Introduction to Artificial Intelligence

Kalev Kask

ICS 271

Fall 2018

http://www.ics.uci.edu/~kkask/Fall-2018 CS271/

Course requirements

Assignments:

- There will be weekly homework assignments, a project, a final (12/13 4-6pm).

Course-Grade:

- Homework will account for 20% of the grade, project 30%, final 50% of the grade.

Discussion:

- Optional. Wed. 9-9:50 and 10-10:50 PCB 1200.

MS CE :

- CS271 can be used to satisfy the requirement

Discussion/Submissions

For course material discussion and questions, we use piazza:

- http://piazza.com/uci/fall2018/cs271

For homework/project submission, we use gradescope

- https://www.gradescope.com/courses/27083
- When register, can use entry code ME7Z2N

Plan of the course

Textbook : http://aima.cs.berkeley.edu/

Part I Artificial Intelligence

1 Introduction

2 Intelligent Agents

Part II Problem Solving

3 Solving Problems by Searching

4 Beyond Classical Search

5 Adversarial Search

6 Constraint Satisfaction Problems

Part III Knowledge and Reasoning

7 Logical Agents

8 First-Order Logic

9 Inference in First-Order Logic

10 Classical Planning

Resources on the internet

Resources on the Internet

- AI on the Web: A very comprehensive list of Web resources about AI from the Russell and Norvig textbook.

Essays and Papers

- What is AI, John McCarthy
- Computing Machinery and Intelligence, A.M. Turing
- Rethinking Artificial Intelligence, Patrick H.Winston

- AI Topics: http://aitopics.net/index.php

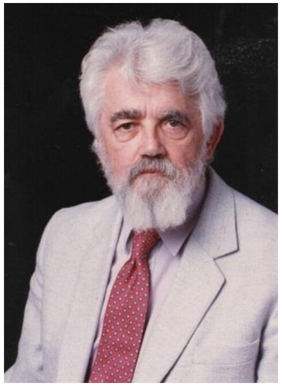
Today's class

- What is Artificial Intelligence?
- A brief History
- State of the art
- Intelligent agents

Today’s class

- What is Artificial Intelligence?

What is Artificial Intelligence
(John McCarthy , Basic Questions)



- **What is artificial intelligence?**
- It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

- **Yes, but what is intelligence?**
- Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

- **Isn't there a solid definition of intelligence that doesn't depend on relating it to human intelligence?**
- Not yet. The problem is that we cannot yet characterize in general what kinds of computational procedures we want to call intelligent. We understand some of the mechanisms of intelligence and not others.

- **More in: http://www-formal.stanford.edu/jmc/whatisai/node1.html**

What is Artificial Intelligence?

- Human-like vs rational-like
- Thought processes vs behavior
- How to simulate human intellect and behavior by a machine.
  - Mathematical problems (puzzles, games, theorems)
  - Common-sense reasoning
  - Expert knowledge: lawyers, medicine, diagnosis
  - Social behavior
- **Things we would call "intelligent" if done by a human**.

The Turing Test

(Can Machine think? A. M. Turing, 1950)

http://aitopics.net/index.php

http://amturing.acm.org/acm_tcc_webcasts.cfm

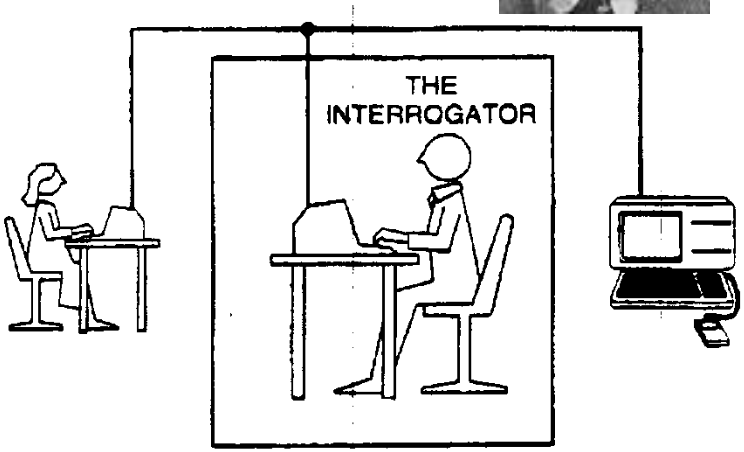


Figure 1.1 The Turing test.

