Efficient Control Synthesis and Learning in Distributed Cyber-Physical Systems

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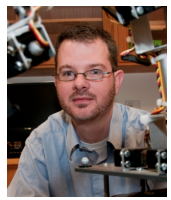
University of Delaware & Boston University

October, 2013

Contributions

University of Delaware

Contributors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- Discrete abstractions
- Grammatical inference

Fu, Tanner, Heinz, & Chandlee, IEEE TAC, 2014

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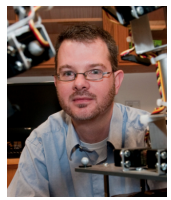
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Building Bridges

Linguistics

- alphabets & strings
- grammars
- inference

Hybrid systems

- dynamics
- automata & languages
- logics

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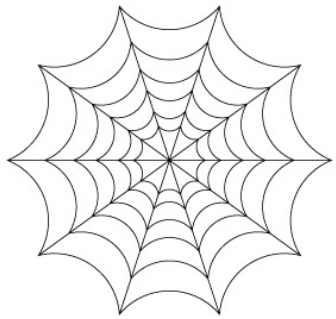

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Common threads

Latin Liquid Dissimilation

a.	nav-alis	'naval'
b.	episcop-alis	'episcopal'
c.	sol-aris	'solar'
d.	lun-aris	'lunar'
e.	flor-alis	'floral'
f.	litor-alis	'of the shore'

✓ . . . l . . . r . . . l . . .

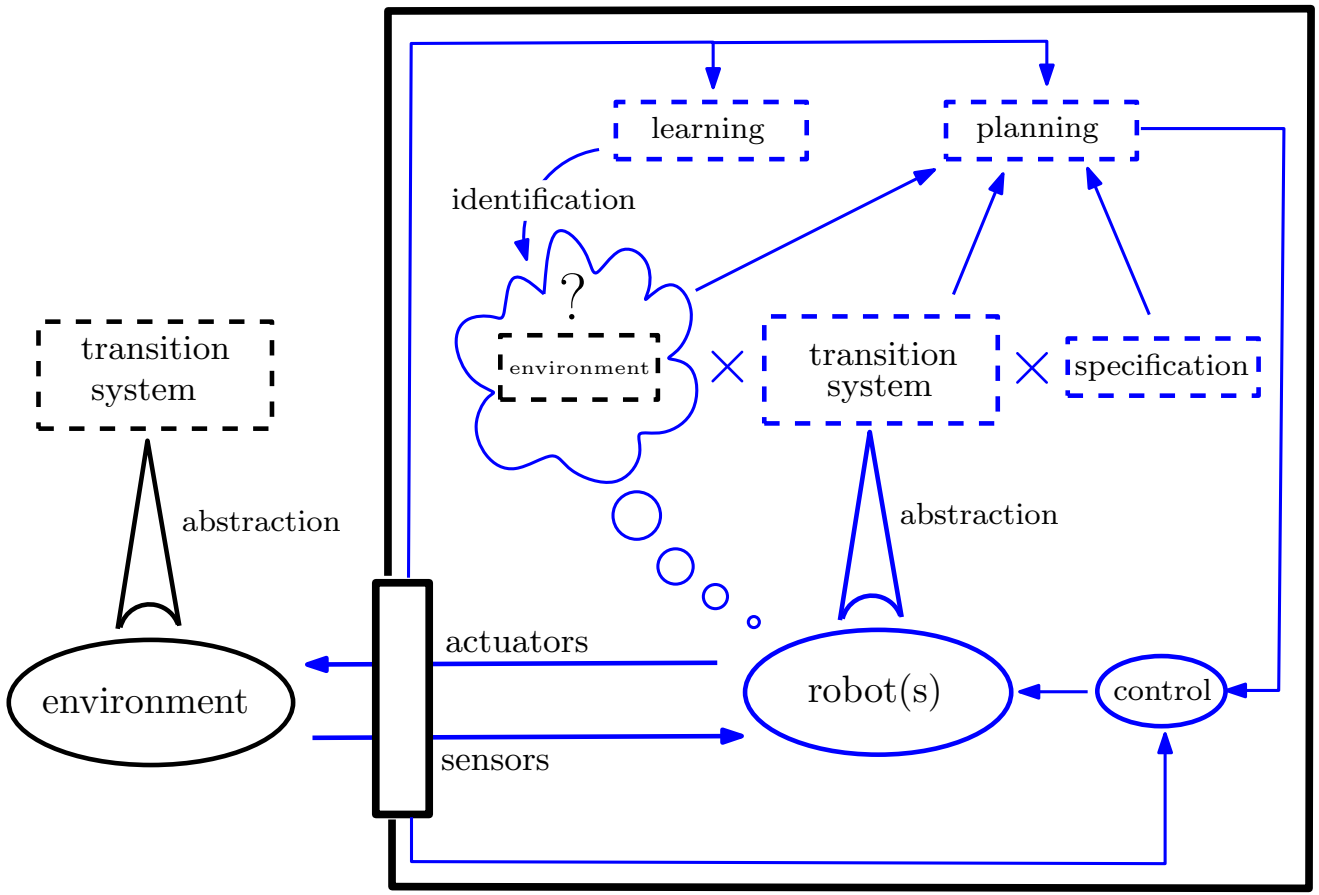
✗ . . . l . . . r . . . r . . .

Robot maneuvers	
a	base from point A to point B
b	pick an object
c	place an object

✓ a b a c a a b a

✗ a b a b a a c a

The Big Picture



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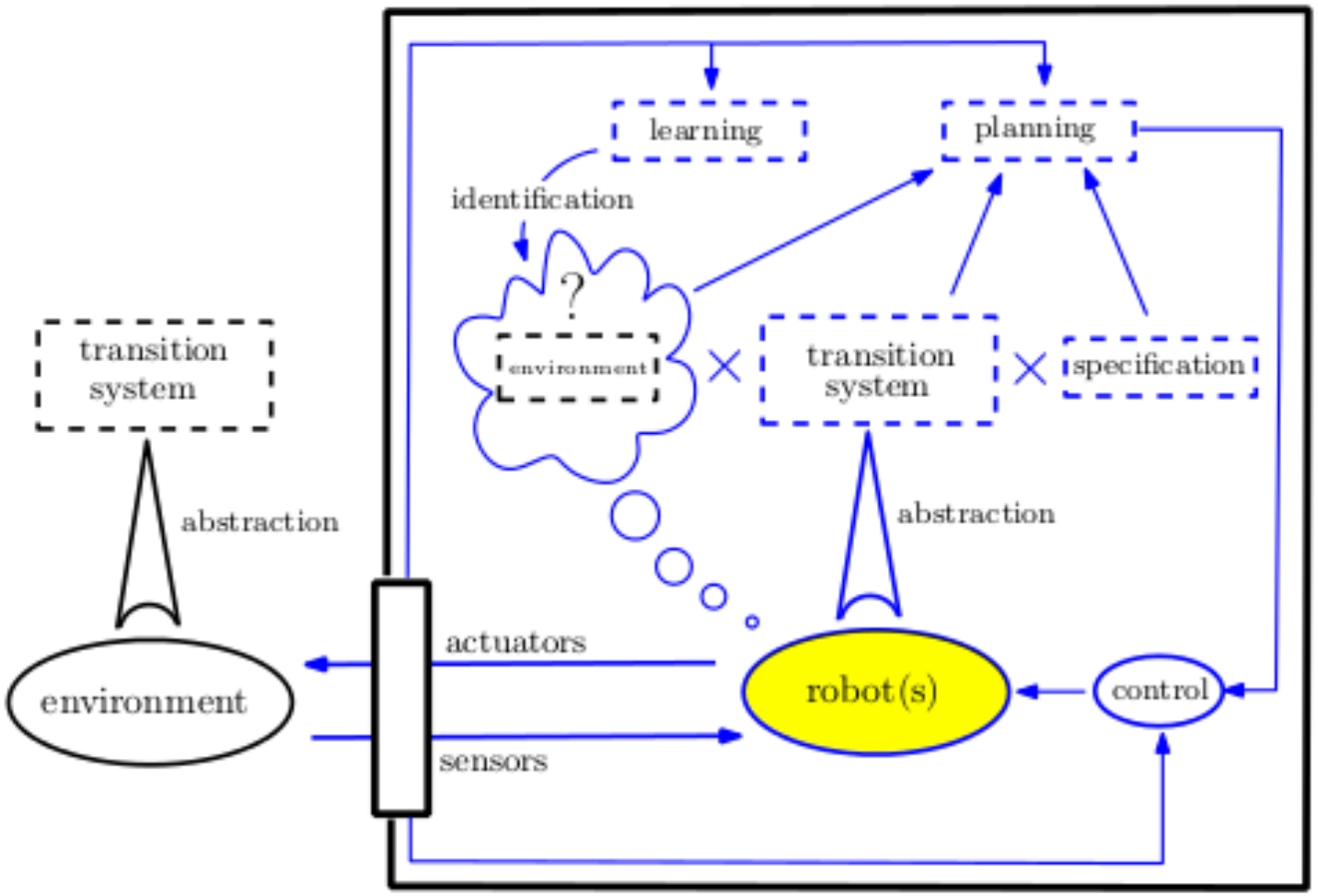

