Reinforcement Learning in Energy Systems

Course Code: 46393
Course Type: Theoretical
Credits: 3
Course Status: Elective Specialized PhD Course
Prerequisite: Supervisor Approval

Aim/Scope/Objectives: This course intends to give the required knowledge to the Ph.D. students for designing intelligent systems based on reinforcement learning, in which the system learns through the interaction between its agents and the environment. The students are trained to implement a research project in Python. This course has extensive application in many fields, such as energy management of different energy systems, operation control and decision-making of different systems, stock markets, and finance.

Course Outline:

1- An overview on Learning Based Systems
- 1-1- Introducing different learning based systems
- 1-2- Basic elements of a reinforcement learning system
- 1-3- Examples for reinforcement learning systems

2- The Official form of Reinforcement Learning Problem
- 2-1- Different structures of intelligent agents
- 2-2- Environment characteristics
- 2-3- Markov decision feature in reinforcement learning problems
- 2-4- Value functions
- 2-5- Optimal policy and Bellman optimality equations

3- Methods of Action Selection
- 3-1- Approximation of action-value
- 3-2- Direct and search methods
- 3-3- Improvement of Softmax search method
- 3-4- Upper confidence bound (UCB) action selection

4- Dynamic Programing
- 4-1- Policy evaluation
- 4-2- Policy improvement
- 4-3- Policy iteration
- 4-4- Value iteration
- 4-5- Performance of dynamic programing

5- Monte Carlo Methods
- 5-1- Monte Carlo value function prediction
- 5-2- Monte Carlo action-value function prediction
- 5-3- Monte Carlo control

- 5-4- On-policy Monte Carlo control
- 5-5- Generalized Policy Iteration (GPI)
- 5-6- Off-policy Monte Carlo control

6- Temporal-Difference Learning

- 6-1- TD prediction
- 6-2- Batch updating in TD
- 6-3- Control based on TD
  - 6-3-1 Sarsa learning algorithm
  - 6-3-2 Q-learning learning algorithm
  - 6-3-3 Expected Sarsa learning algorithm
- 6-4- Evaluation methods of reinforcement learning algorithms

7- n- Step Temporal-Difference Learning and Eligibility Trace

- 7-1- n- Step bootstrapping methods
  - 7-1-1 n-Step TD prediction
  - 7-1-2 n-Step Sarsa learning algorithm
- 7-2- Eligibility trace
  - 7-2-1 TD(λ) prediction
  - 7-2-2 Sarsa (λ) learning algorithm

8- Advance Topics in Reinforcement Learning

- 8-1- Generalization in Reinforcement Learning
- 8-2- Deep Reinforcement Learning and DQN
- 8-3- Policy Gradient Methods
- 8-4- Actor-Critic Methods
- 8-5- Imitation Learning
- 8-6- Maximum Entropy Reinforcement Learning

Grading: 50% Final exam, 10% Homework, 40% Research Project by the Python

References:

1- Richard S. Sutton, Andrew G. Barto, “Reinforcement Learning: An Introduction”, second edition, MIT press, 2018.
2- Hao Dong, Zihan Ding, Shanghang Zhang, “Deep Reinforcement Learning, Fundamentals, Research and Applications, Springer, 2020.
3- Miugel Morales, “Grokking Deep Reinforcment Learning”, Manning Publications Co., 2022.
4- Aske Plaat, “Deep Reinforcement Learning”, Springer, 2022.
5- Ivan Gridin, “Practical Deep Reinforcement Learning with Python”, BPB online, 2022.
6- Maxim Lapan,”Deep Reinforcement Learning Hands-On”, Second edition, Packt, 2020.
7- Sudharsan Ravichandiran, “Hands on Reinforcement Learning with Python”, Packt publishing, 2018.
8- Andrea Lonza, “Reinforcement Learning Algorithms with Python”, Packt publishing, 2019.
9- Farrukh Akhtar, “Practical Reinforcement Learning, Develop Self Evolving, Intelligent Agents with Open AI Gym, Python and Java”, Packt publishing, 2017.
10- Mohit Sewak, “Deep Reinforcement Learning, Frontiers of Artificial intelligence”, Springer, 2019.
11- Teng Liu, “Reinforcement Learning- Enabled Intelligent Energy Management for Hybrid Electric Vehicles”, Morgan and Claypool, 2019.