- Requires:
  - Natural language
  - Knowledge representation
  - Automated reasoning
  - Machine learning
  - (vision, robotics) for full test

What is Artificial Intelligence?

Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

The textbook advocates "acting rationally“

How to simulate humans intellect and behavior by a machine.
- Mathematical problems (puzzles, games, theorems)
- Common-sense reasoning
- Expert knowledge: lawyers, medicine, diagnosis
- Social behavior

Today’s class

- What is Artificial Intelligence?
- A brief history
- State of the art
- Intelligent agents

The foundation of AI

Philosophy, Mathematics, Economics, Neuroscience, Psychology, Computer Engineering

Features of intelligent system

- Deduction, reasoning, problem solving
- Knowledge representation
- Planning
- Learning
- Natural language processing
- Perception
- Motion and manipulation

Tools

- Search and optimization
- Logic
- Probabilistic reasoning
- Neural networks

The Birthplace of “Artificial Intelligence”, 1956

- **Darmouth workshop, 1956: historical meeting of the precieved founders of AI met: John McCarthy, Marvin Minsky, Alan Newell,   and Herbert Simon.**

- **A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence. J. McCarthy, M. L. Minsky, N. Rochester, and C.E. Shannon. August 31, 1955. "We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."** ***And this marks the debut of the term*** **"artificial intelligence.“**

- **50 anniversery of Darmouth workshop**
- List of AI-topics

History of AI

- McCulloch and Pitts (1943)
  - Neural networks that learn
- Minsky and Edmonds (1951)
  - Built a neural net computer
- Darmouth conference (1956):
  - McCarthy, Minsky, Newell, Simon met,
  - Logic theorist (LT)- Of Newell and Simon proves a theorem in Principia Mathematica-Russel.
  - The name "Artficial Intelligence" was coined.
- 1952-1969 (early enthusiasm, great expectations)
  - GPS- Newell and Simon
  - Geometry theorem prover - Gelernter (1959)
  - Samuel Checkers that learns (1952)
  - McCarthy - Lisp (1958), Advice Taker, Robinson's resolution
  - Microworlds: Integration, block-worlds.
  - 1962- the perceptron convergence (Rosenblatt)

More AI examples

Common sense reasoning (1980-1990)

- Tweety
- Yale Shooting problem

Update vs revise knowledge

The OR gate example: A or B → C

- Observe C=0, vs Do C=0

Chaining theories of actions

Looks-like(P) → is(P)
Make-looks-like(P) → Looks-like(P)

Makes-looks-like(P) → is(P) ???

Garage-door example: garage door not included.

- Planning benchmarks
- 8-puzzle, 8-queen, block world, grid-space world
- Cambridge parking example

Smoked fish example… what is this?

History, continued

- 1966-1974 a dose of reality
  - Problems with computation
- 1969-1979 Knowledge-based systems
  - Weak vs. strong methods
  - Expert systems:
    - Dendral : Inferring molecular structures (Buchanan et. Al. 1969)
    - Mycin : diagnosing blood infections (Shortliffe et. Al, certainty factors)
    - Prospector : recommending exploratory drilling (Duda).
  - Roger Shank: no syntax only semantics
- 1980-1988: AI becomes an industry
  - R1: Mcdermott, 1982, order configurations of computer systems
  - 1981: Fifth generation
- 1986-present: return to neural networks
- 1987-present :
  - **AI becomes a science**: HMMs, planning, belief network
- 1995-present: The emergence of intelligent agents
  - Ai agents (SOAR, Newell, Laired, 1987) on the internet, technology in web-based **applications** , recommender systems. Some researchers (Nilsson, McCarthy, Minsky, Winston) express discontent with the progress of the field. AI should return to human-level AI (they say).
- 2001-present: The availability of data;
  - The knowledge bottleneck may be solved for many applications: learn the information rather than hand code it
  - Big Data (e.g. social media, sensors, DBs, etc.)
  - Massive (parallel) computing power – (e.g. Deep Learning/Neural Nets)

State of the art

- **Game Playing:** Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997; AlphaGo 2018 beats GO world champion.
- **Robotics vehicles**:
  - 2005 Standford robot won DARPA Grand Challenge, driving autonomously 131 miles along unrehearsed desert trail
  - Staneley (Thrun 2006). No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
  - 2007 CMU team won DARPA Urban Challenge driving autonomously 55 miles in a city while adhering to traffic laws and hazards
  - Self-driving cars (Google, Uber, Tesla, etc.)
- **Autonomous planning and scheduling**:
  - During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
  - NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- **Speech recognition (e.g. Siri, …)**
- DARPA grand challenge 2003-2005, Robocup
- **Machine translation** (From English to Arabic, 2007)
- **Natural language processing**: Watson won Jeopardy (Natural language processing), IBM 2011.
- **Neural Nets + Deep Learning** – 100+B parameters, 100+M nodes, 100+ layers