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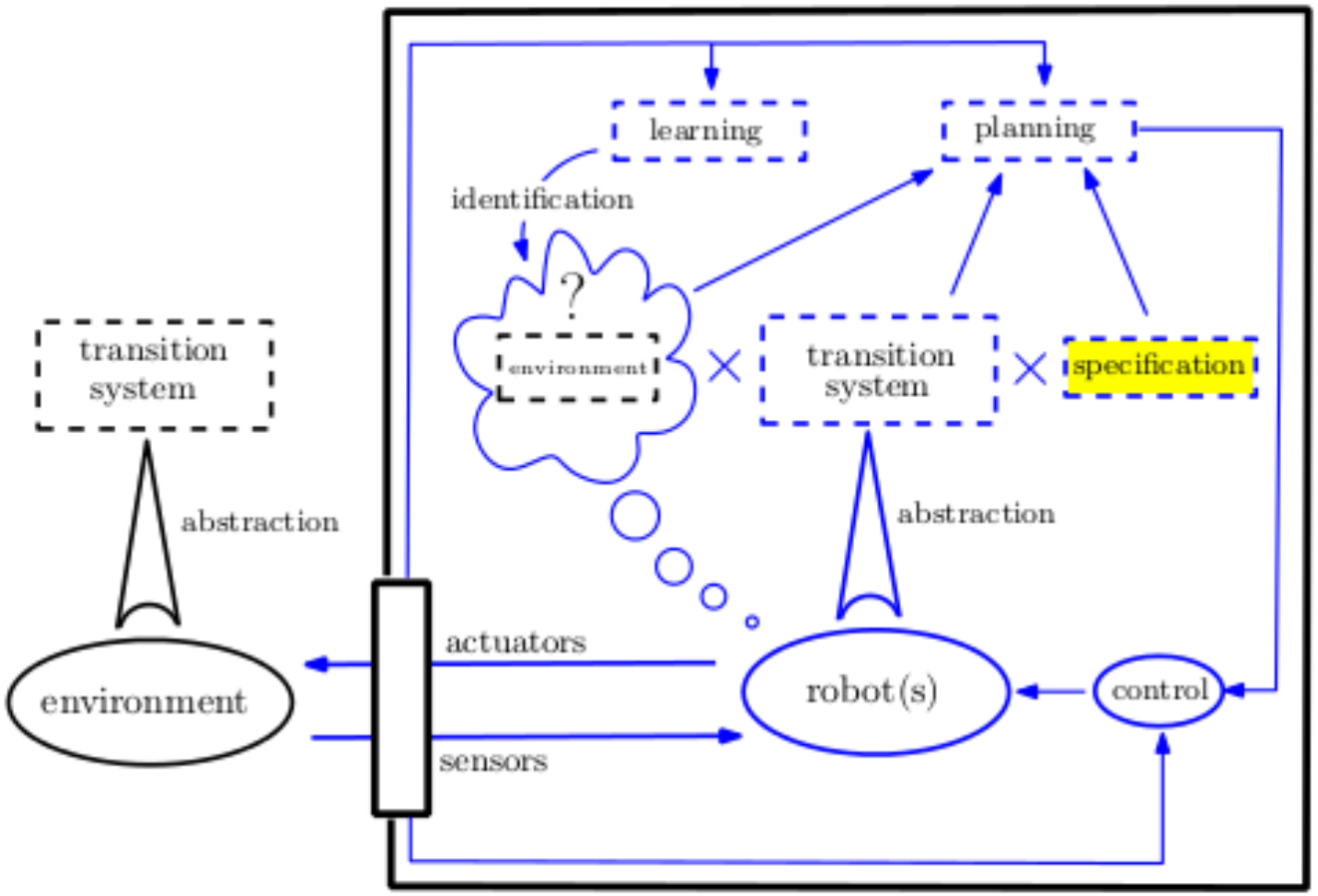

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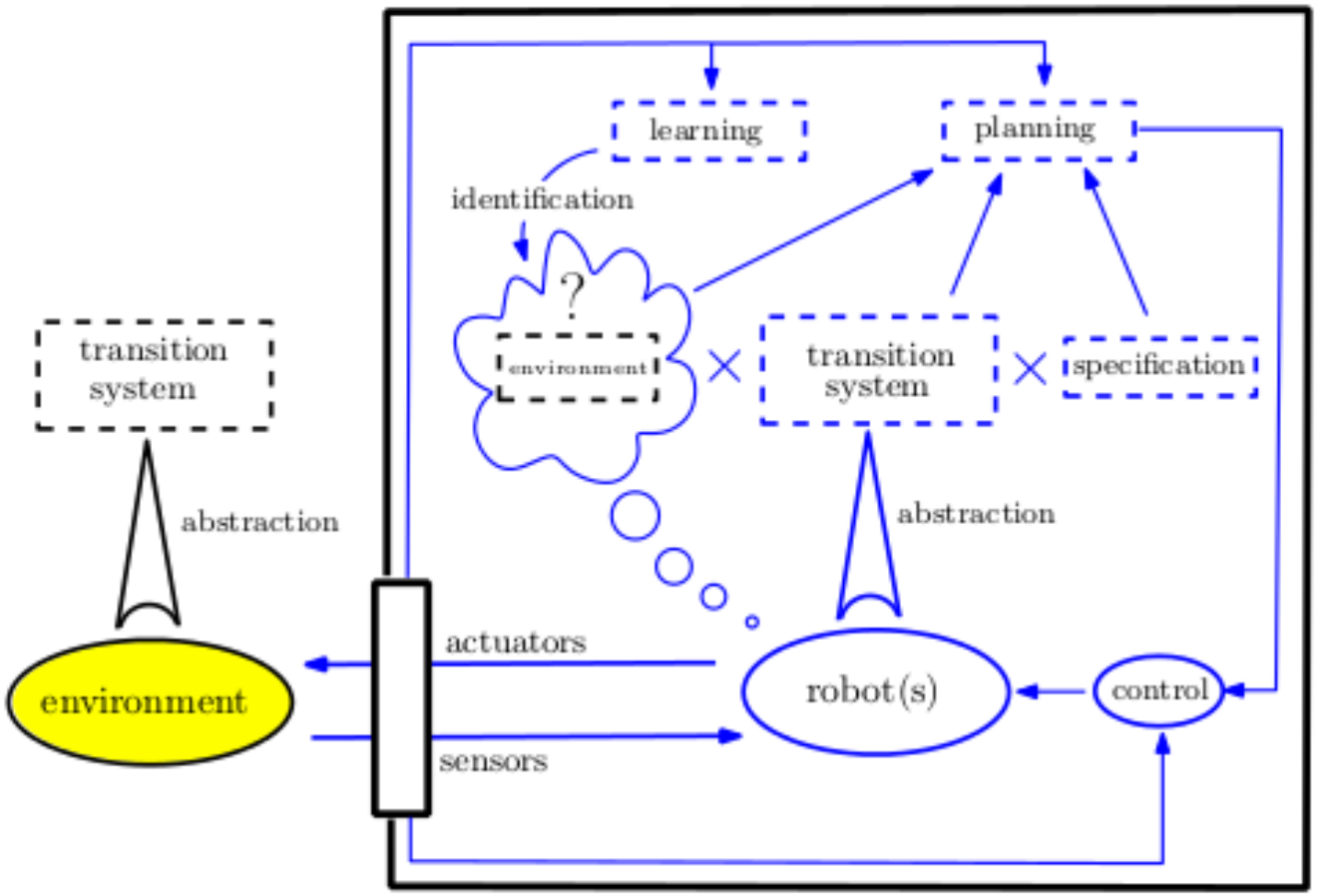

