Introduction to Reinforcement Learning

w/ some applications to Energy

LEC 1b: Motivation and History

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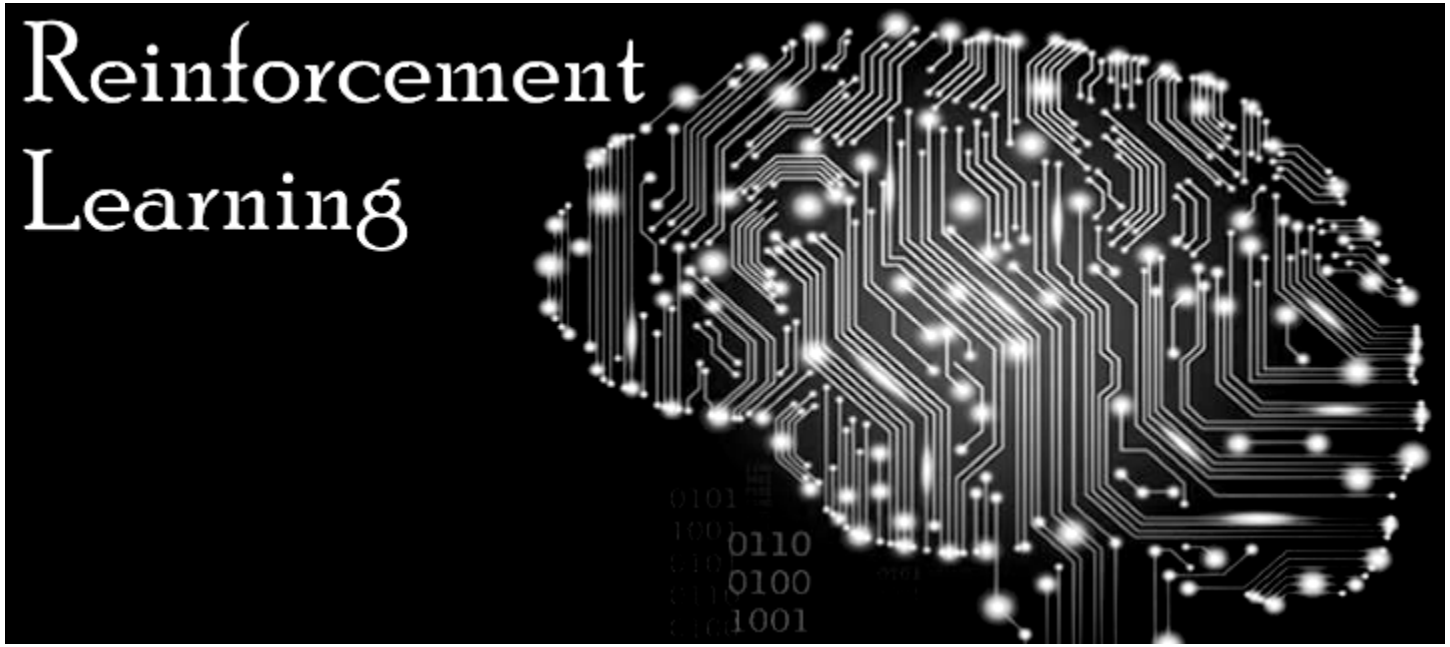
TA: Xinyi Zhao

Summer 2020



Motivation

What problems does RL solve?