Current “Hot” areas/applications

- Big Data
- with Machine Learning
- Deep Learning/Neural nets

- Transportation/robotics
- Vision
- Internet/social media

Today's class

- What is Artificial Intelligence?
- A brief History
- State of the art
- Intelligent agents

Agents

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

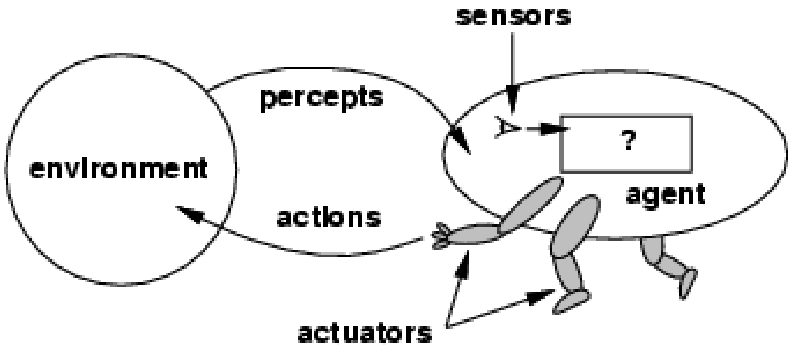
- Human agent: eyes, ears, and other organs for sensors; hands, legs, mouth, and other body parts for actuators

- Robotic agent: cameras and infrared range finders for sensors; various motors for actuators

Agents

- Agents and environments
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

Agents and environments



- The agent function maps from percept histories to actions:

$$[f: \mathcal{P}^{\star} \rightarrow \mathcal{A}]$$

- The agent program runs on the physical architecture to produce *f*

- agent = architecture + program

What's involved in Intelligence?

- **Ability to interact with the real world**
  - to perceive, understand, and act
  - e.g., speech recognition and understanding and synthesis
  - e.g., image understanding
  - e.g., ability to take actions, have an effect

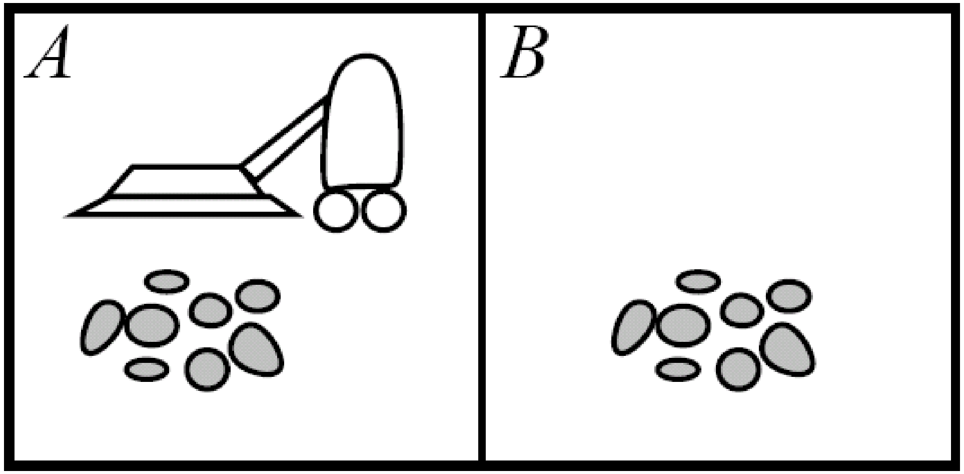
- **Knowledge Representation, Reasoning and Planning**
  - modeling the external world, given input
  - solving new problems, planning and making decisions
  - ability to deal with unexpected problems, uncertainties

- **Learning and Adaptation**
  - we are continuously learning and adapting
  - our internal models are always being "updated"
    - e.g. a baby learning to categorize and recognize animals

Implementing agents

- **Table look-ups, Model-based, Goal-oriented, Utility, Learning**
- **Autonomy**
  - All actions are completely specified
  - no need in sensing, no autonomy
  - example: Monkey and the banana
- **Structure of an agent**
  - agent = architecture + program
  - Agent examples
    - medical diagnosis
    - Satellite image analysis system
    - part-picking robot
    - Interactive English tutor
    - cooking agent
    - taxi driver

Vacuum-cleaner world



Percepts: location and contents, e.g., $[A, Dirty]$

Actions: $Left$, $Right$, $Suck$, $NoOp$

A vacuum-cleaner agent

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean]$, $[A, Clean]$	$Right$
$[A, Clean]$, $[A, Dirty]$	$Suck$
⋮	⋮

function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = *B* **then return** *Left*

What is the right function?
Can it be implemented in a small agent program?

