Reasoning about Actions

Introduction to Reasoning about Actions

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Objectives

Objective

Explain the idea of reasoning about actions

What is Reasoning about Actions?

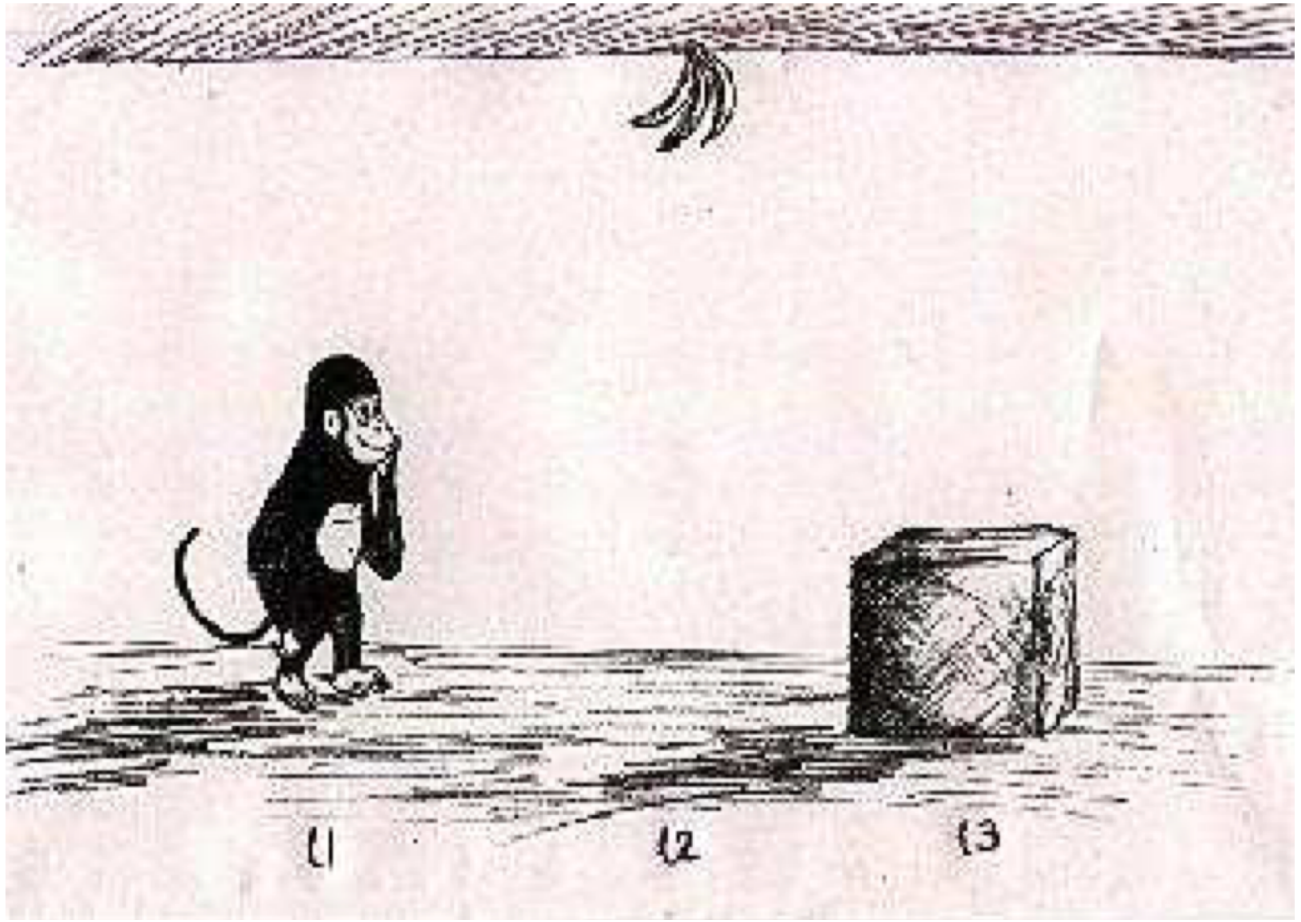
Concerned with developing appropriate formalisms for describing the properties of actions

An action is anything that can be executed and may change the state of the world:

- walking to a location
- buying an item
- shooting a turkey
- sending a message in a network
- binding of a ligand to a receptor
- ...

