COMP34212 Lecture 1: Introduction to Cognitive Robotics and Cognitive Systems

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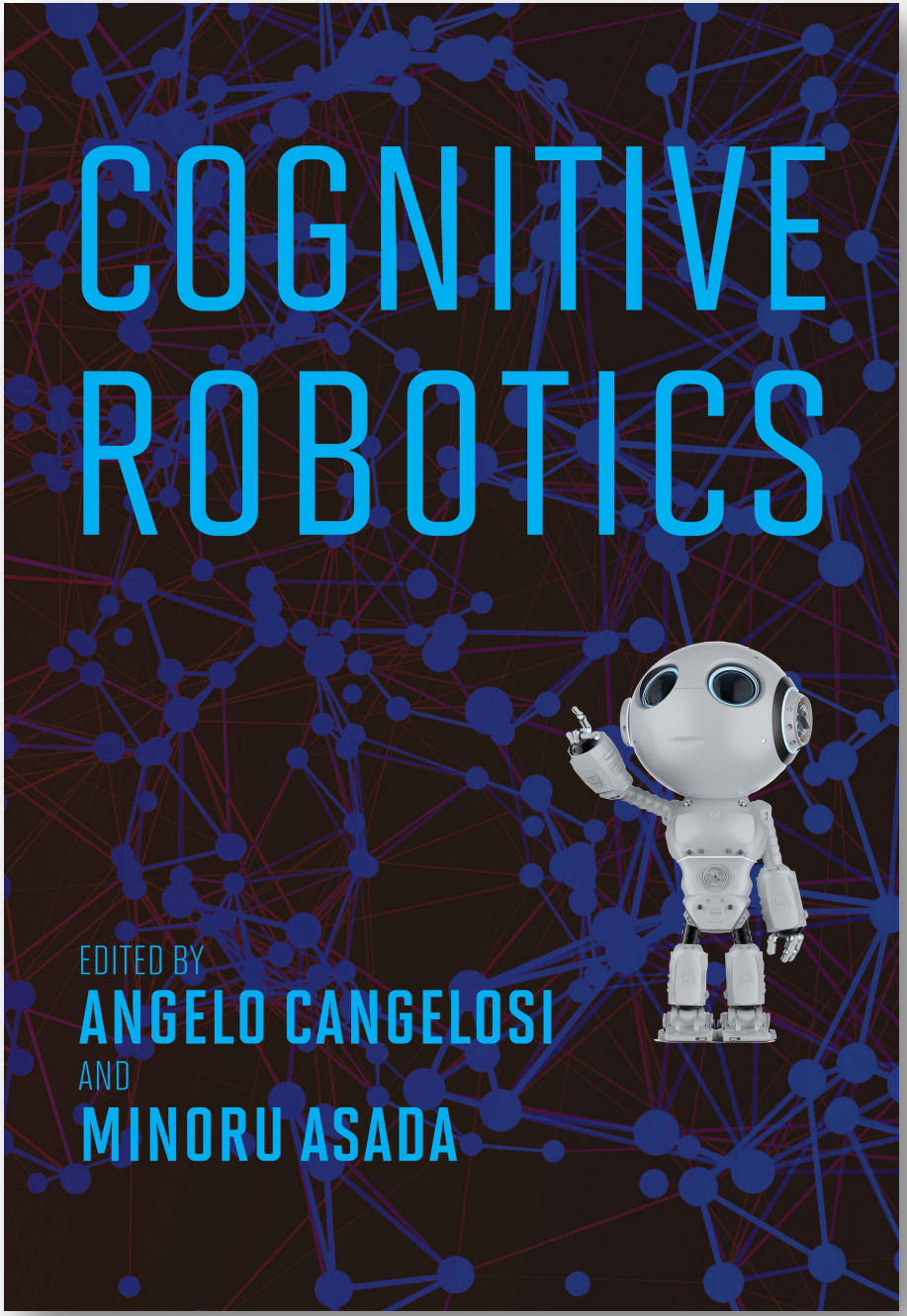
Content

- Definition and history
  - Cognitive Robotics
    - Artificial Cognitive Systems
  - Intelligent Robotics
- What is Cognition
- Modelling Cognitive Robots/Systems
  - Marr’s Abstraction Hierarchy