Rationality

Fixed performance measure evaluates the environment sequence

- one point per square cleaned up in time T?
- one point per clean square per time step, minus one per move?
- penalize for $> k$ dirty squares?

A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date

Rational $\neq$ omniscient
Rational $\neq$ clairvoyant
Rational $\neq$ successful

Rational $\Rightarrow$ exploration, learning, autonomy

Task Environment

- Before we design a rational agent, we must specify its **task environment**:

PEAS:

Performance measure

Environment

Actuators

Sensors

PEAS

- Example: Agent = taxi driver
  - Performance measure: Safe, fast, legal, comfortable trip, maximize profits
  - Environment: Roads, other traffic, pedestrians, customers
  - Actuators: Steering wheel, accelerator, brake, signal, horn
  - Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

PEAS

- Example: Agent = Medical diagnosis system
  - Performance measure: Healthy patient, minimize costs, lawsuits
  - Environment: Patient, hospital, staff
  - Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)
  - Sensors: Keyboard (entry of symptoms, findings, patient's answers)

PEAS

- Example: Agent = part-picking robot
  - Performance measure: Percentage of parts in correct bins
  - Environment: Conveyor belt with parts, bins
  - Actuators: Jointed arm and hand
  - Sensors: Camera, joint angle sensors

Environment Types

- Fully observable (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.

- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)

- Episodic (vs. sequential): An agent's action is divided into atomic episodes. Decisions do not depend on previous decisions/actions.

Environment Types

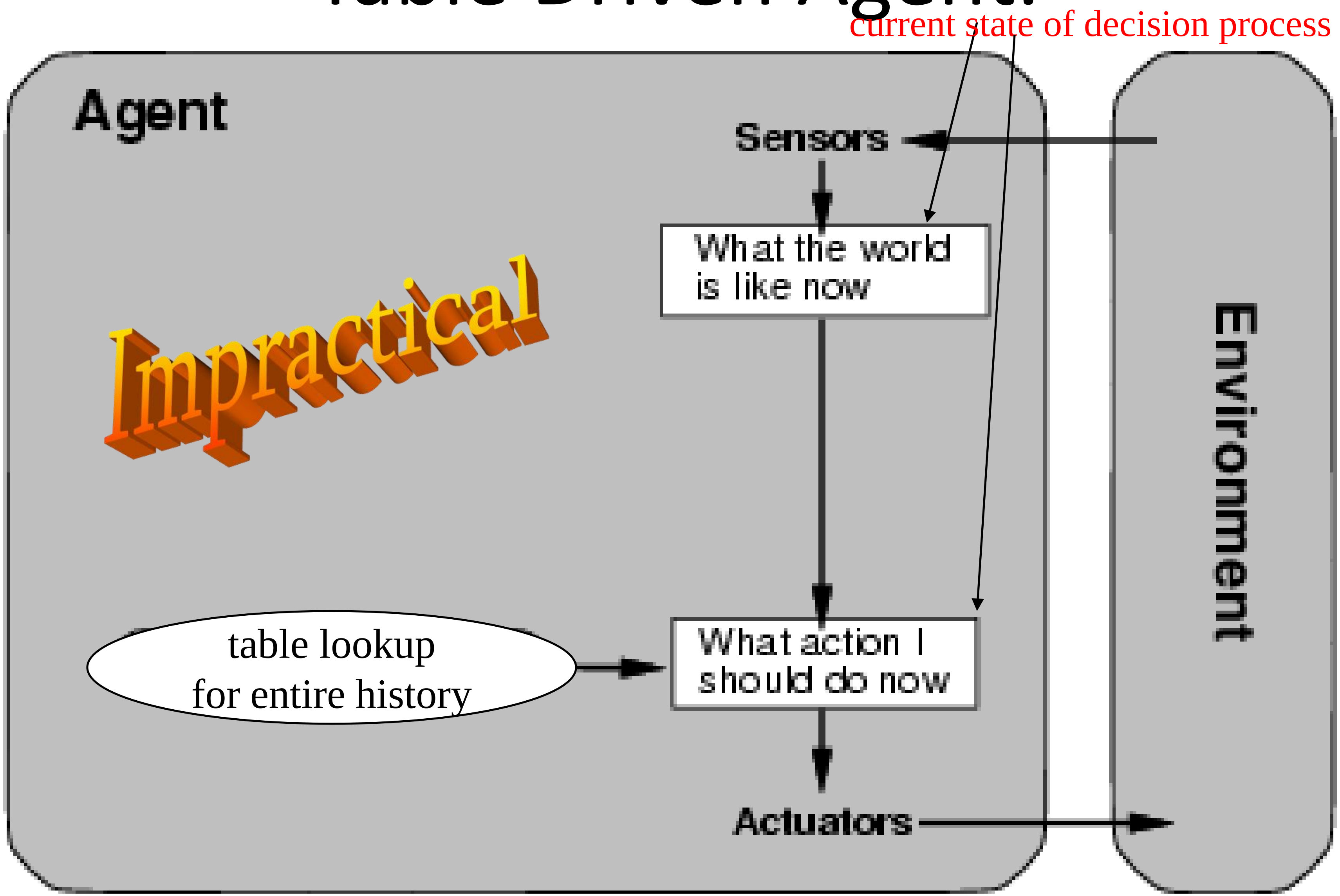
- Static (vs. dynamic): The environment is unchanged while an agent is deliberating. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does)

- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions.

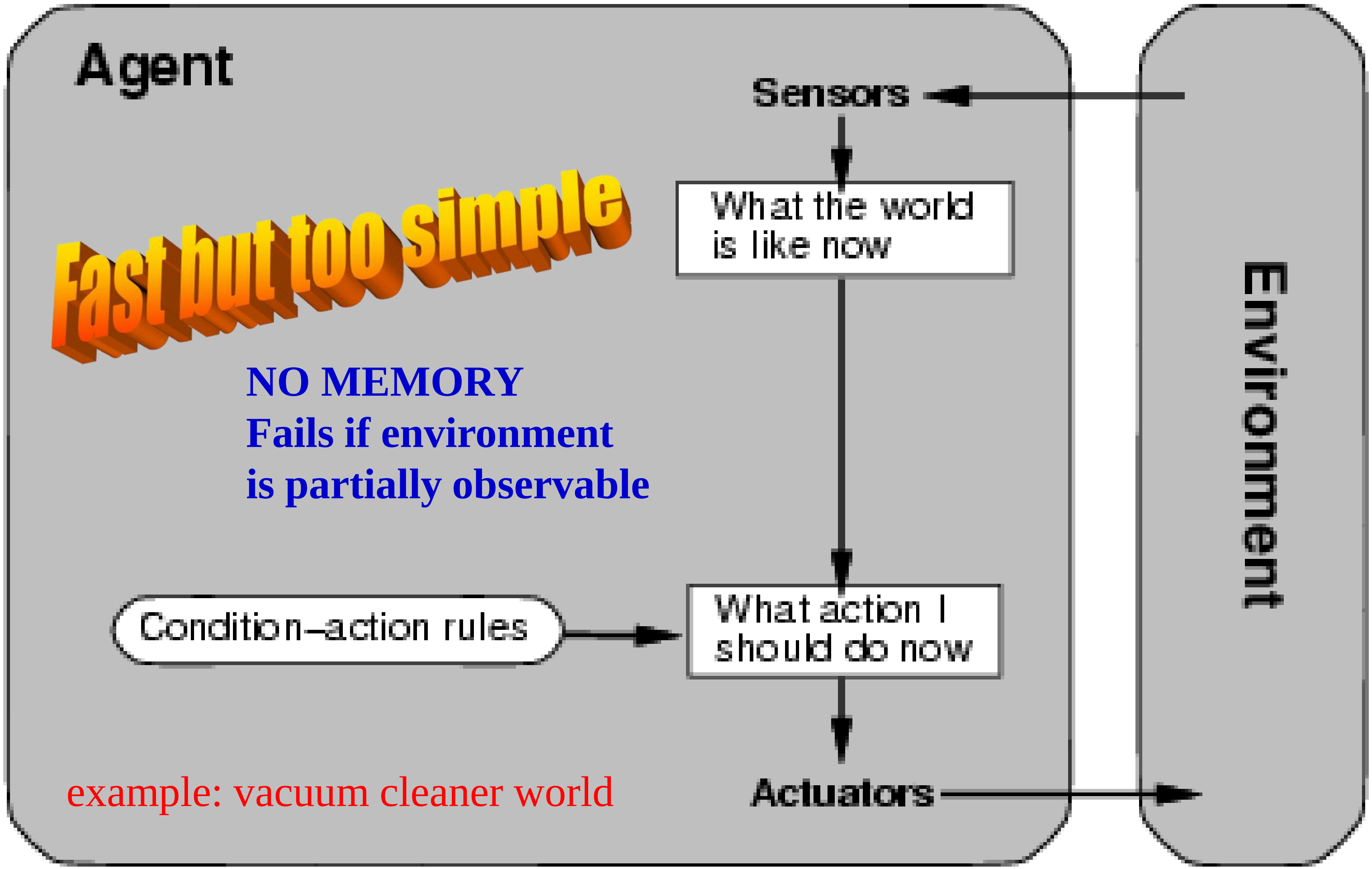
  How do we represent or abstract or model the world?