Example 1: Moonshot

Optimality in Control Systems Design

R. Kalman 1960

Rocket Orbit Injection

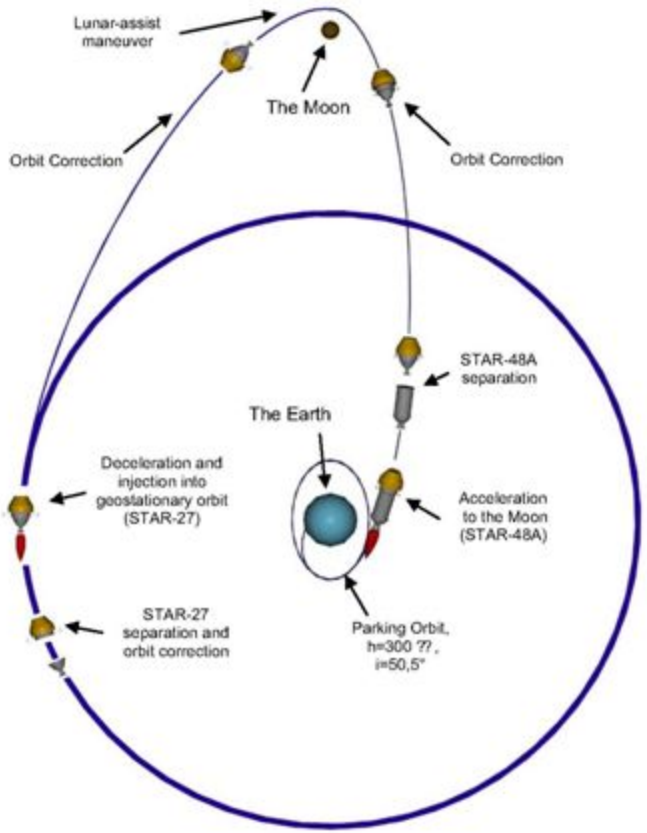


Fig. 1-1. Trajectory scheme

ISC Kosmotras Proprietary 9

http://microsat.sm.bmstu.ru/e-library/Launch/Dnepr_GEO.pdf

Dynamics

$$\dot{r} = w$$

$$\dot{w} = \frac{v^2}{r} - \frac{\mu}{r^2} + \frac{F}{m}\sin\phi$$

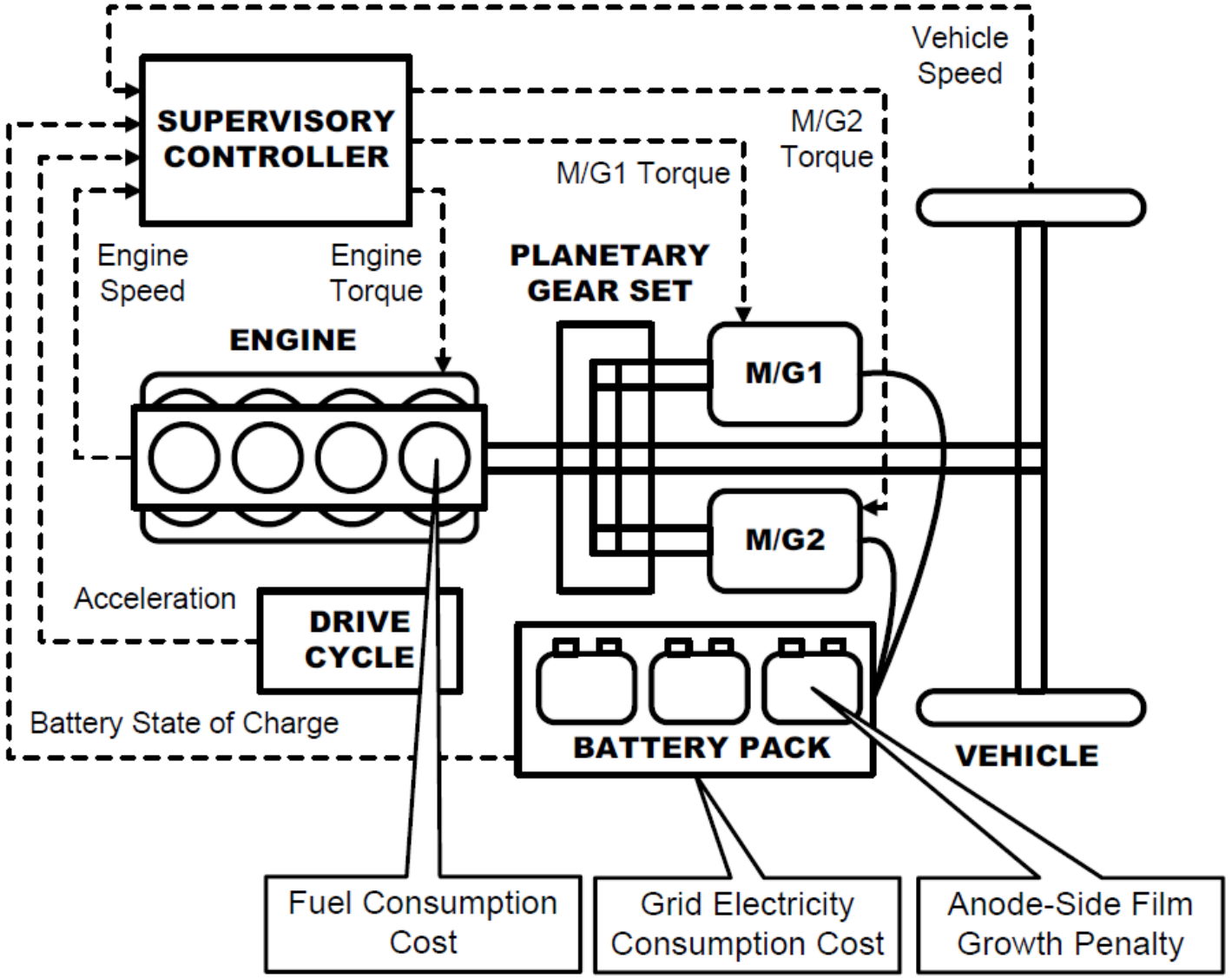
$$\dot{v} = \frac{-wv}{r} + \frac{F}{m}\cos\phi$$