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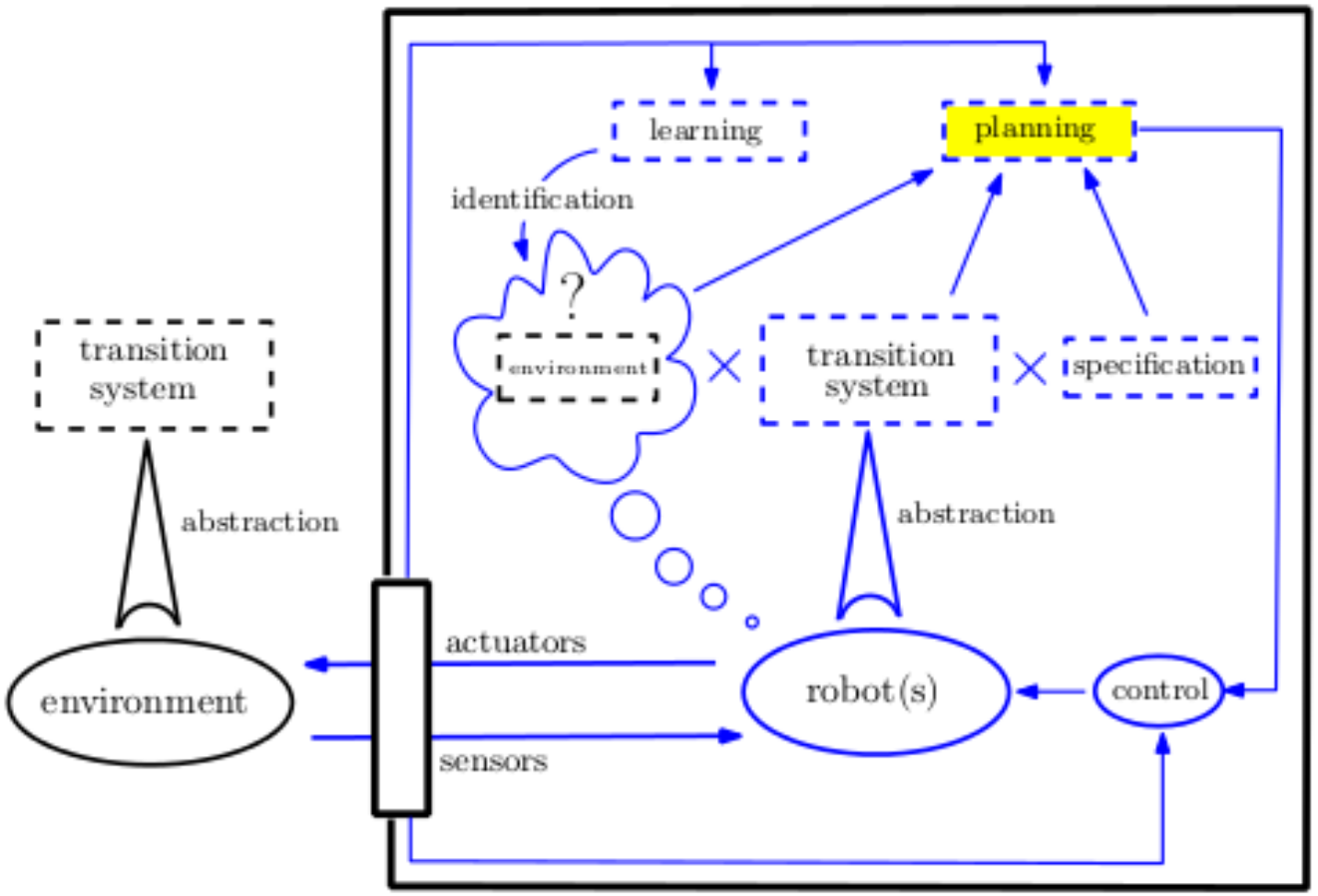

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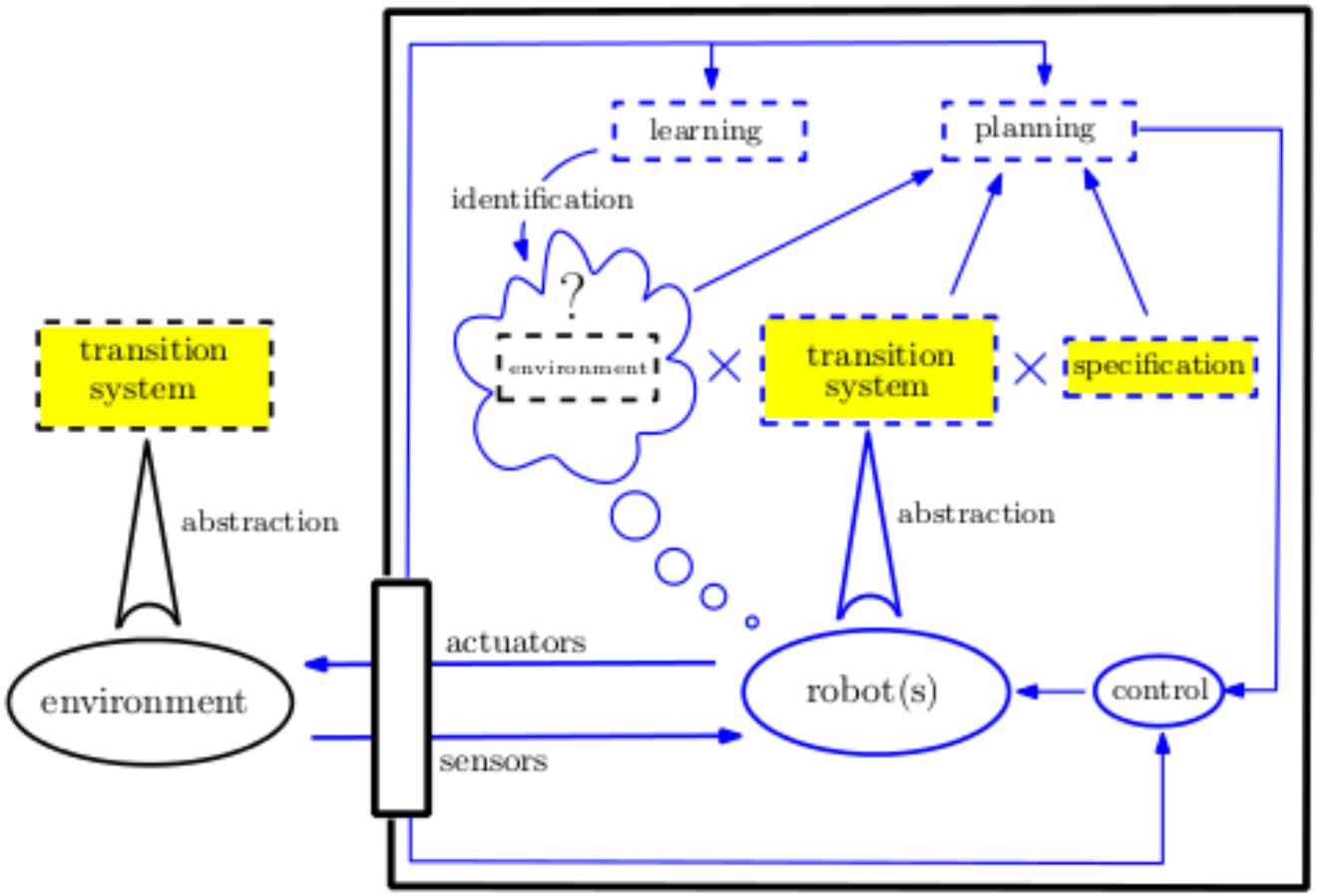

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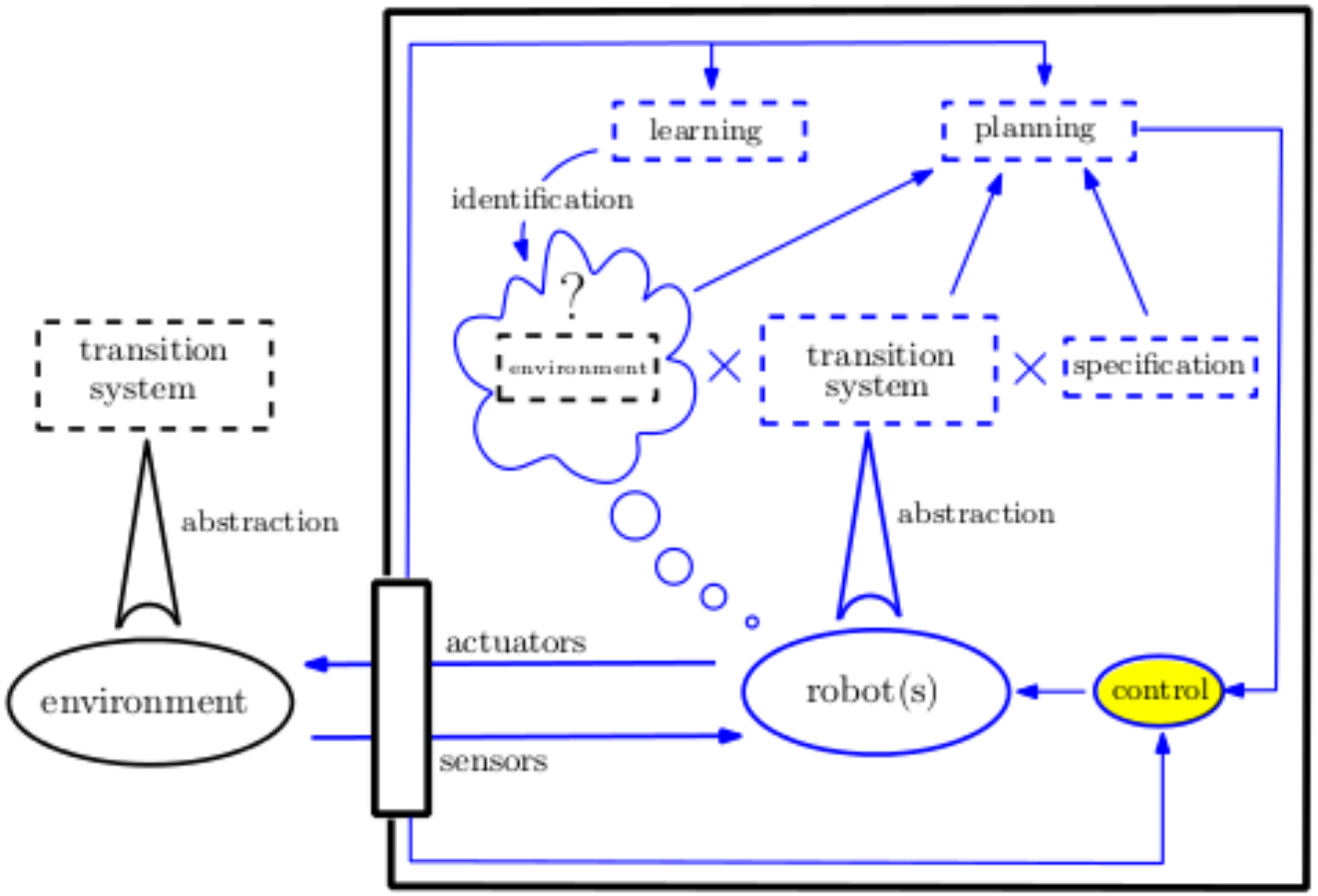