- Single agent (vs. multi-agent): An agent operating by itself in an environment. Does the other agent interfere with my performance measure?

Table Driven Agent.



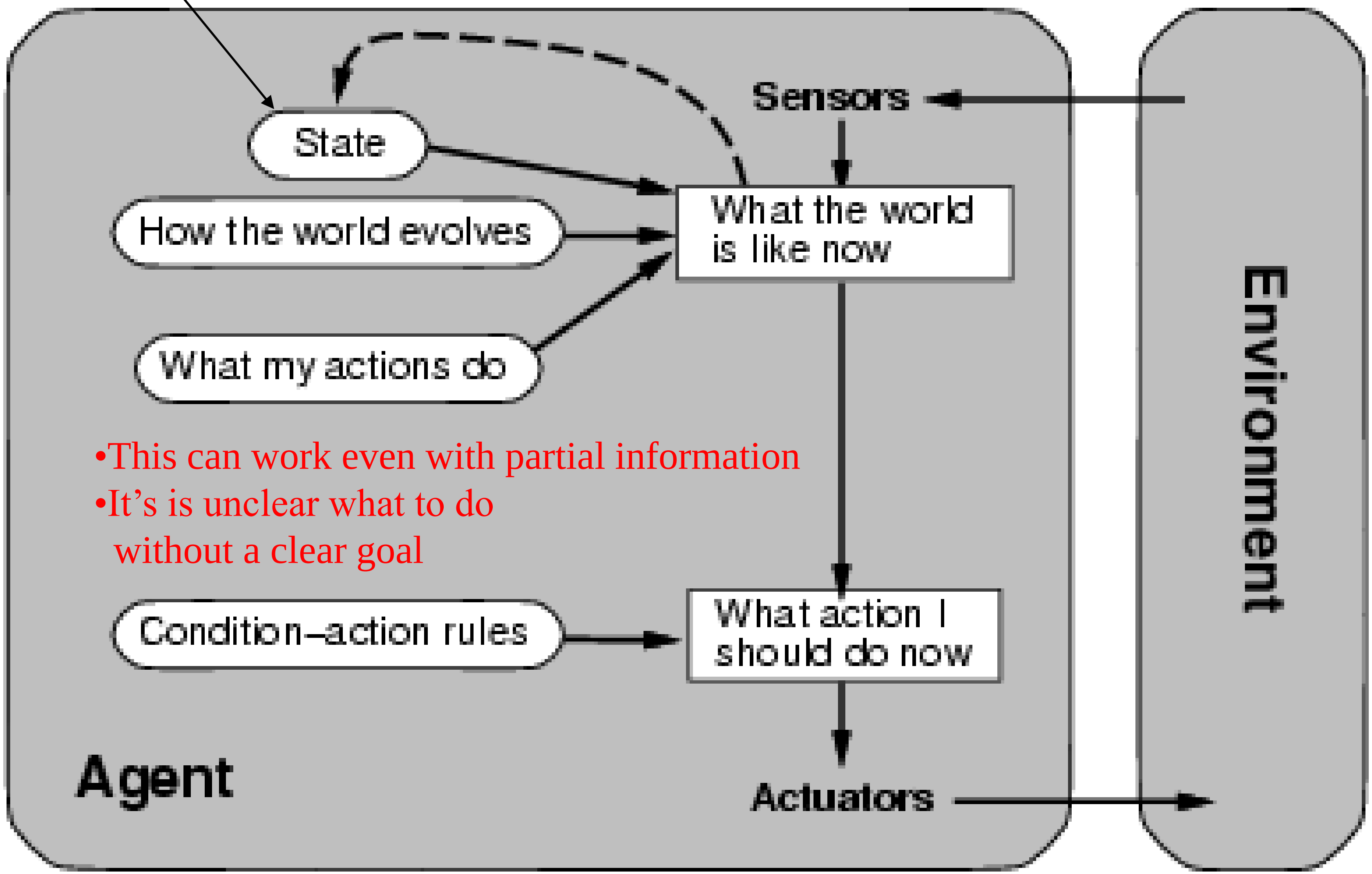
