# Systems Sciences Introduction
# Semester 2025-I
# Workshop No. 3 — Machine Learning & Cybernetics Implementation

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Welcome to the third and final preparatory workshop of the *Systems Sciences* course before the ultimate project submission! Building upon the outcomes and design foundations from **Workshop #1** (systems design) and **Workshop #2** (dynamical systems), this session focuses on integrating **machine learning** and **cybernetics** into your *Autonomous Adaptive Agent Simulation*. You will implement key features—ranging from sensor-driven feedback loops to advanced reinforcement learning algorithms—to bring your agent closer to real-world applications.

**Workshop Scope and Objectives:**

- **Machine Learning Integration:** Combine reinforcement learning (Q-learning or DQN) with your previously outlined dynamic frameworks to optimize agent behavior.
- **Cybernetic Control Mechanisms:** Finalize and refine feedback loops to ensure real-time self-regulation, adaptability, and resilience to environmental fluctuations.
- **Multi-Agent Extension (Optional):** Explore how multiple autonomous agents might interact, coordinate, or compete within the same environment.
- **Preparation for Final Delivery:** Ensure your repository, documentation, and project pipeline are set up for a smooth transition to the *final project submission*.

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**Methodology and Deliverables:**

1. **Machine Learning Implementation:**
   - *Algorithms and Frameworks:* Implement or refine Q-learning and/or Deep Q-Networks (DQN). Incorporate libraries such as TensorFlow, PyTorch, or Stable-Baselines3.
   - *Cybernetic Feedback Integration:* Map sensor inputs and environmental data to your reward functions, ensuring alignment with your dynamic system design.
2. **Agent Testing and Evaluation:**
   - *Experimental Setup:* Define test cases or scenarios (e.g., random seeds, altered environment parameters) to validate the agent's learning under various conditions.
   - *Performance Metrics:* Collect and compare metrics like episode reward, learning curves, and convergence speed to ensure your agent progresses toward defined objectives.
3. **Optional Multi-Agent Extension:**
   - *Communication Protocols:* If applicable, design inter-agent communication strategies such as message passing or shared memory.
   - *Cooperative or Competitive Interactions:* Demonstrate how multiple agents behave under your established feedback loops, focusing on distributed decision-making.
4. **Documentation and GitHub Repository:**
   - Create a new folder, `Workshop-3`, in your GitHub repository. Store scripts related to ML algorithms, environment configuration, and any new simulation code.
   - Include a `README.md` that summarizes your approach, links to relevant files, and outlines how to run experiments or replicate your results.
   - Include a detailed `report` that summarizes your findings, including:
     - A summary of the machine learning algorithms implemented.
     - A description of the feedback loops and their integration with the learning process.
     - An analysis of the agent's performance, including metrics and visualizations.
     - Any challenges faced during implementation and how they were addressed.
     - Future work or improvements that could be made to the system.

**Deadline: Friday, June 13th, 2025, 8:00**. Submissions after this deadline may affect your ability to incorporate feedback before the final project presentation.

**Notes:**

- Please keep your deliverables in **English** and compile them into a single **PDF** report.
- Cite all external sources (research papers, software repositories, or tutorials) used to inform your ML or cybernetic implementations.
- The work completed here will form the **core** of your final project. Focus on clarity, reproducibility, and rigorous testing to ensure a successful final submission.

*Use this workshop to unite your designs (Workshop #1) and dynamics (Workshop #2) with advanced machine learning methods, creating a truly adaptive, cybernetic system. Good luck, and prepare to showcase a cutting-edge agent in the final project!*