$$\dot{m} = -Fm$$

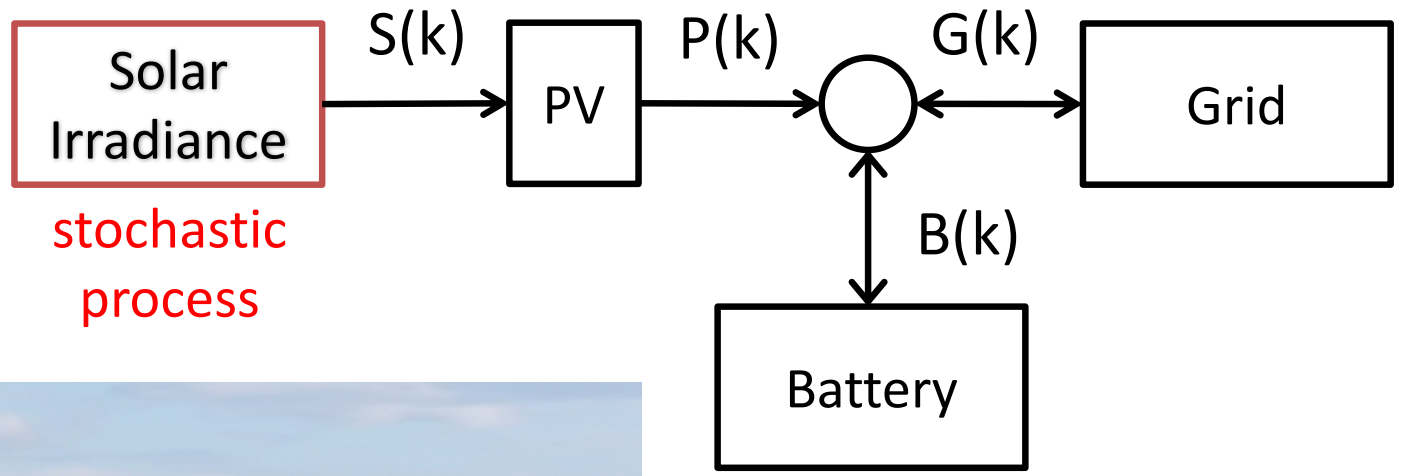
Objectives

- Get to orbit in minimum time
- Use minimum fuel

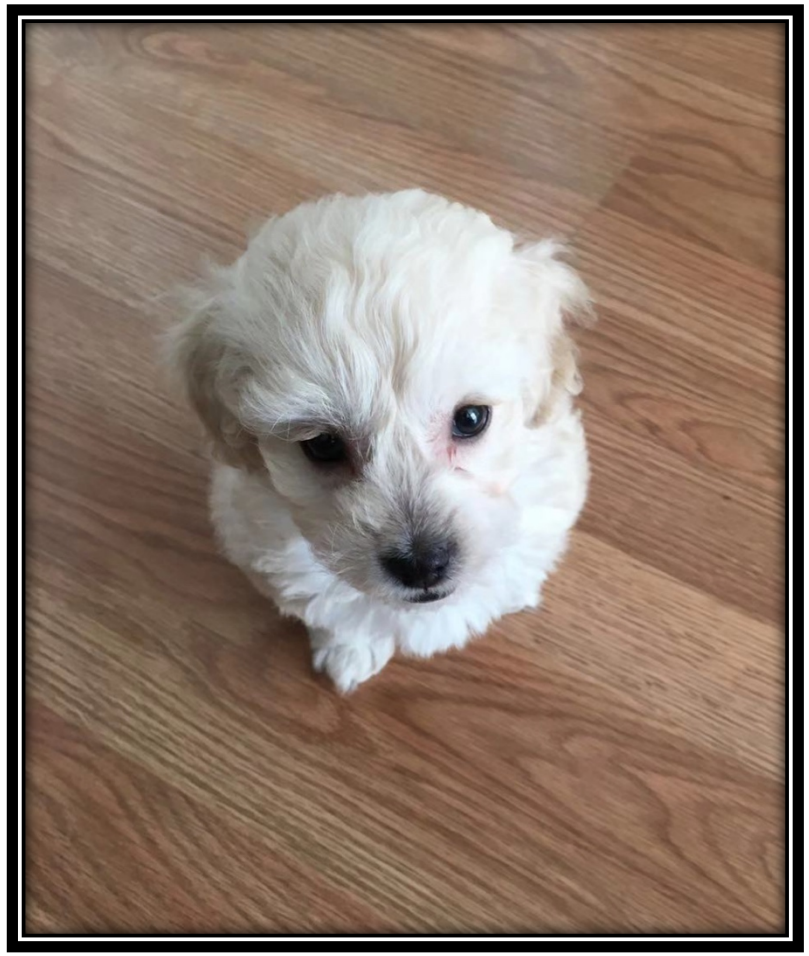
Example 2:
Hybrid Vehicle Energy Management