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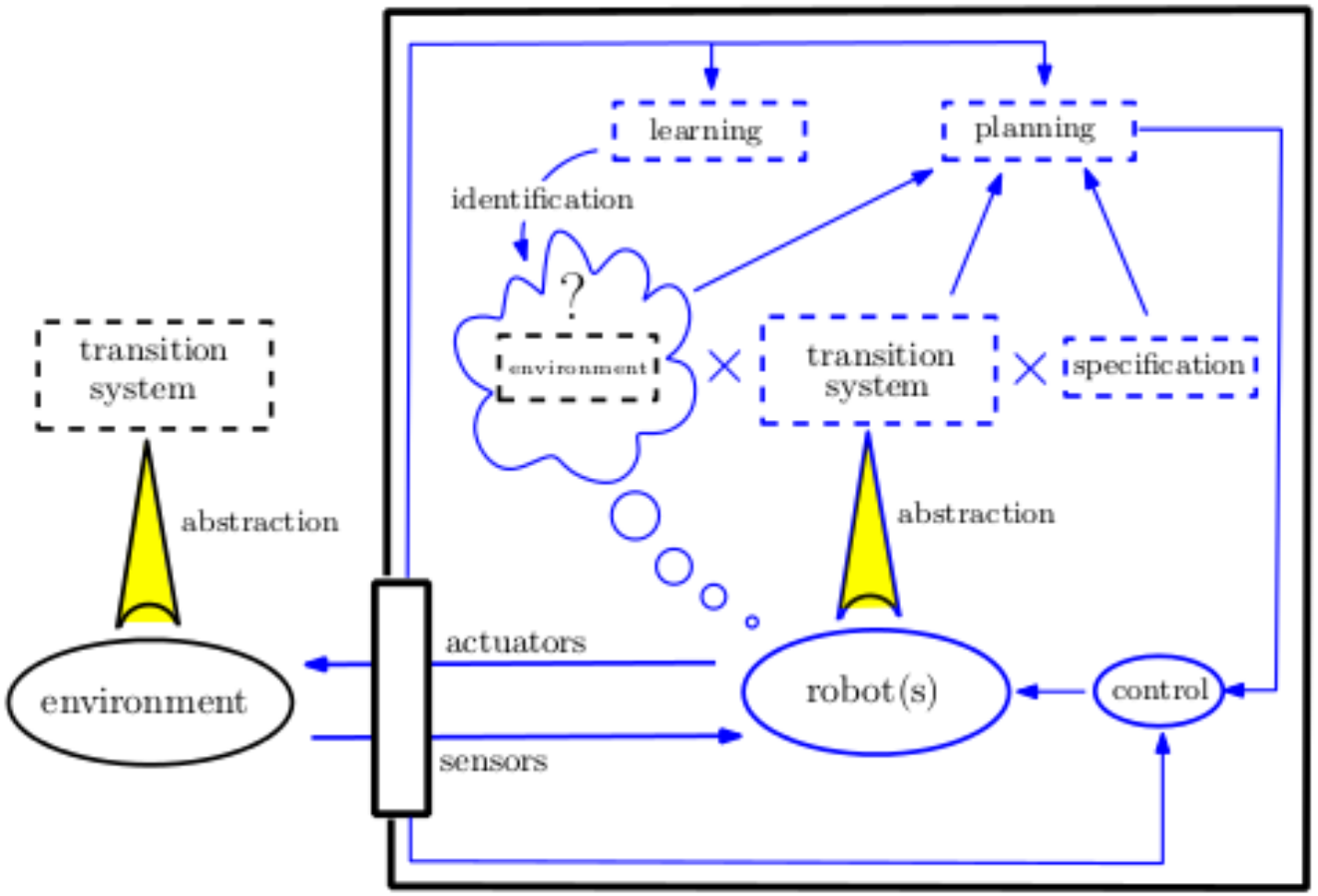

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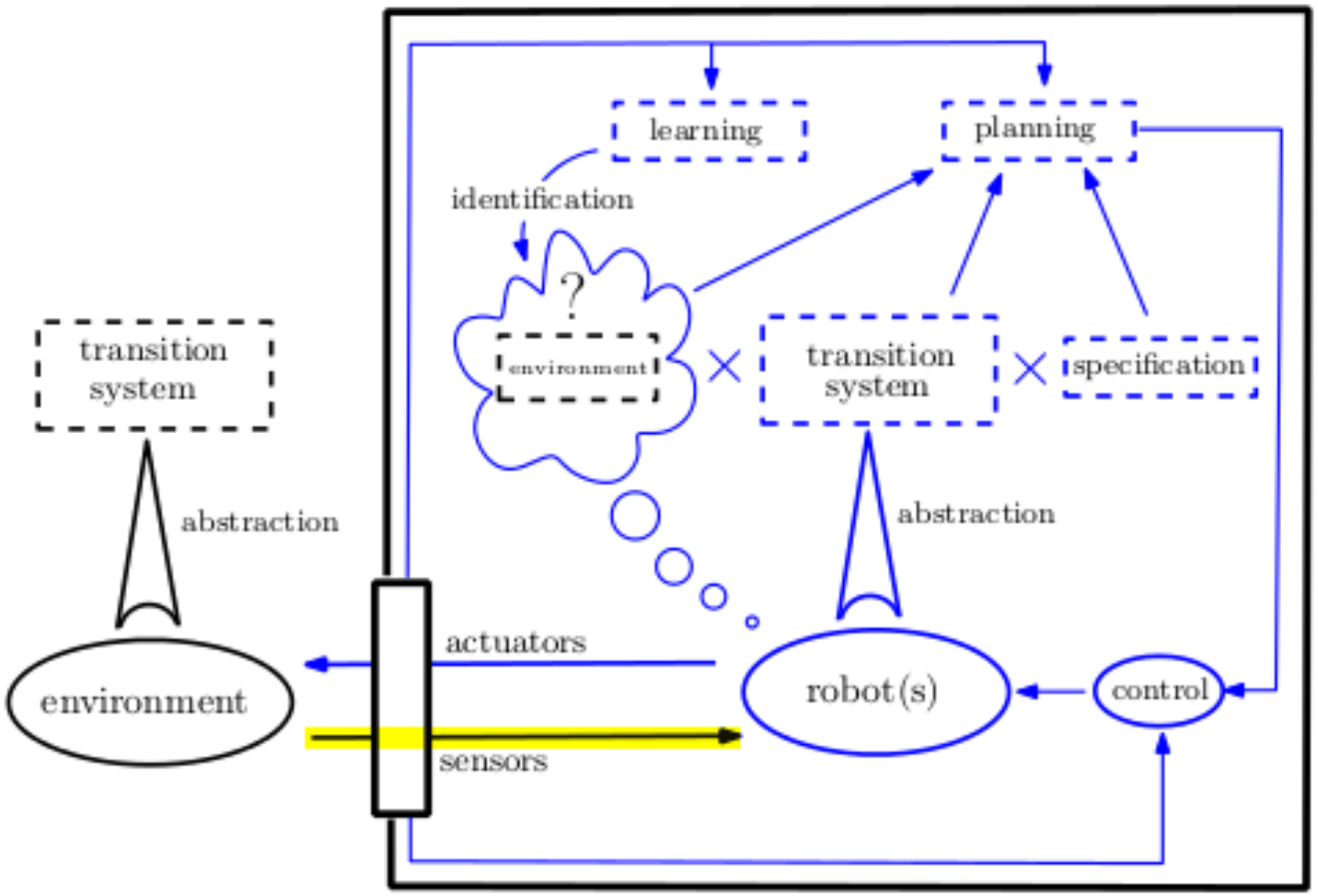

