Artificial Cognitive Systems

Module 6: Development and Learning

Lecture 2: Development vs. learning; phylogeny vs. ontogeny

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Development vs. Learning

Development

A process which an agent undergoes to

Expand its repertoire of possible actions (building on existing abilities)

Extend the time horizon of its capacity for prospection:

the ability to anticipate (a) events and (b) the need to act

Development vs. Learning

Development

Non-monotonic:

To discover new ways of doing things

(a) inhibit existing abilities

(b) allow for (or cause) changes in the physical structure of the agent

Development vs. Learning

Learning

a process for estimating or improving the parameter values that govern the behaviour of a known model

Development

a process for generating or discovering the model itself

requires two-way interaction between agent and world: structural coupling

Learning

1. Supervised

   Teaching signals are directional error signals

2. Reinforcement

   Teaching signals are scalar reward or reinforcement signals

   (maximize the cumulative sum of rewards over time)

3. Unsupervised

   No teaching signals

   (uncover statistical regularities)

Learning

4. Self-Supervised

- A form of unsupervised learning where the data provides the supervision
- In general, withhold some part of the data, and task the network with predicting it
- The task defines a proxy loss, and the network is forced to learn what we really care about,
  e.g. a semantic representation, in order to solve it

from (Zisserman 2018)

https://project.inria.fr/paiss/files/2018/07/zisserman-self-supervised.pdf

Learning

- Supervised: Cerebellum

  Internal models of the environment
  Short-cut models of input-output associations learned elsewhere

- Reinforcement: Basal Ganglia

  Evaluate given state;
  Select action

- Unsupervised: Cerebral Cortex

  Represent external state & internal context;
  Provide common representational framework for Cerebellum and BG

(Doya 1999)

Learning

- Hippocampus – Cortex Complementary Learning
- Hippocampus: rapid auto- and hetero-associative learning
- Hippocampus reinstates neo-cortex memories

(McClelland et al. 1995)

Phylogeny
(Cognitive Architecture)

Ontogeny
(Learning & Development + Motivations)

Drives
Value System

(Merrick 2017)

Phylogeny vs. Ontogeny

What is the minimal architecture required to configure a cognitive system & enable it to boot-strap cognitive development?

Cognitivist stance:

- Balance between ‘pre-knowledge’ and acquirable knowledge
- What do you need to know in order to learn?

Phylogeny vs. Ontogeny

What is the minimal architecture required to configure a cognitive system & enable it to boot-strap cognitive development?

Emergent stance

- Balance between phylogeny and ontogeny
- Phylogeny

  Evolution of the system configuration from generation to generation

- Ontogeny

  Adaptation, development, and learning of the system during its lifetime

Reading

Vernon, D. Artificial Cognitive Systems – A Primer, MIT Press, 2014, Chapter 6

Hsu, J. "Will the Future of AI Learning Depend More on Nature or Nurture?"
https://spectrum.ieee.org/tech-talk/robotics/artificial-intelligence/ai-and-psychology-researchers-debate-the-future-of-deep-learning

Further Reading

A. Zisserman, Self-supervised Learning, 2018.

https://project.inria.fr/paiss/files/2018/07/zisserman-self-supervised.pdf

Yann LeCun Cake Analogy 2.0

https://medium.com/syncedreview/yann-lecun-cake-analogy-2-0-a361da560dae