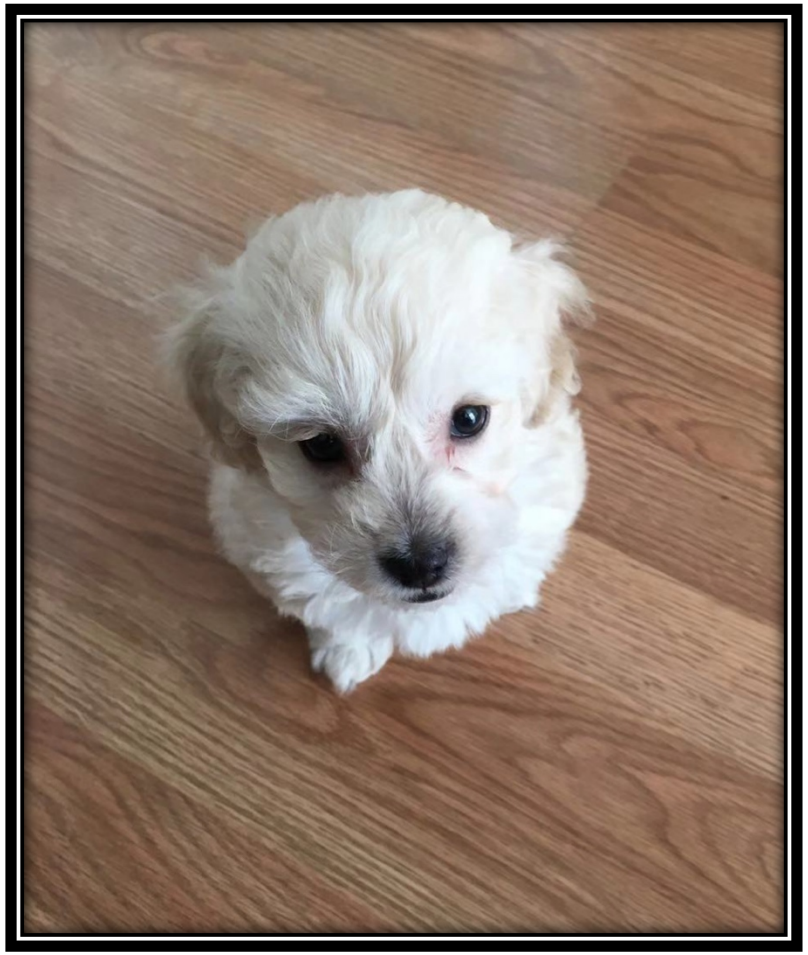
Example 3:
Clean Energy

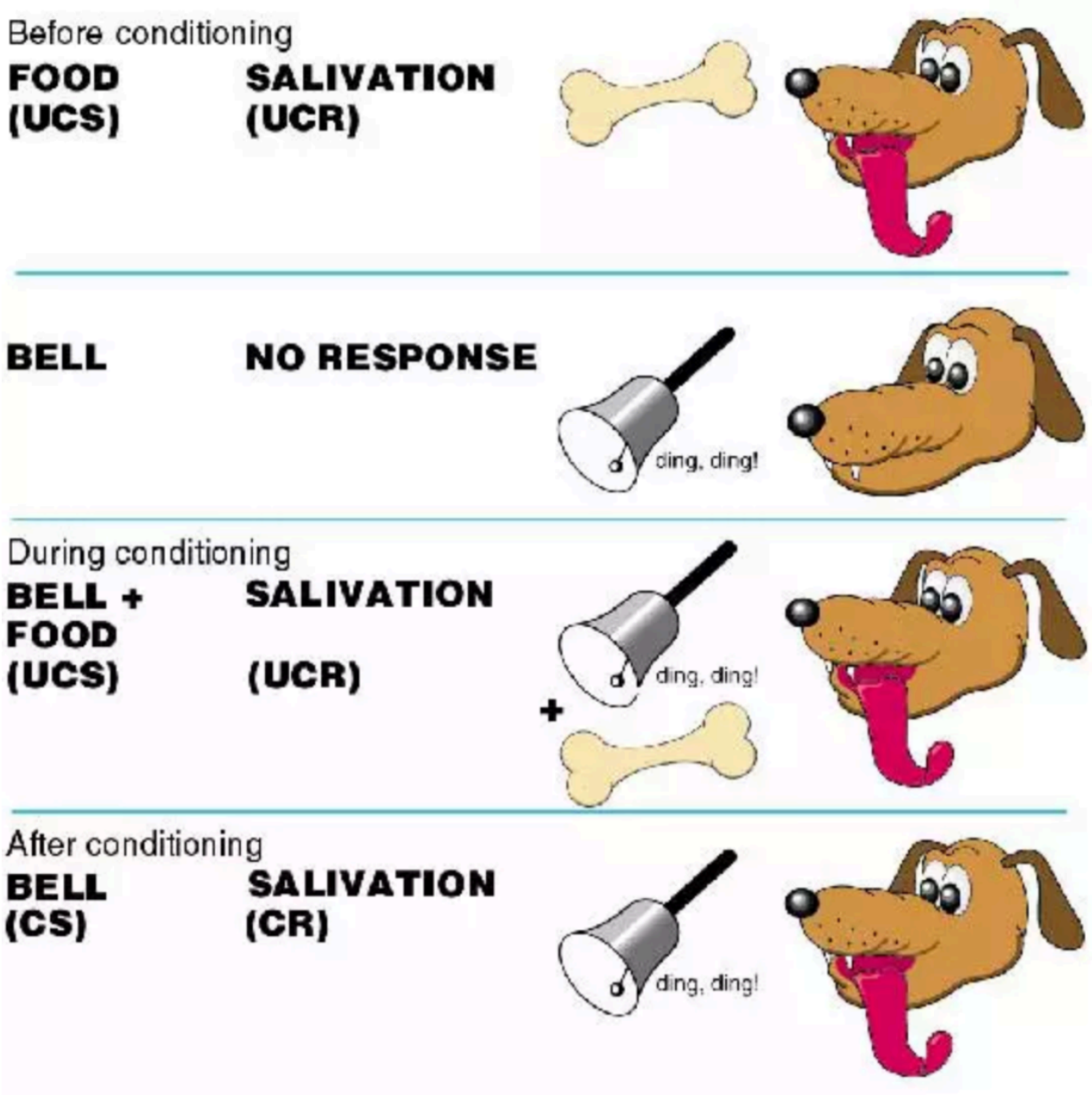


Example 4: My puppy *Juno*

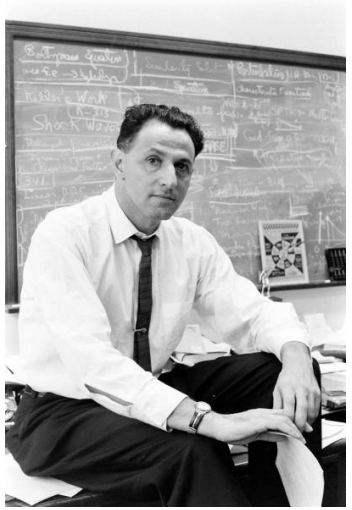


Short History – Ivan Pavlov (1890s)





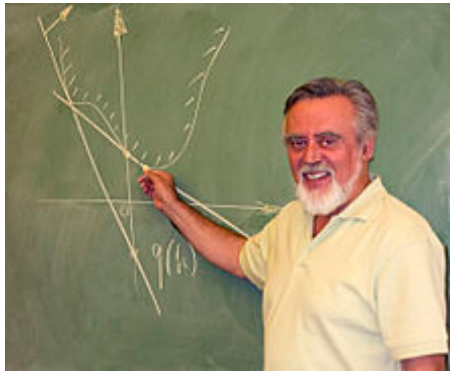
Short History – 20th Century



Richard Bellman – 1950s
Dynamic Programming
Markov Decision Processes
Optimal Control

