

# ECEN 743: Reinforcement Learning

## Introduction



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# What is Reinforcement Learning?

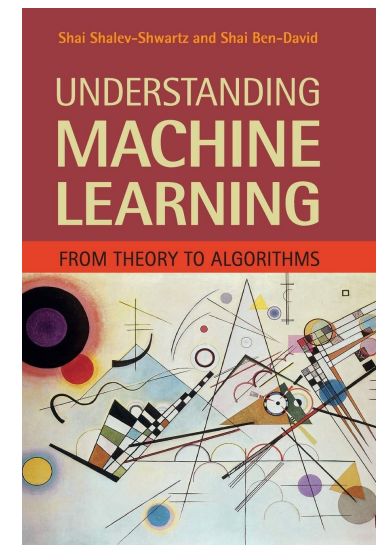
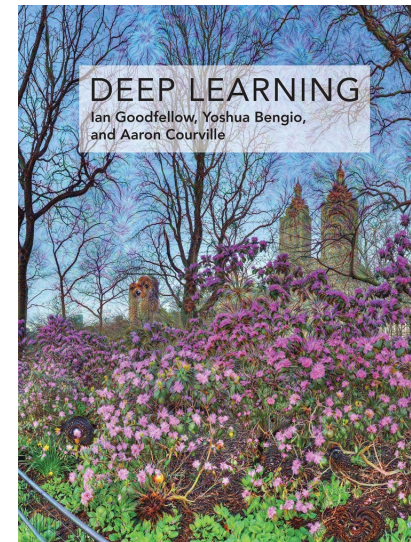
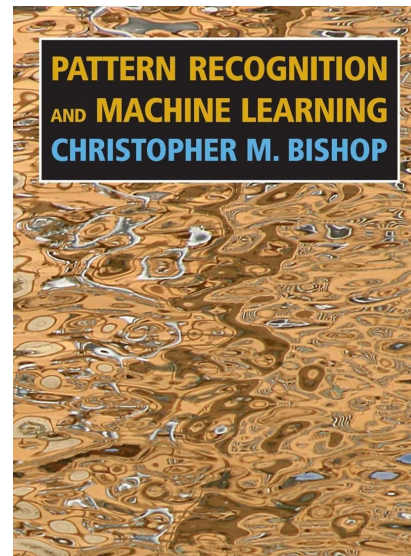
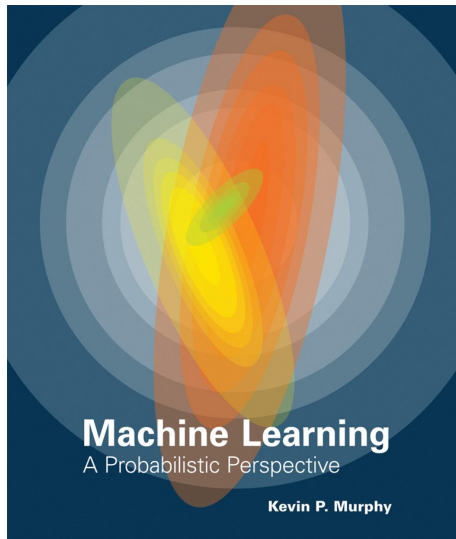
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[Murphy, 2012] Kevin Murphy, “Machine Learning, A Probabilistic Perspective”, MIT Press, 2012.

# Three Main Classes of Machine Learning

- Supervised learning
- Unsupervised learning
- Reinforcement learning

# Supervised Learning

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- Supervised learning is the class of machine learning where the goal is to learn a function that maps an input to an output based on example input-output pairs (labelled data)