Monkey and Bananas

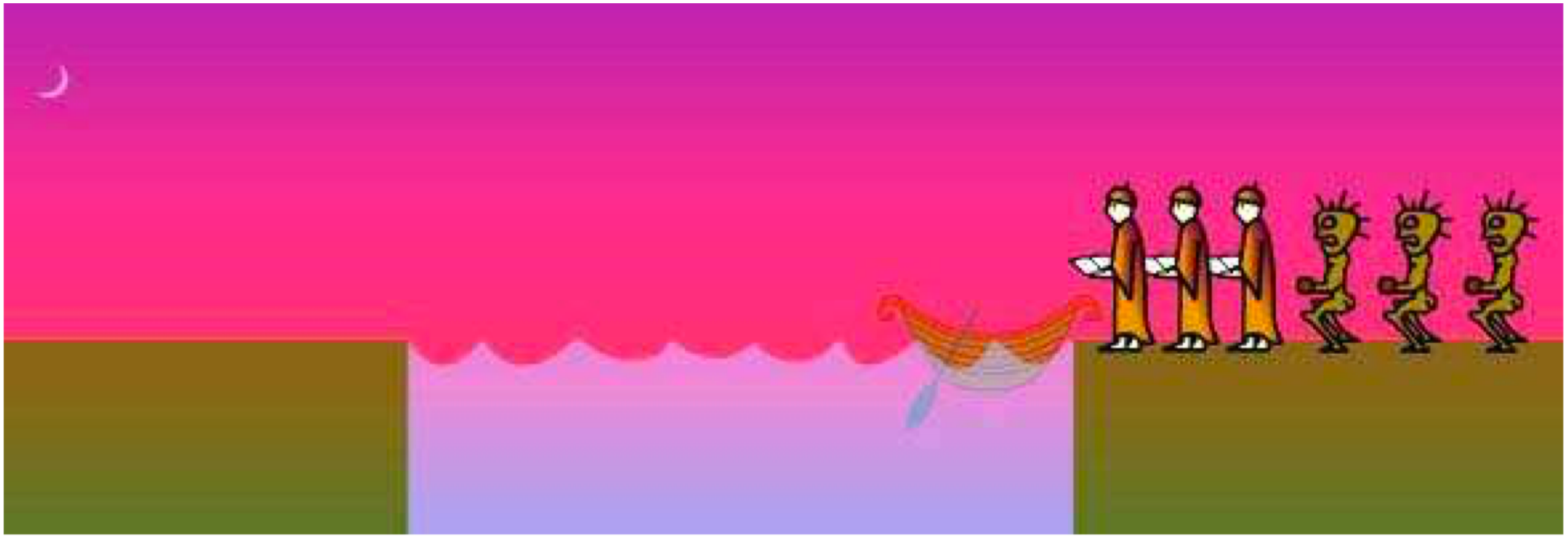
How can the monkey grasp the bananas?



(Drawing by Esra Erdem)

Missionaries and Cannibals Puzzle

How can they cross the river?



(https://www.learn4good.com/games/puzzle/boat.htm)

Action Description Languages

Formal models of parts of natural language that are used for describing the effects of actions.

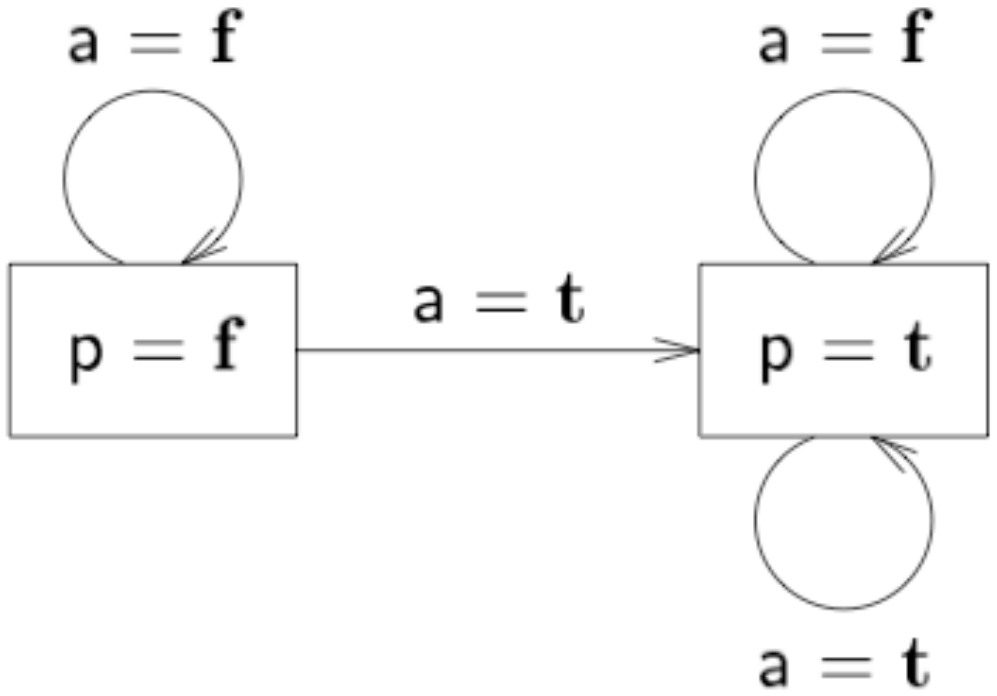
Define "transition systems"—directed graphs whose vertices correspond to states and whose edges are labeled by actions.