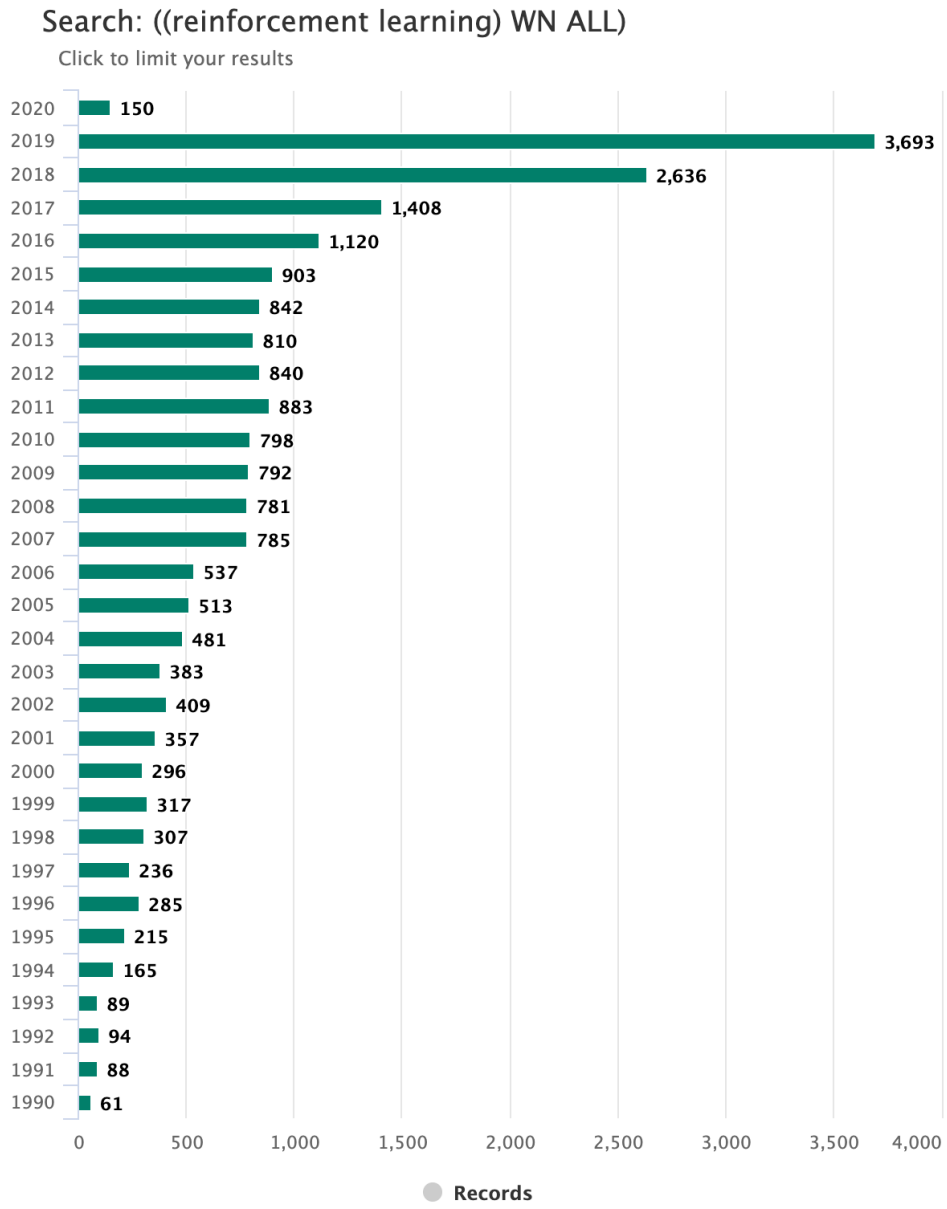
Chris Watkins – 1989
Q-learning

Paul Werbos – 1970s-1990s
PhD Thesis: Backpropagation
”Heuristic Dynamic Programming”