Definition

*Cognitive robotics is the field that combines insights and methods from **AI**, as well as **cognitive and biological sciences**, to **robotics***

Cangelosi & Asada, 2022



Open Access link (MIT Press Direct)

The MIT Press

Terminology

- **Cognitive Robotics**

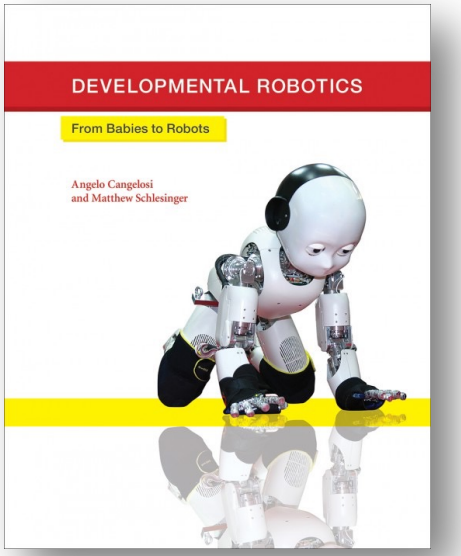
  The design of sensorimotor and cognitive capabilities in intelligent robots, taking direct inspiration from cognitive and biological sciences”

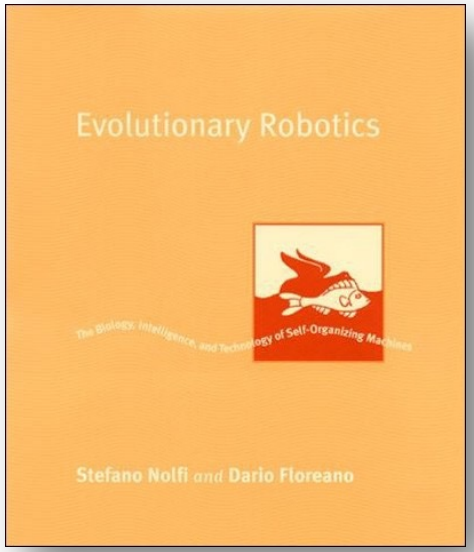
- **Artificial Cognitive Systems**
  - Modelling of simulated and embodied/robotic agents taking inspiration from natural and cognitive systems

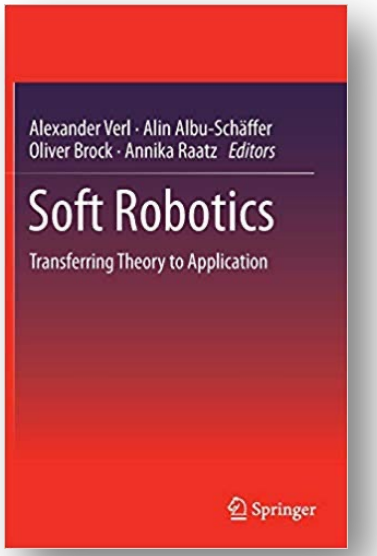
- **Intelligent Robotics** (Robotics and AI)
  - *Engineering* approach to the design of *intelligent* capabilities in robots using *any Artificial Intelligence* methods

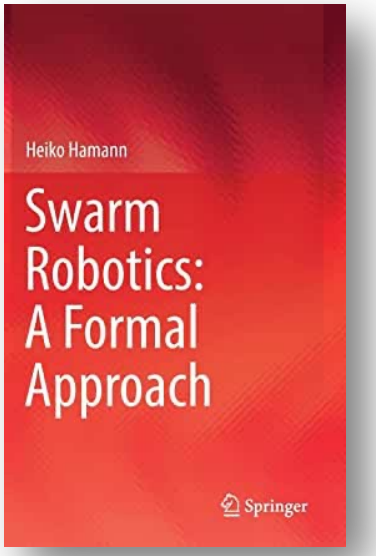
Terminology II

- Cognitive Robotics **Approaches**
  - Developmental Robotics (Cangelosi & Schlesinger 2015)
  - Evolutionary Robotics (Nolfi & Floreano 2002)
  - Swarm Robotics (Dorigo et al. 2014; Hamann 2018)
  - Soft Robotics (Laschi et al. 2016; Veri et al. 2015)









