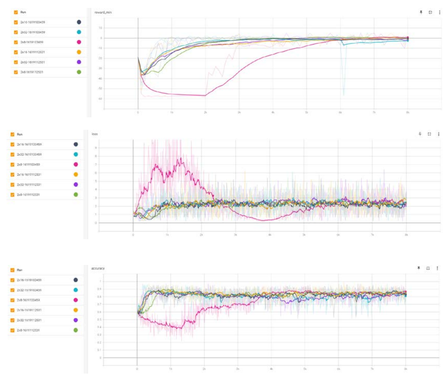
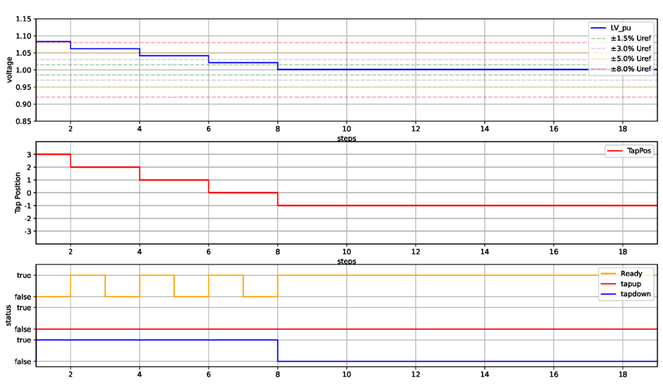


Figure 2: Online HIL Training and Validation Setup

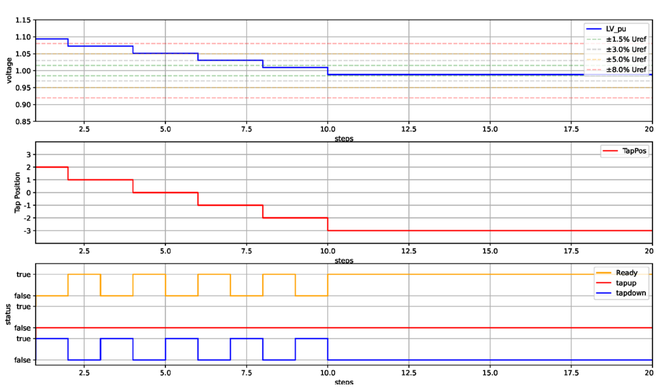
Ergebnisse



Offline Training



RCP Training



Online HIL Training and Validation

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