Simple reflex agents



Model-based reflex agents

description of
current world state

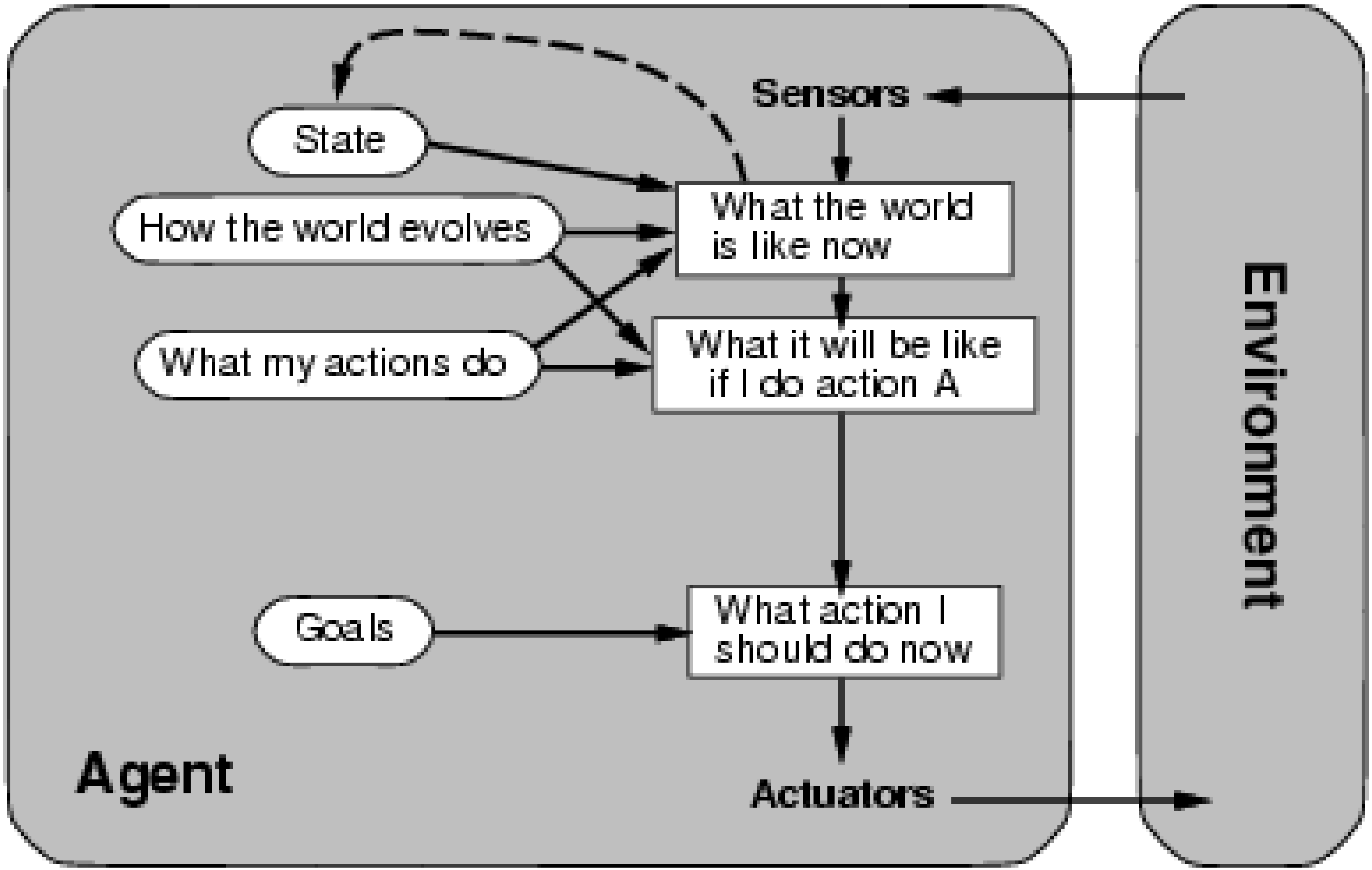
Model the state of the world by:
modeling how the world changes
how it's actions change the world