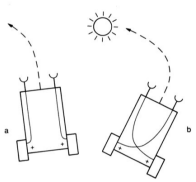
Concepts

- Principles and theories influencing CR
  - Embodied cognition theories (Wilson, Pfeifer, Barsalou)
  - AI and knowledge-based systems (Levesque & Reiter)
  - Behavior-Based Robotics (Brooks)
  - Synthetic methodologies (Walter's Tortoise, Braitenberg's Vehicles, Langton's Aartificial Life, Edelman's neurorobotics)

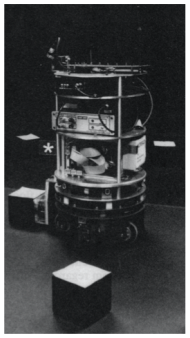
History

Tortoises

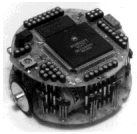
Shakey



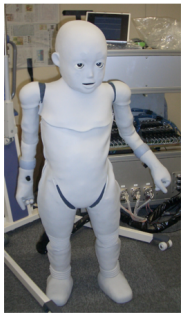
Vehicles



Darwin



Khepera



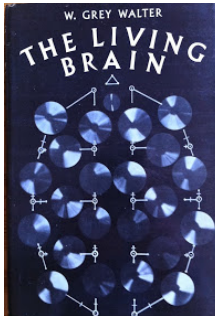
CB2

iCub

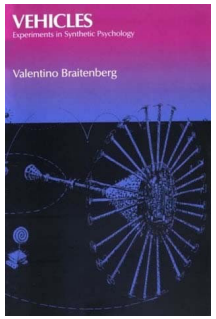
Octopus

1950 1966 1986 1992 1999 2007 2008 2015

1950 1960 1970 1980 1990 2000 2010 2020

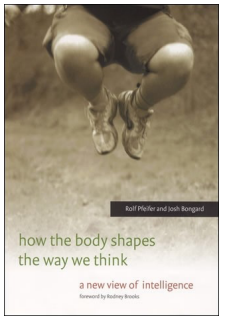


Walter
1953

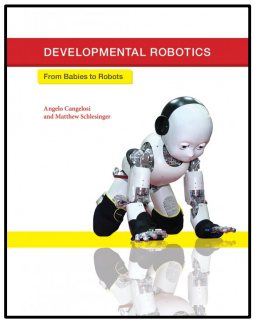


Braitemberg
1986

Di Giuseppe
1998



Pfeifer & Bongard
2007

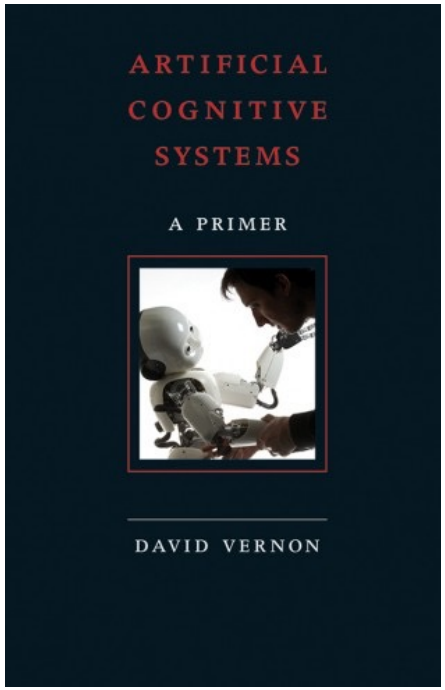


Cangelosi & Schlesinger
2015

History: Cognitive robots and books (from Cangelosi & Asada 2022)