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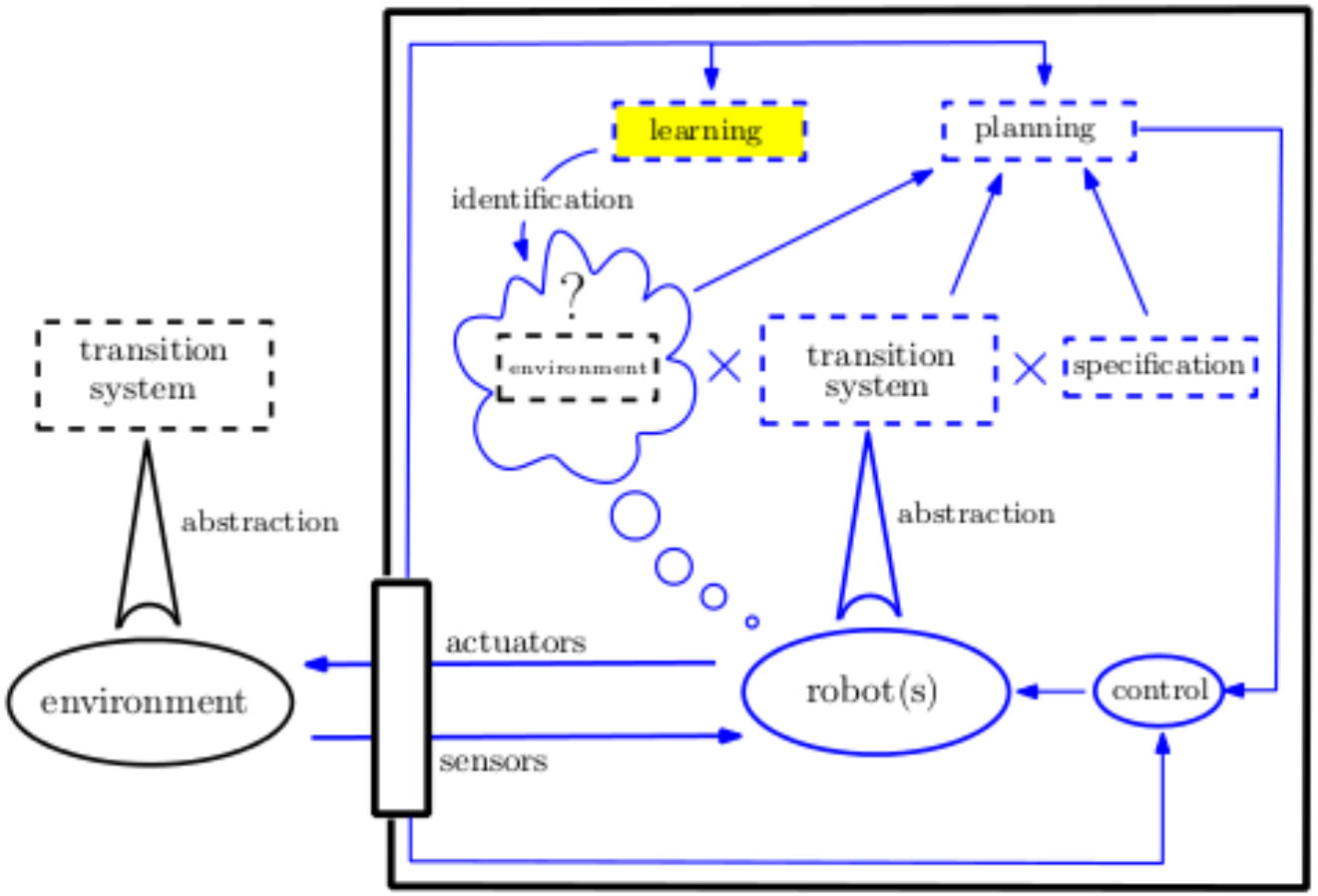

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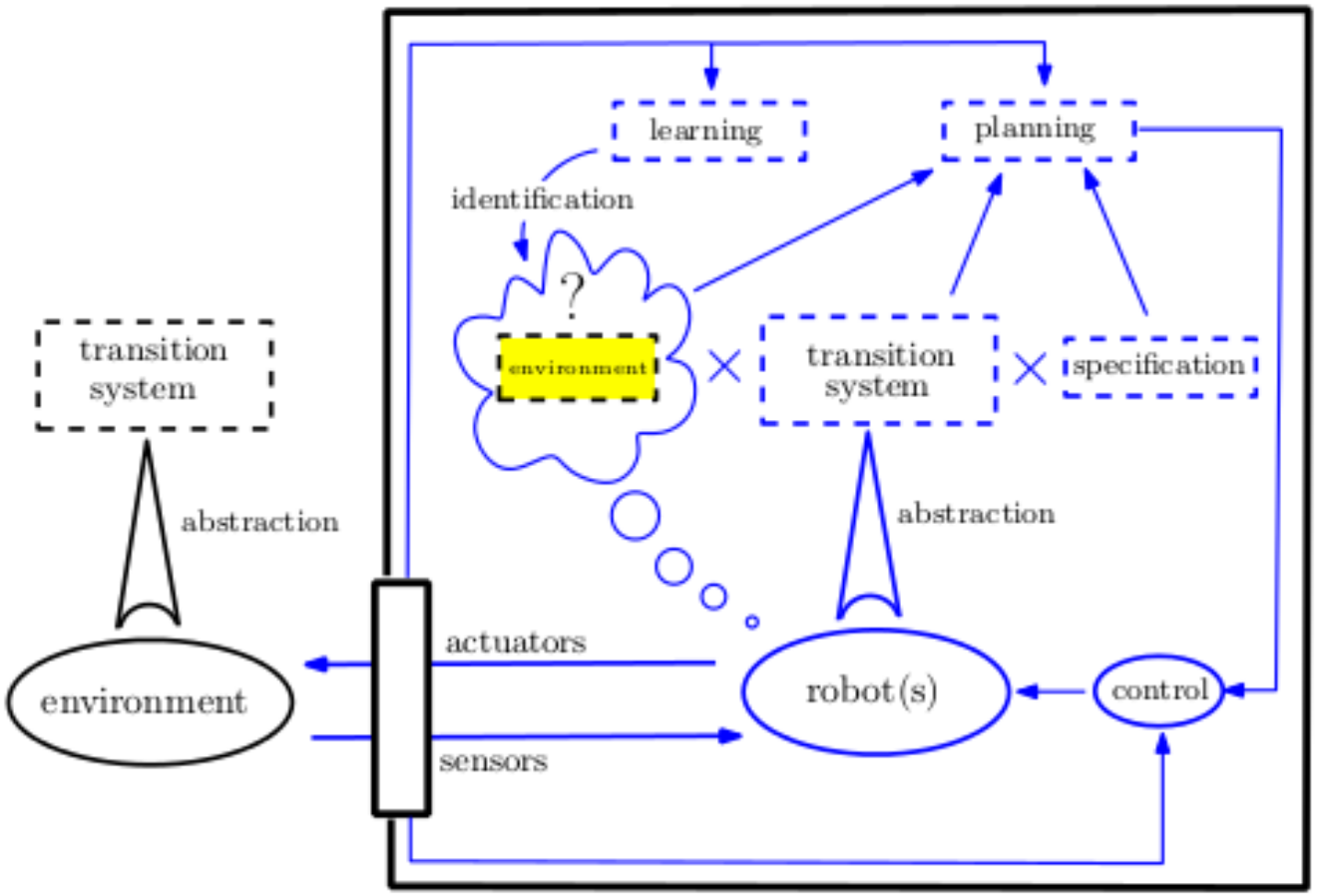