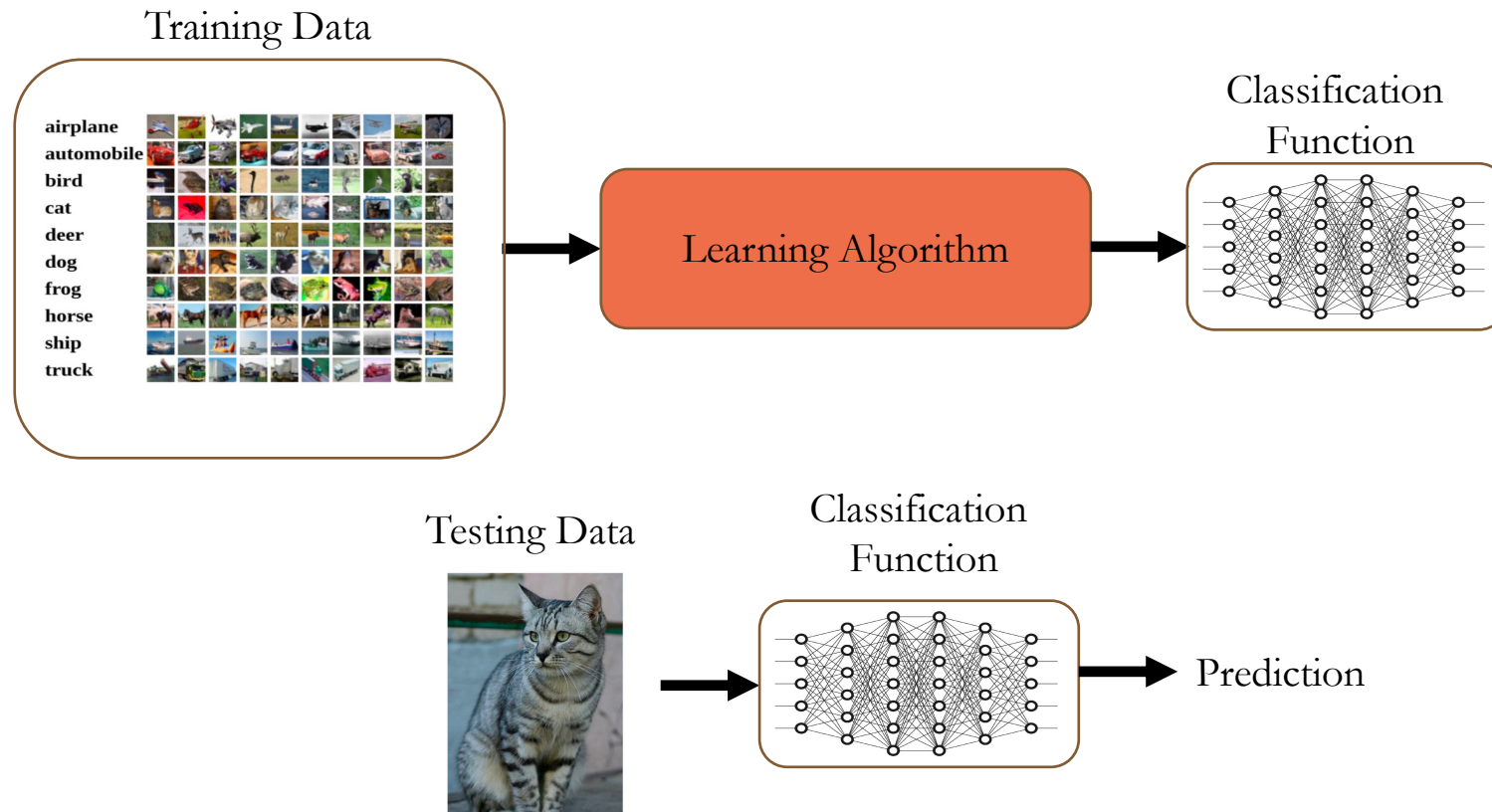


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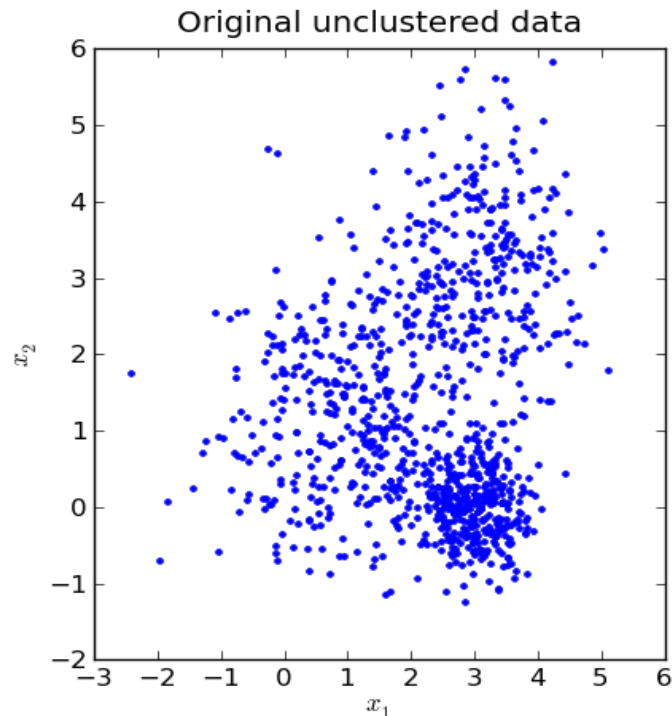
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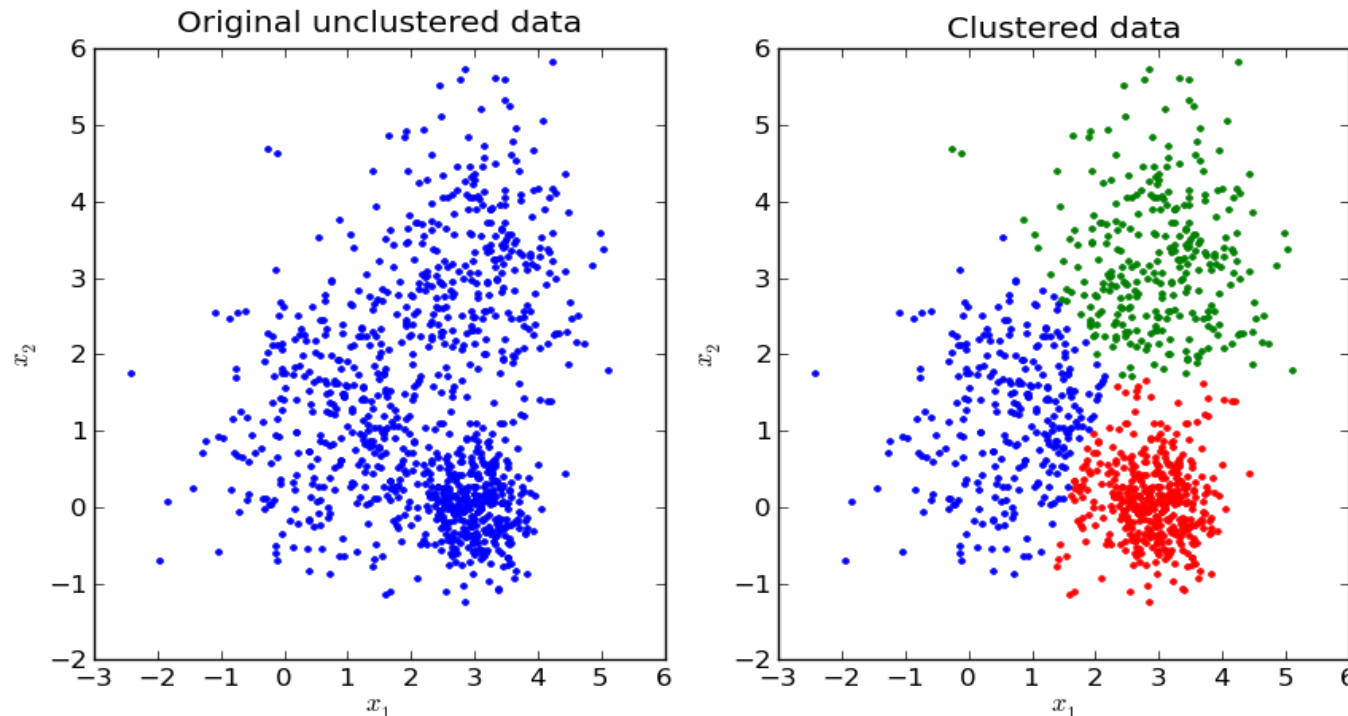