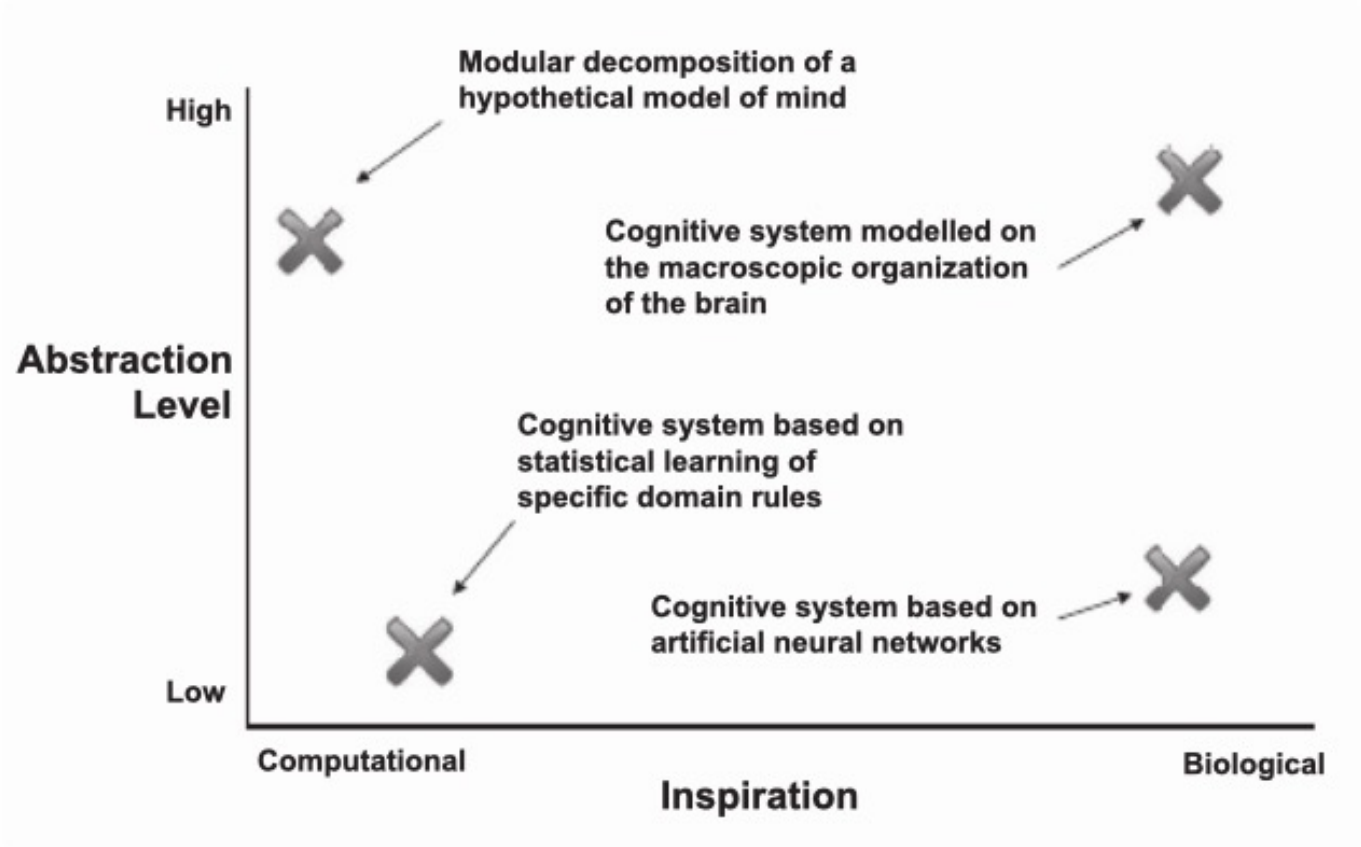
Modelling Cognitive Systems

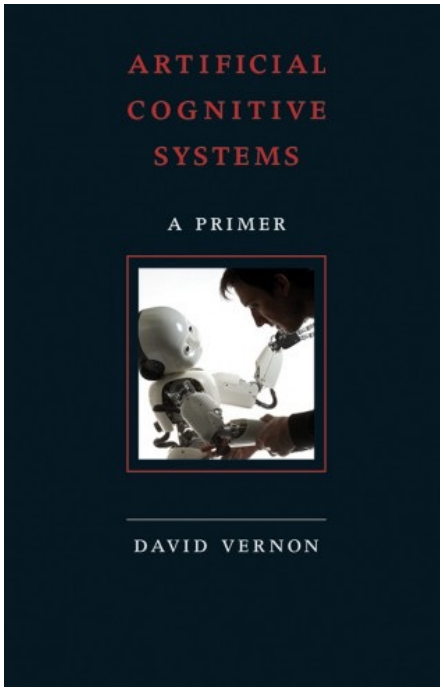
- Artificial Cognitive Systems
  - Modelling human- and animal-like capabilities in simulated/physical agents
  - Four criteria
    - **Computational / bio-inspired** spectrum
    - **Level of abstraction** in the biological model



Vernon D. (2014). *Artificial Cognitive Systems*: A Primer. MIT Press

Modelling Cognitive Systems





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What is Cognition?