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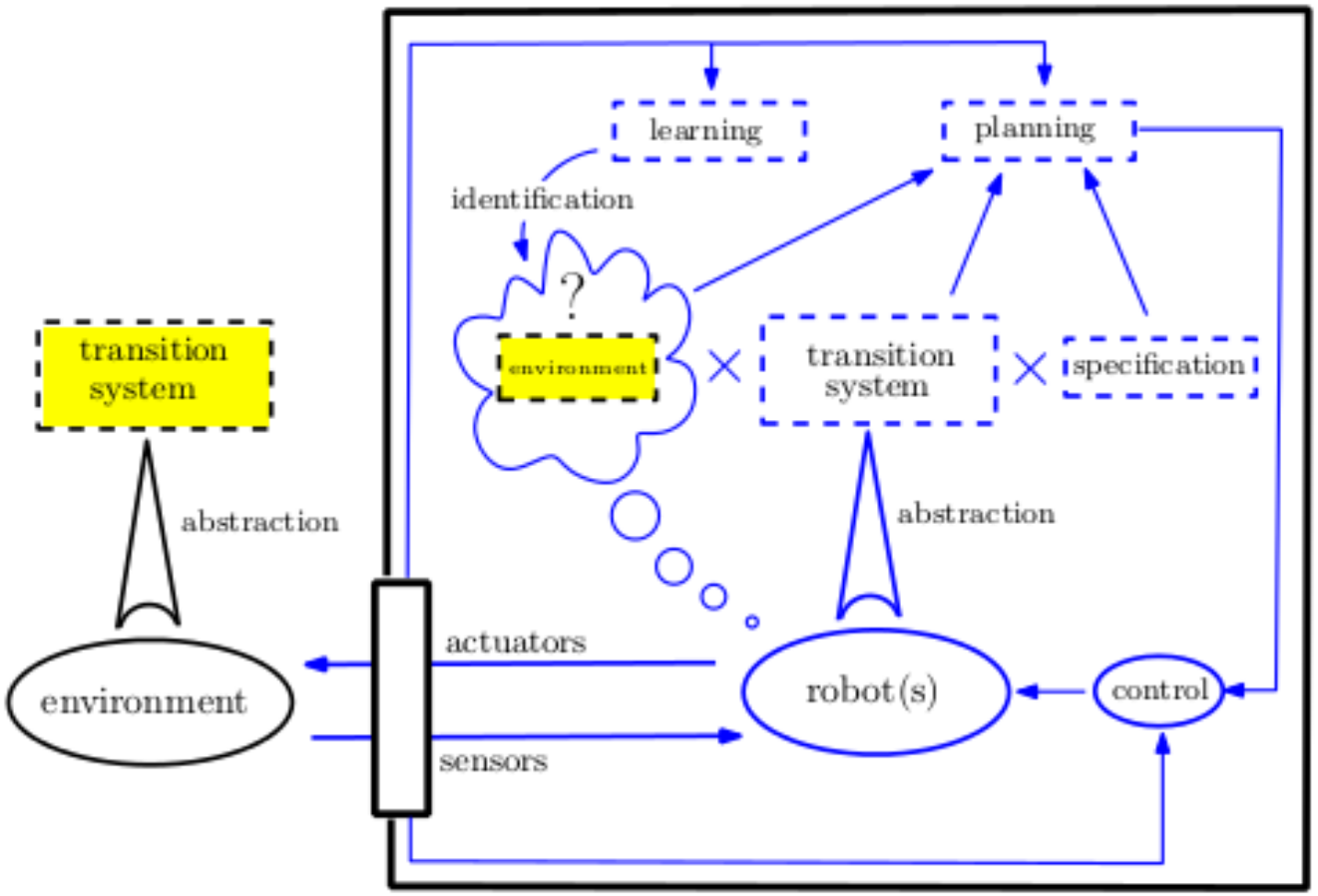
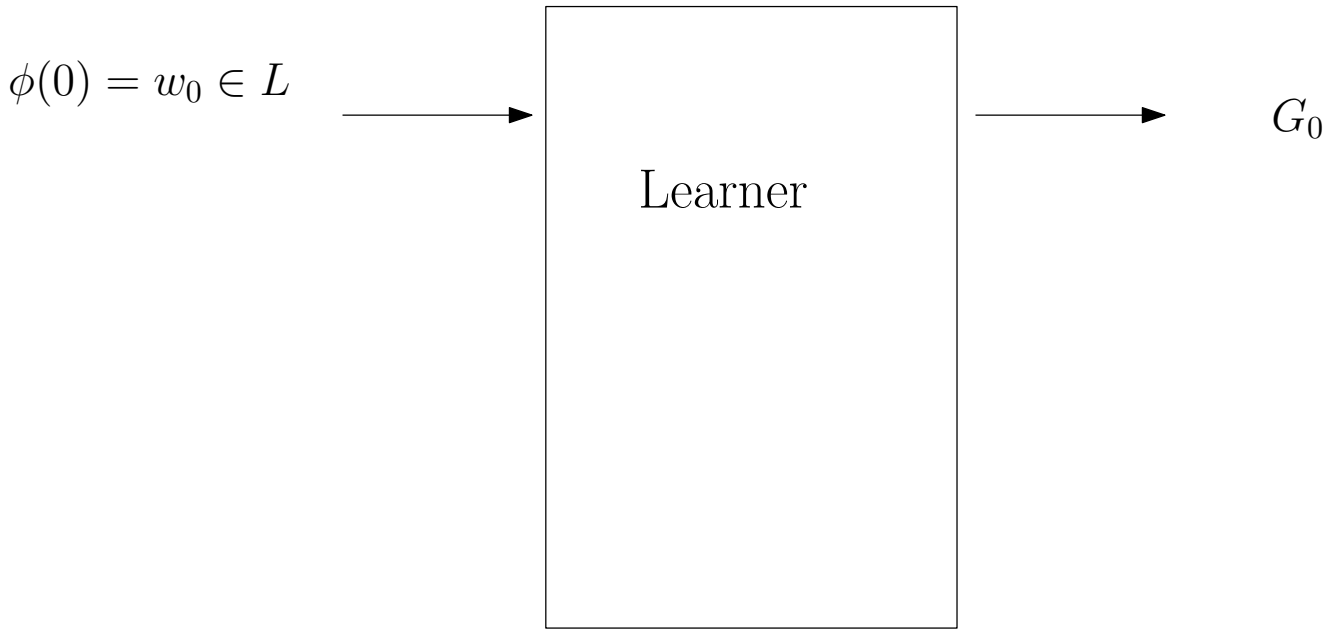


Inference on languages



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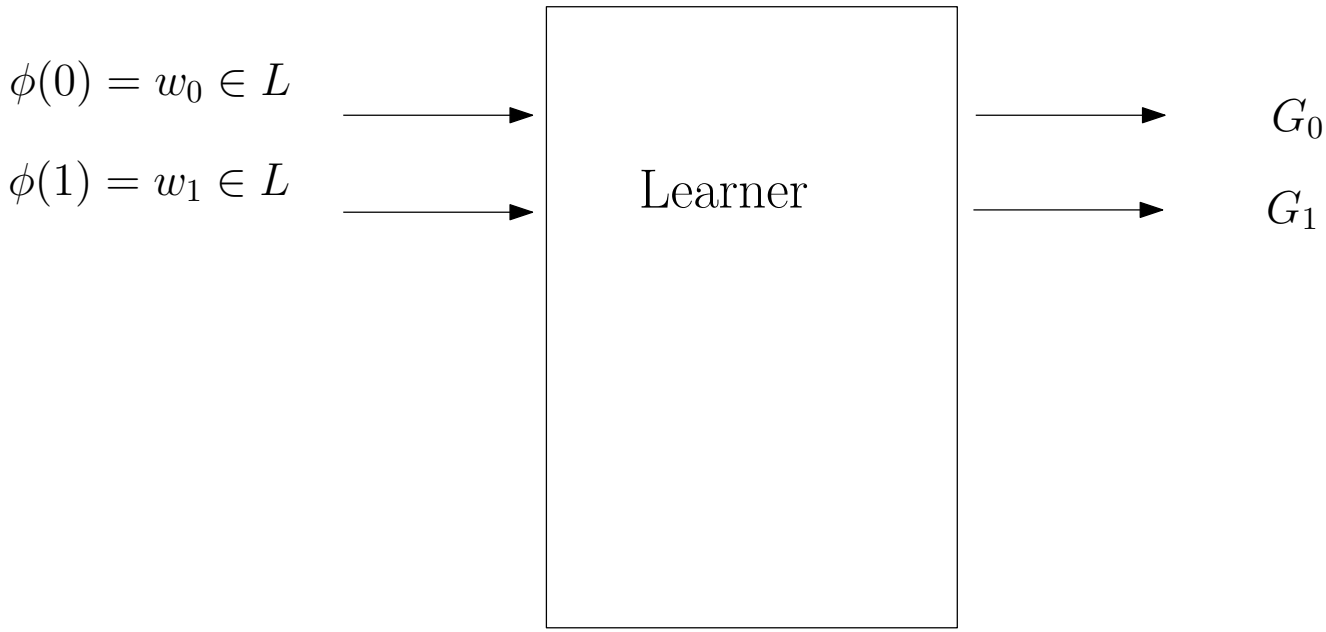

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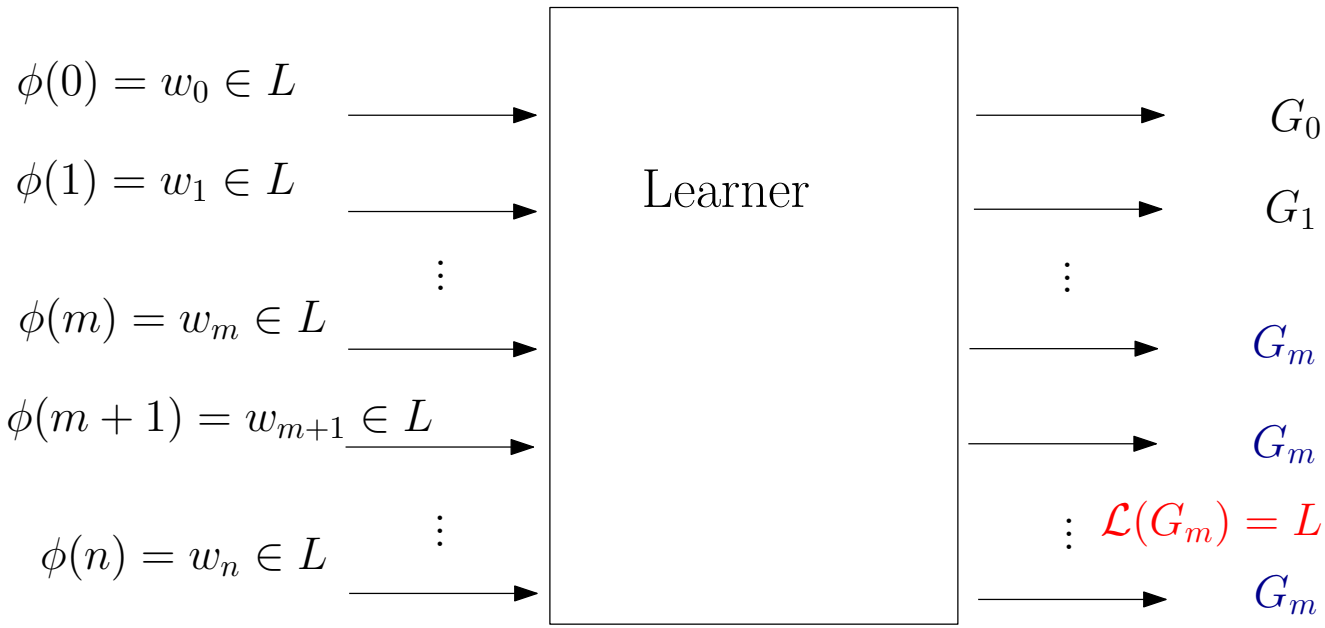
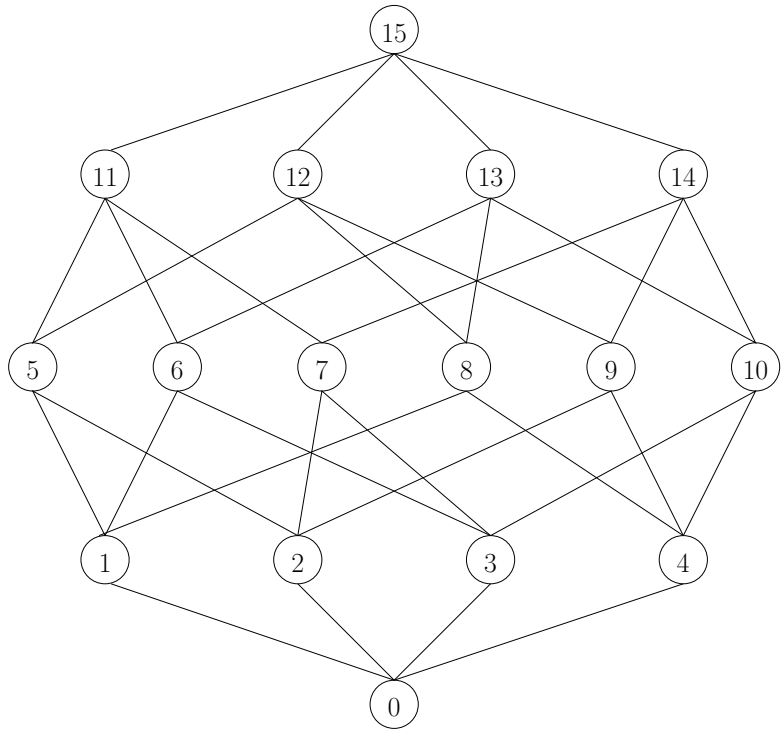