- STRIPS [Fikes and Nilsson, 1971]
- ADL [Pednault, 1994]
- Situation Calculus [McCarthy and Hayes, 1969; Reiter, 2001]
- Event Calculus [Shanahan, 1995]
- Temporal Action Logics [Doherty, Gustafsson, Karlsson and Kvarnstrom, 1998]
- A [Gelfond and Lifschitz, 1998]
- C+ [Giunchiglia, Lee, Lifschitz, McCain and Turner, 2004]
- …

Transition System

A transition system is a directed graph

- whose vertices correspond to the states of the world
- whose edges are labelled by actions



Fluents and Commonsense Law of Inertia

Fluent: anything that depends on the state of the world

- Whether the monkey has the bananas
- Whether the monkey is on the box
- The locations of the monkey, the bananas and the box (multi-valued fluents)

The Commonsense law of inertia: by default, the values of fluents remain unchanged after executing actions

The Frame Problem: how to formalize the commonsense law of inertia, that is, how to represent inertial fluents

- It was solved in mid 1990's

Yale Shooting Problem [Hanks & McDermott, 1987]

Yale Shooting problem: Fred is initially alive and a gun is initially unloaded. Loading the gun, waiting for a moment, and then shooting the gun at Fred is expected to kill Fred.

$$alive(0)$$

$$\neg loaded(0)$$

$$load(0) \rightarrow loaded(1)$$

$$loaded(2) \wedge shoot(2) \rightarrow \neg alive(3)$$

$\not\vdash \neg alive(3)$

Q: What is wrong?

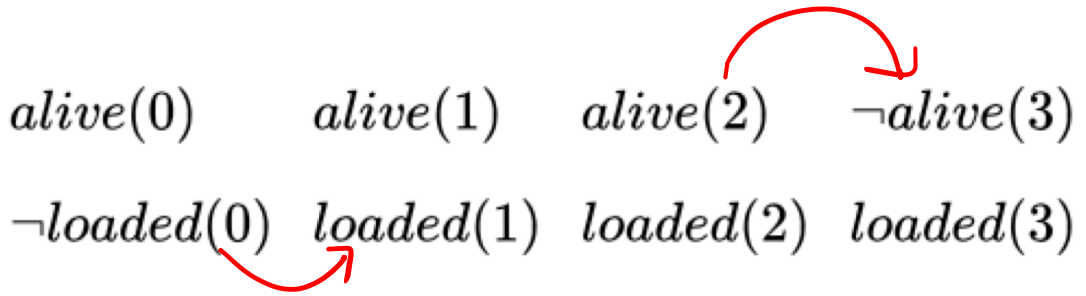
Yale Shooting Problem, cont'd

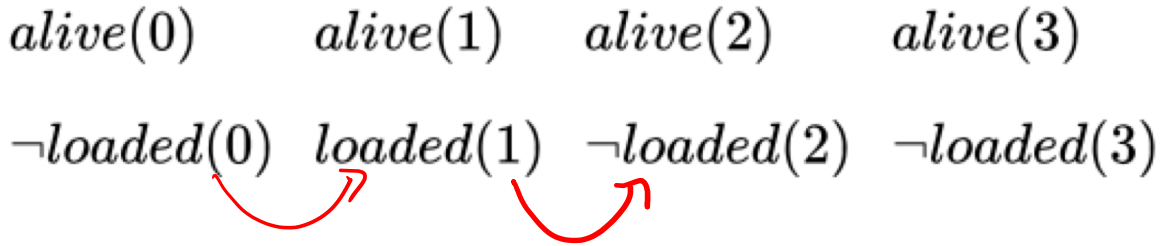
Early attempts were based on minimizing the changes

- Consider only the models that minimize changes in alive and loaded

$$alive(0)$$
$$\neg loaded(0)$$
$$load(0) \rightarrow loaded(1)$$
$$loaded(2) \wedge shoot(2) \rightarrow \neg alive(3)$$

load(0)
shoot(2)





Q: What is still wrong?

Wrap-Up