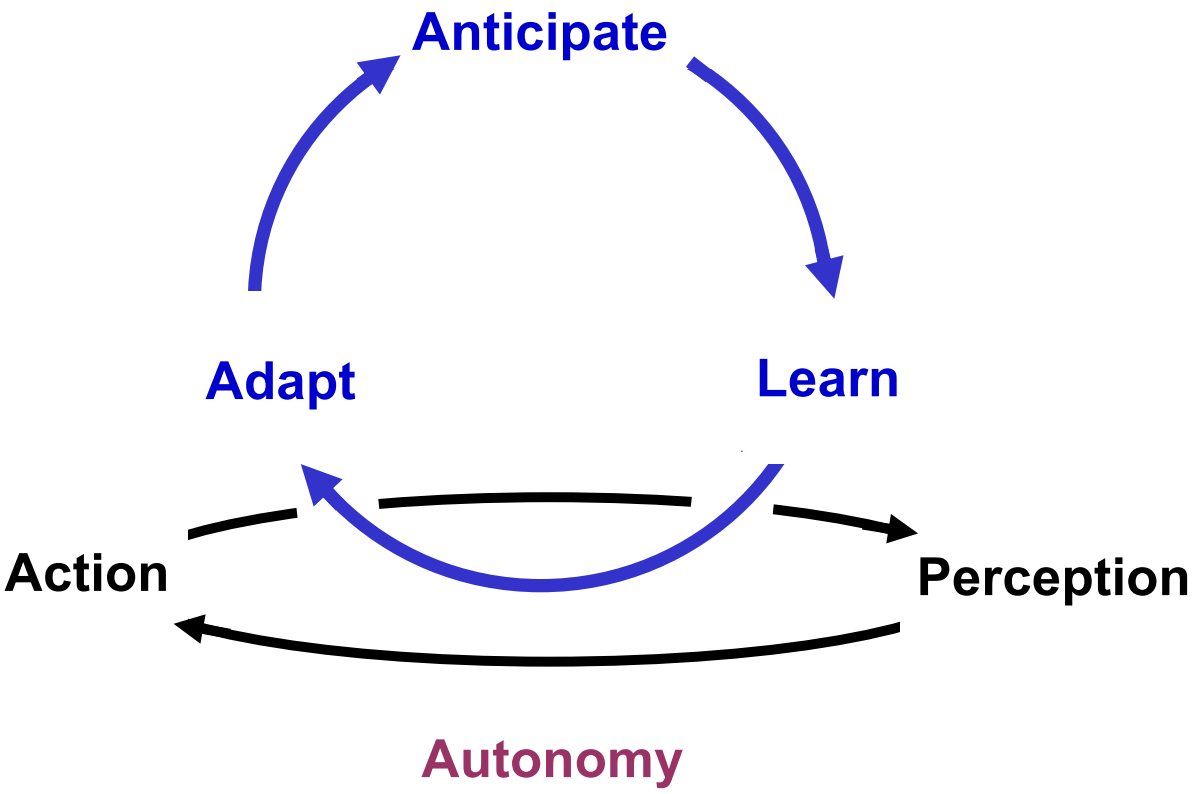
"*Cognition is the process by which an* ***autonomous*** *system* ***perceives*** *its environment,* ***learns*** *from experience,* ***anticipates*** *the outcome of events,* ***acts*** *to pursue goals, and* ***adapts*** *to changing circumstances*" (Vernon 2014)

But definitions of cognition can depend on

- **what** cognition is for and
- **how** cognition is realized in physical systems

Vernon D. (2014). *Artificial Cognitive Systems*: A Primer. MIT Press

What is Cognition?