What's in the box



Definition 3 $\bigsqcup(S) \stackrel{def}{=} minimum\ x \in V\ such\ that\ (\forall y \in S)[y \sqsubseteq x]$

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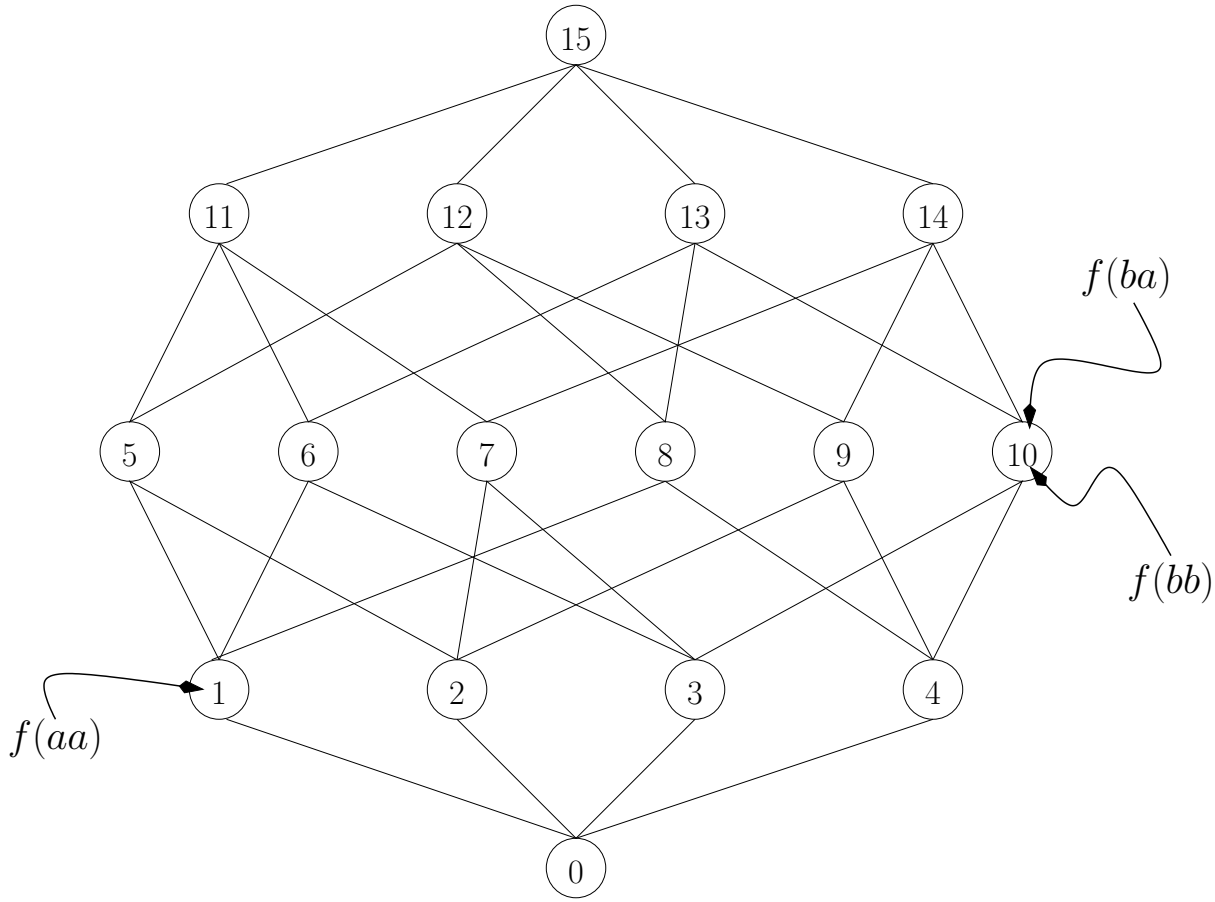

$$f : \Sigma^* \to V$$

$$(\forall x \in V)[\exists D \subseteq \Sigma^*, \text{finite}, x = \bigsqcup\{f(y) \mid y \in D\}]$$

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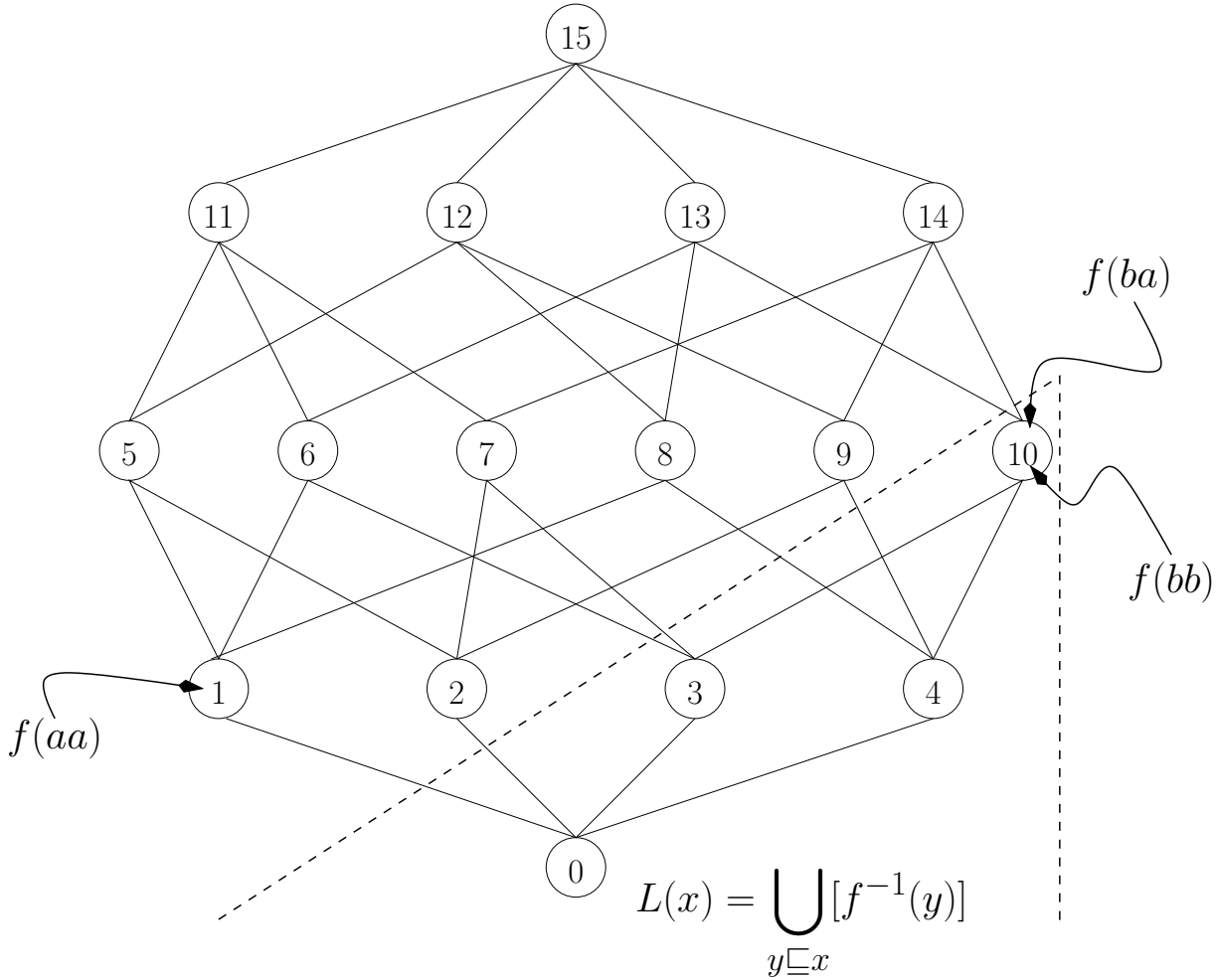