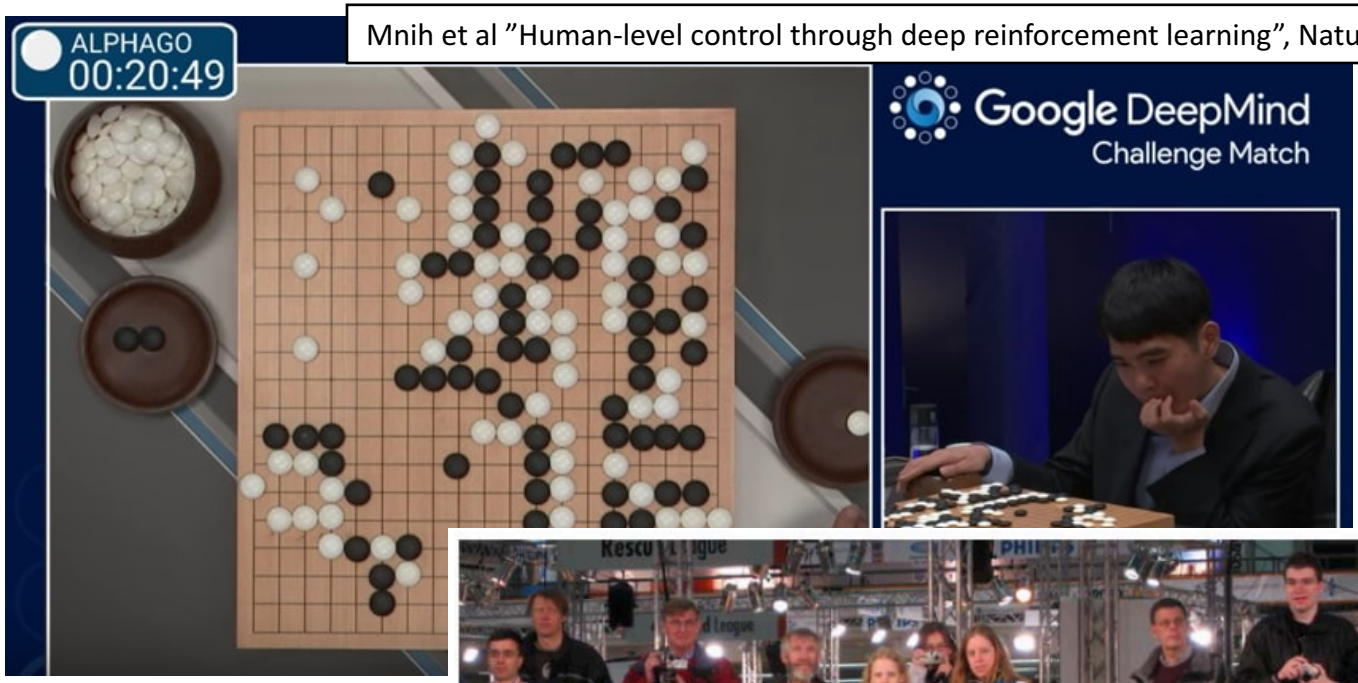


Dimitri Bertsekas – 1990s-2000s
Dynamic Programming
Neuro-dynamic programming

Recent History – 21st Century



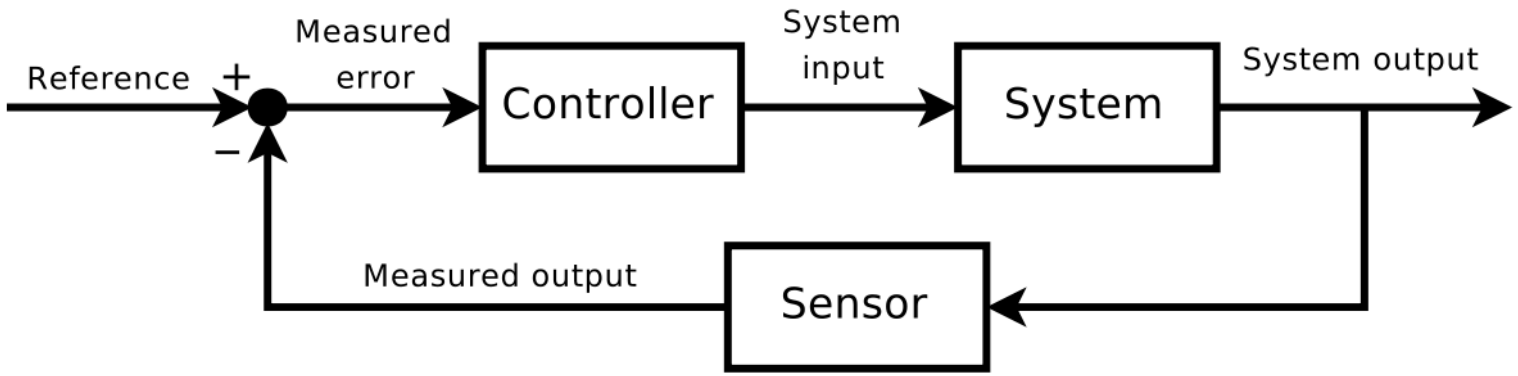
Mnih et al ”Human-level control through deep reinforcement learning”, Nature, 2015



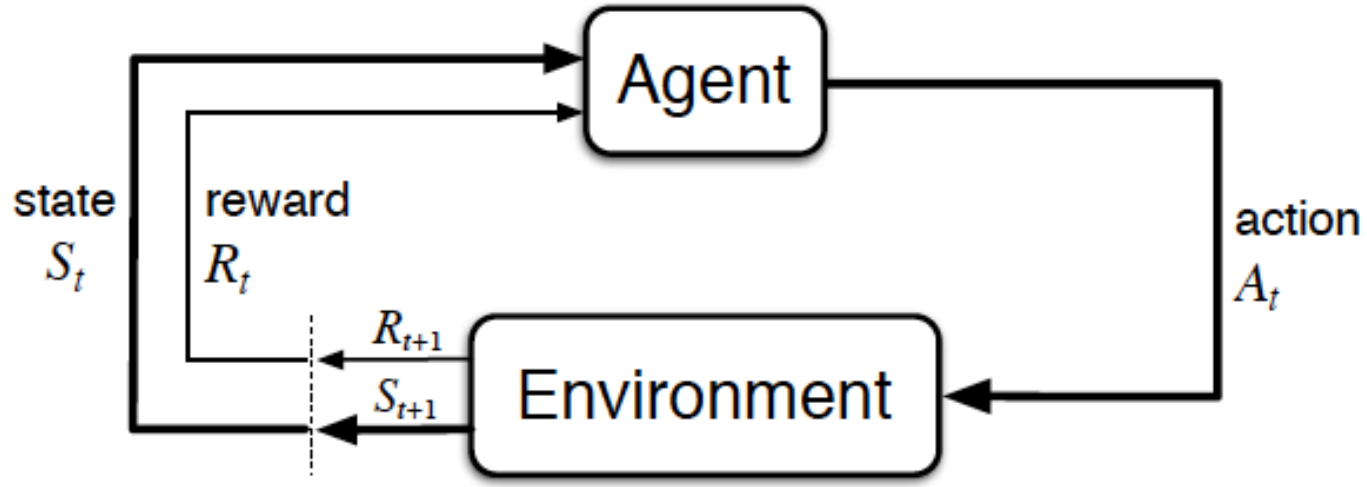
Reidmiller, Gabel, Hafner, Lange ”Reinforcement Learning for Robot Soccer”, 2009