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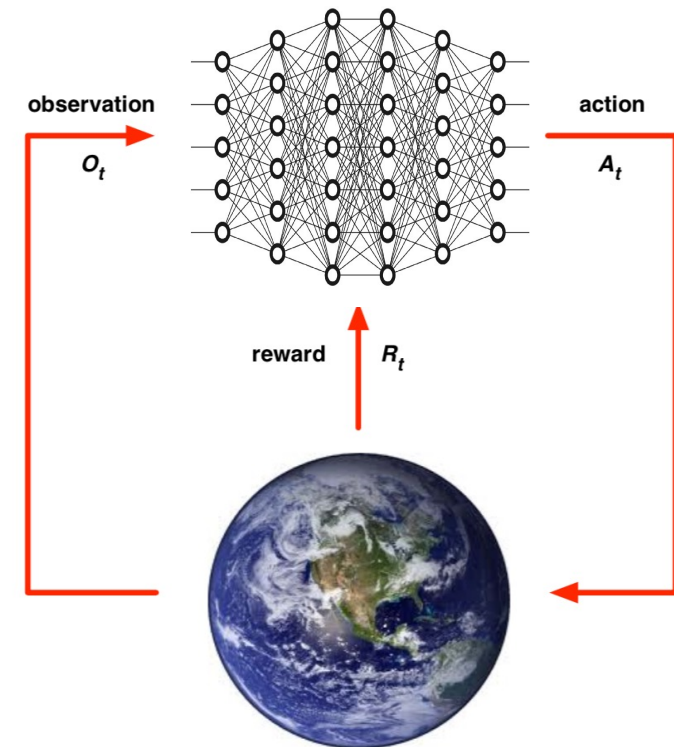
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- Agent and the environment:
  - At each time step  $t$ , the agent:
    - Gets an observation  $o_t$
    - Executes an action  $a_t$
    - Receives reward  $r_t$
  - The goal is to select the sequence of actions in order to maximize the cumulative reward