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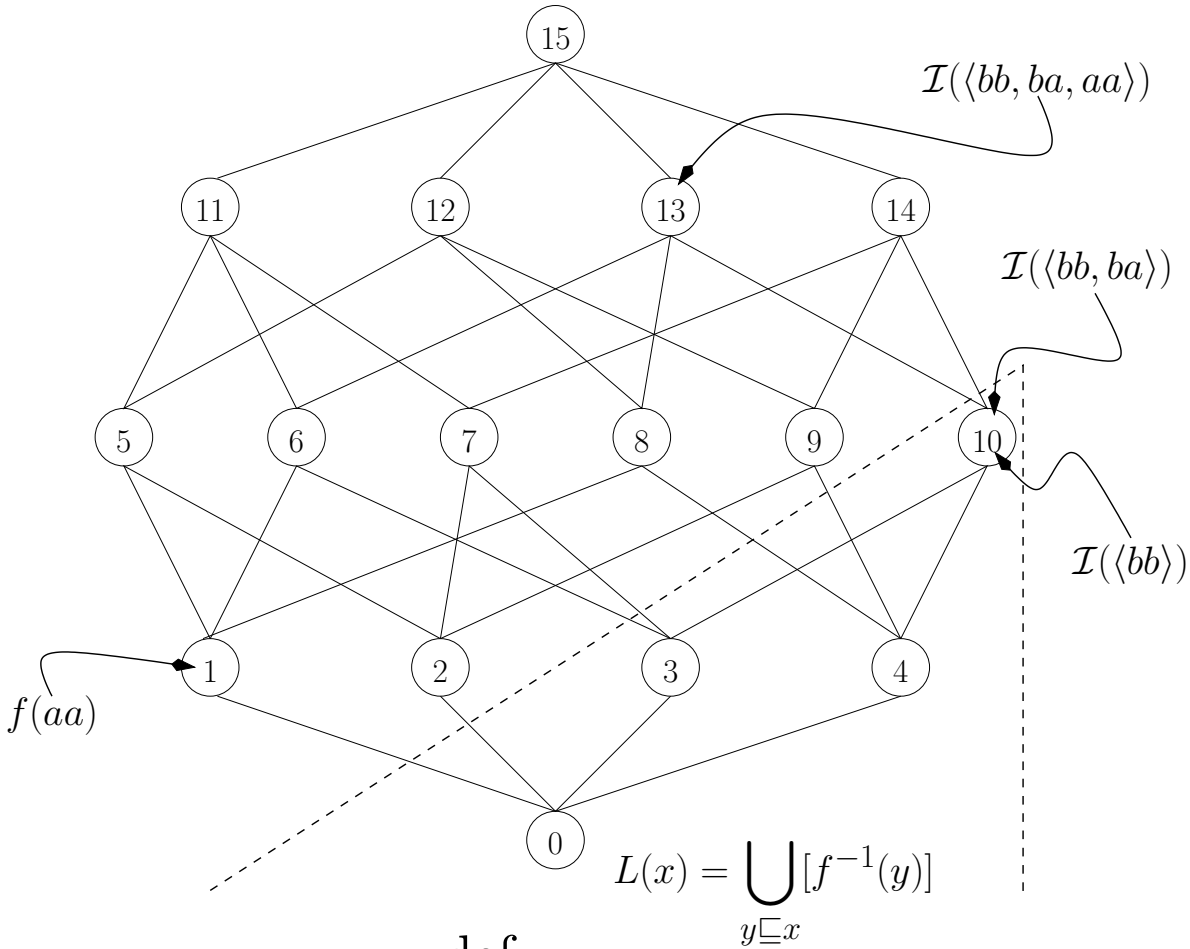
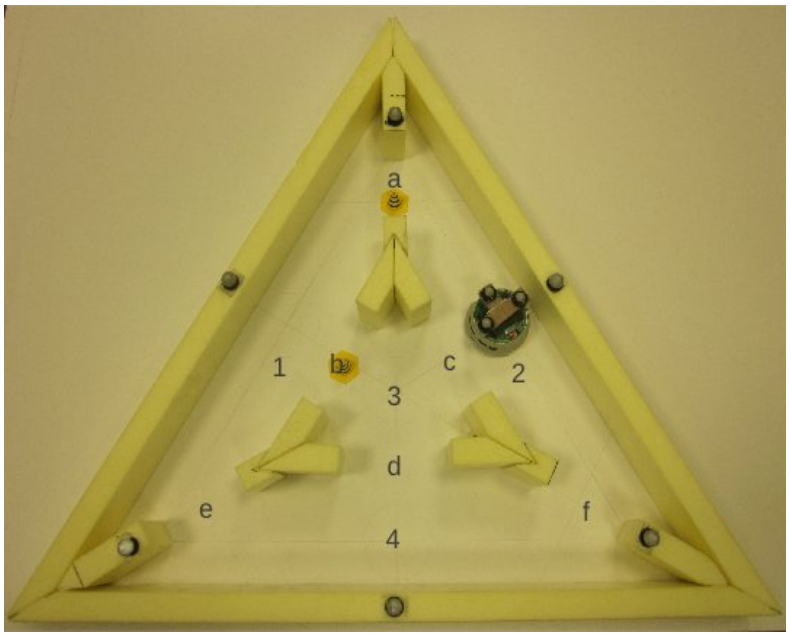
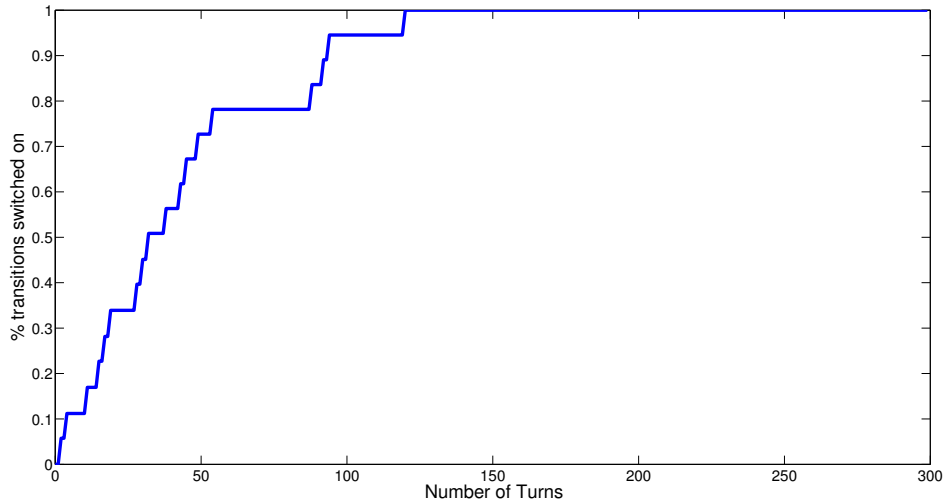


$$\mathcal{I}(t[0]) \stackrel{\text{def}}{=} f(t(0)),$$

$$\mathcal{I}(t[i+1]) \stackrel{\text{def}}{=} \mathcal{I}(t[i]) \sqcup f(t(i+1))$$

What game am I playing?





Theorem

Let $\mathcal{L}$ be identifiable in the limit from positive presentation by a normal-form learner GIM. *If, for all $A_2 \in \mathsf{SA}(\mathsf{GIM})$, there exists $\mathcal{A}_2 \in \mathsf{range}(\mathsf{GIM})$ such that $L(\mathcal{A}_2) = L_2\big((A_1 \circ A_2) \ltimes \mathcal{A}_s\big)$, then $\mathit{GAMES}\big(A_1, \mathcal{A}_s, \mathsf{SA}(\mathsf{GIM})\big)$ is identifiable in the limit from positive presentations.*

What is different and useful

- A different learning paradigm:
  - Reinforcement learning: learning to control
    vs
  - Grammatical inference: learning the context
- Modular: does not constrain synthesis nor inference
- Probabilistic modeling not the only option
- Efficient: structure allows factoring

Outcomes

Research

- Publications
  - 8 Journal
  - 13 Conference
- Software

Education & Outreach

- Graduates: 2 MSc, 2 PhD
- RISE mentorship (BU)
- BSA merit badges (UD)
- Interdisciplinary training

Broader overarching goals

- bridges between different disciplines
- cross-cutting problems
- "multi-lingual" new generation of scholars

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