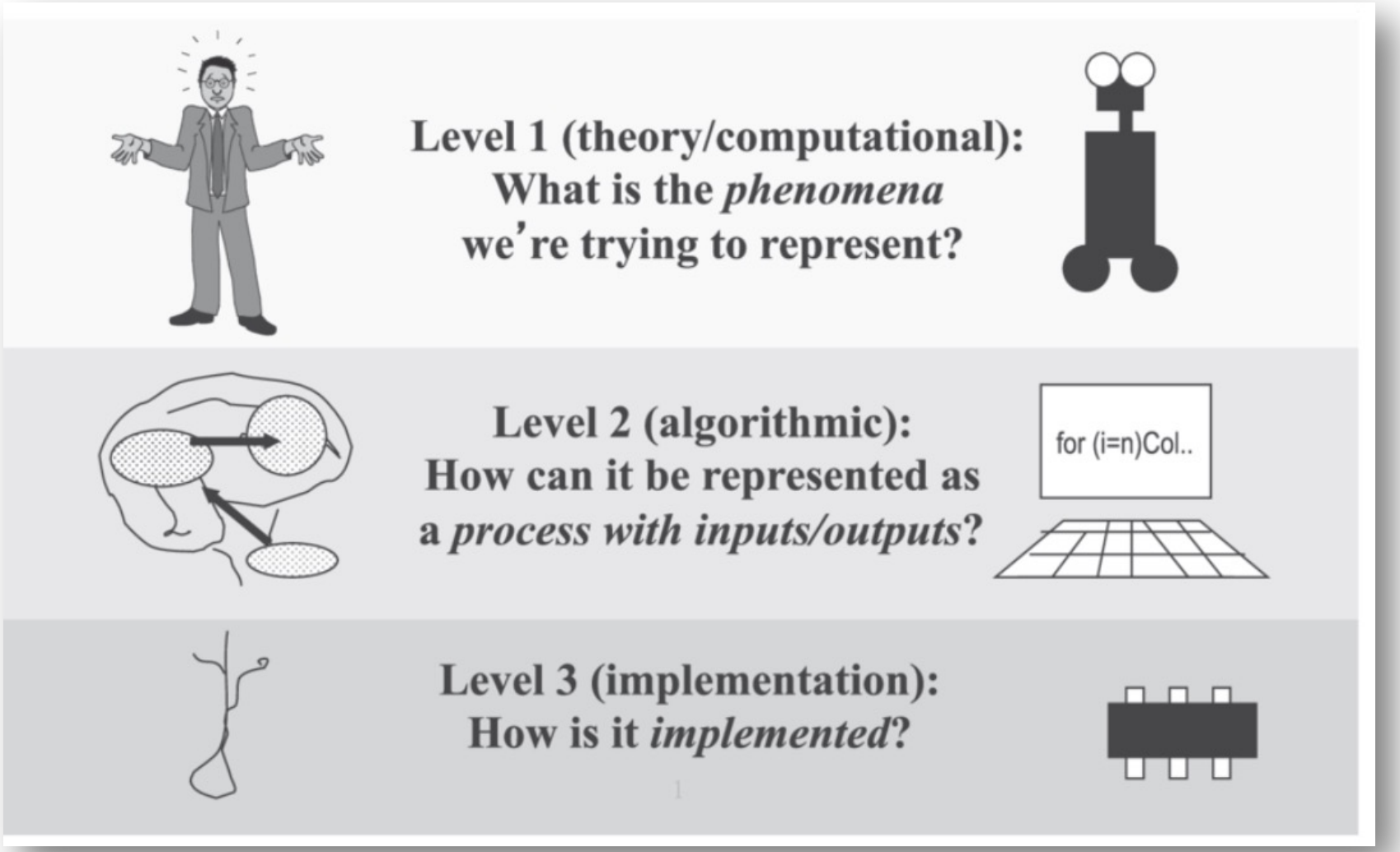
Cognition as cycle of anticipation

Vernon D. (2014). *Artificial Cognitive Systems*: A Primer. MIT Press

Marr's Levels of Abstraction

- A theoretical/computational model is an abstraction of a real system
- Marr's Levels of Abstraction (Marr 1982)
  - From computer vision to cognitive systems
  - Levels of analysis and understanding of a system
  - Hierarchical and sequential levels
    1. Computational / theory
    2. Representation / algorithmic
    3. Implementation

Marr's Abstraction Hierarchy



From Murphy 2019

Summary and Reading

- Definition and history
  - Cognitive Robotics vs. Intelligent Robotics
- What is cognition
- Modelling Cognitive Robots/Systems
  - Marr's Abstraction Hierarchy

- **Reading**
  - Chapter 1 of Cangelosi & Asada (2022), Cognitive Robotics, MIT Press
  - (optional) *Vernon D (2014). Artificial Cognitive Systems. MIT Press. Chapter 1 in Google books