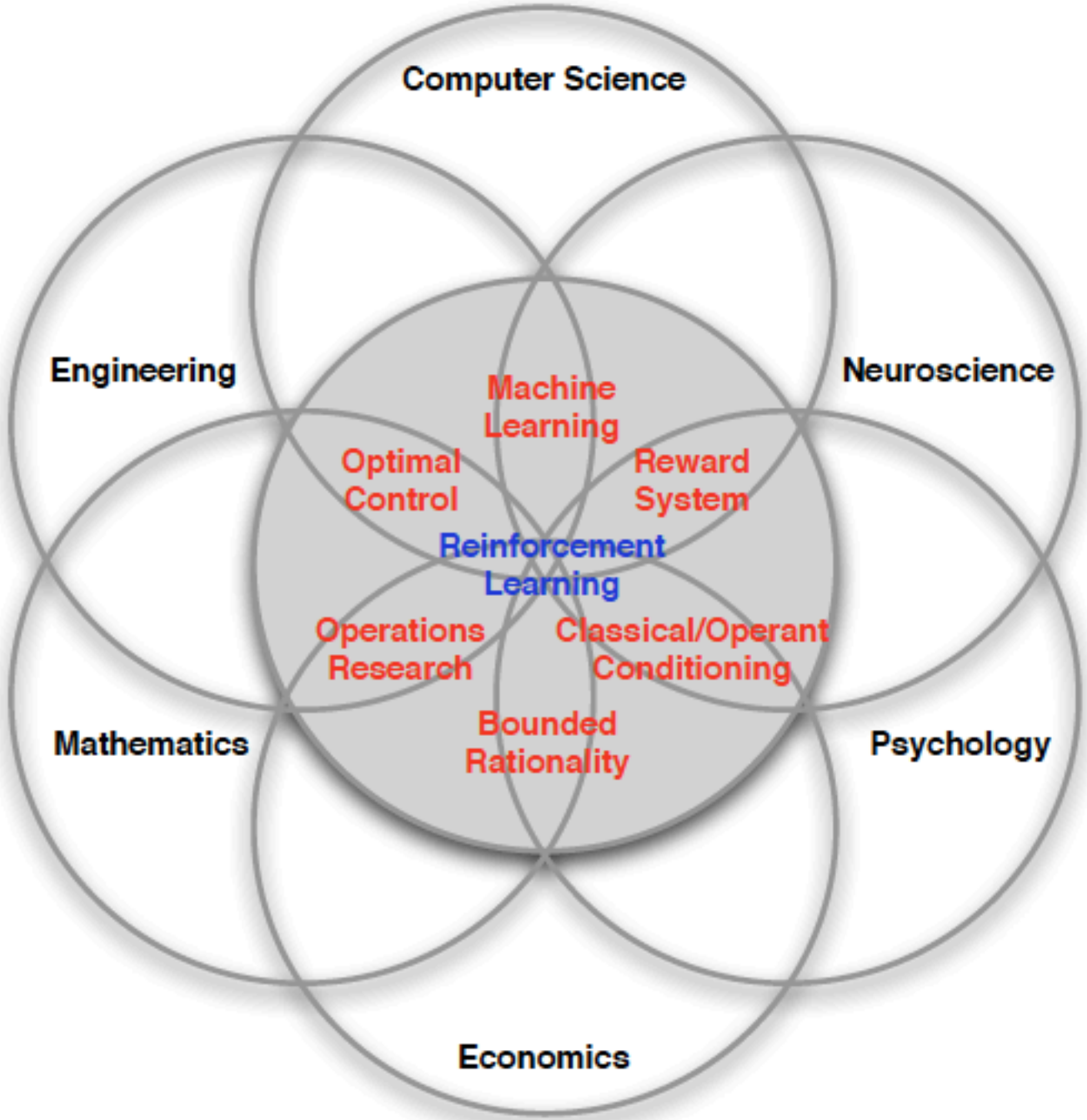
Problem Setup

Control Engineer view



Computer Science view




Computer Science
Engineering
Neuroscience
Machine Learning
Optimal Control
Reward System
Reinforcement Learning
Operations Research
Classical/Operant Conditioning
Bounded Rationality
Mathematics
Psychology
Economics

Key Characteristics of RL

- Dynamic system
- Reward/cost
- Learning