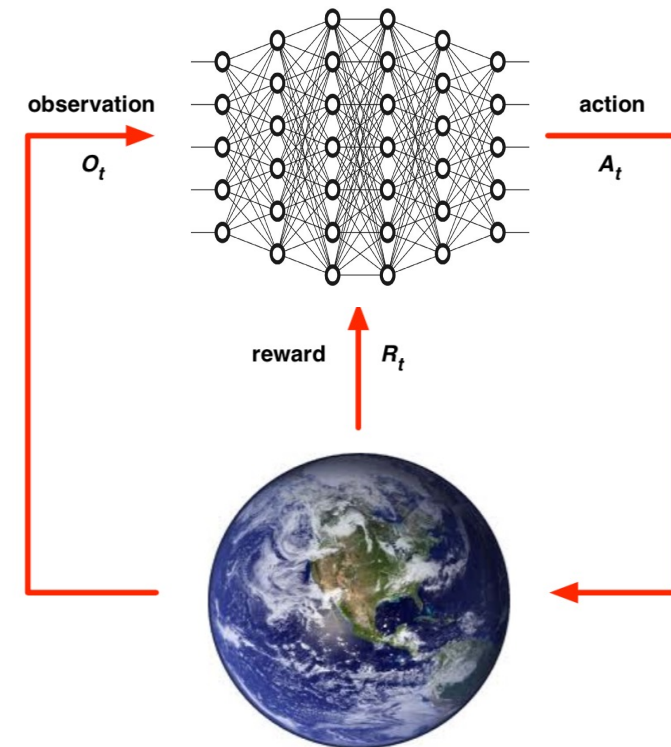


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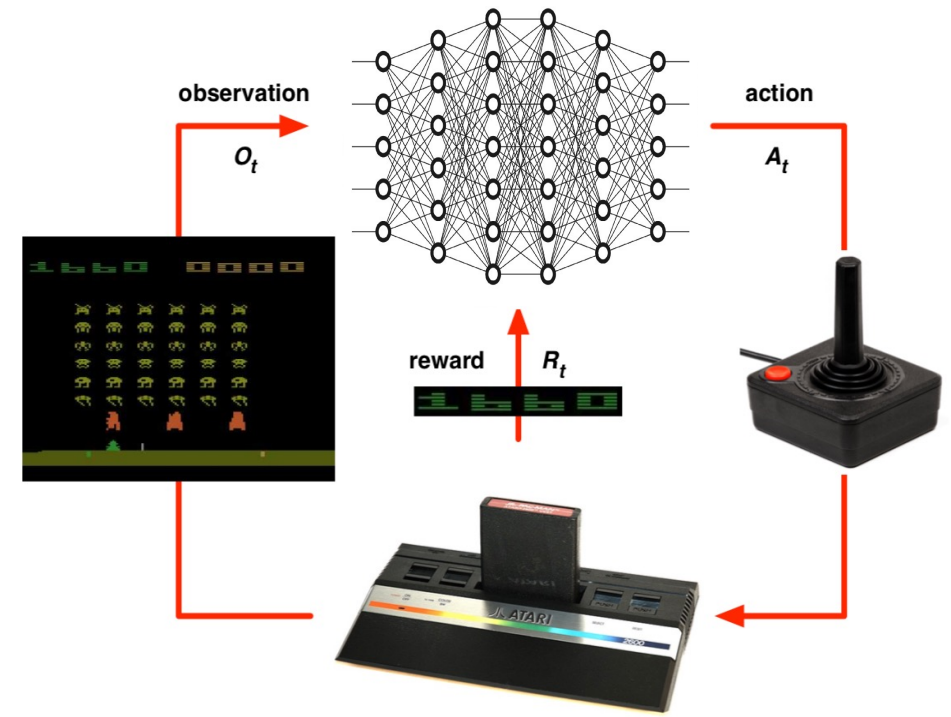
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  - The model of the environment is unknown
    - Rules of the game are unknown



# Reinforcement Learning: Challenges

- No prior data: RL agent (algorithm) generates data, by taking actions in an unknown environment
- Data generated is not i.i.d.
- No supervisor: optimal policy has to be learnt from the rewards observed in the self-generated data
- Actions have long term consequences, rewards are often delayed
- Dynamical systems issues: feedback and stability

# Reinforcement Learning: Examples

- RL for playing Atari Games (Mnih et al. “Human-level control through deep reinforcement learning”, Nature, 2015)

# Reinforcement Learning: Examples

- RL for playing Go (Silver et al. “Mastering the game of Go with deep neural networks and tree search”, Nature, 2016)

# Reinforcement Learning: Examples

- RL for robotics (Kumar et al. “RMA: Rapid Motor Adaptation for Legged Robots”, RSS, 2021)

# Reinforcement Learning: Examples

- RL for drone control (V. Saj, B. Lee, D. Kalathil, M. Benedict, “Robust Reinforcement Learning Algorithm for Vision-based Ship Landing of UAVs”, 2022)



# Reinforcement Learning: Examples

- YouTube video compression from DeepMind ([Link](#))
- Several application from Microsoft, including in Azure platform, recommendation systems, video streaming, robotics ([Link](#))
- Fast matrix multiplication algorithm from DeepMind ([Link](#))
- Optimizing and finetuning ChatGPT ([Link](#))
- Fast chip design algorithm from Google ([Link](#))
- Optimizing recommendation systems from Netflix ([Link](#))
- Optimizing recommendation systems from Google ([Link](#))
- Playing strategic games from Meta ([Link](#))

# Course Syllabus Overview