- This can work even with partial information
- It's is unclear what to do without a clear goal

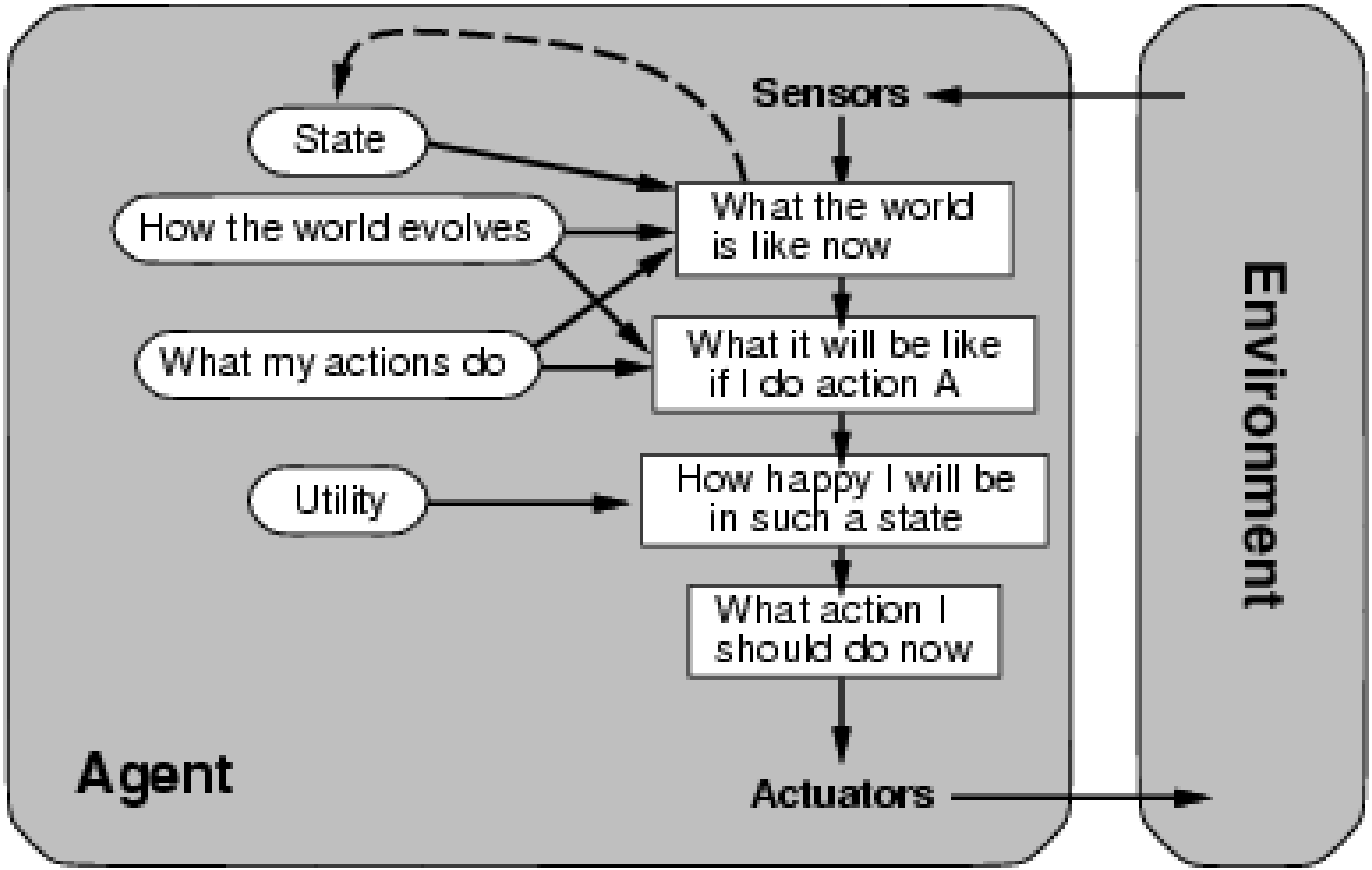
Goal-based agents

Goals provide reason to prefer one action over the other.
We need to predict the future: we need to plan & search



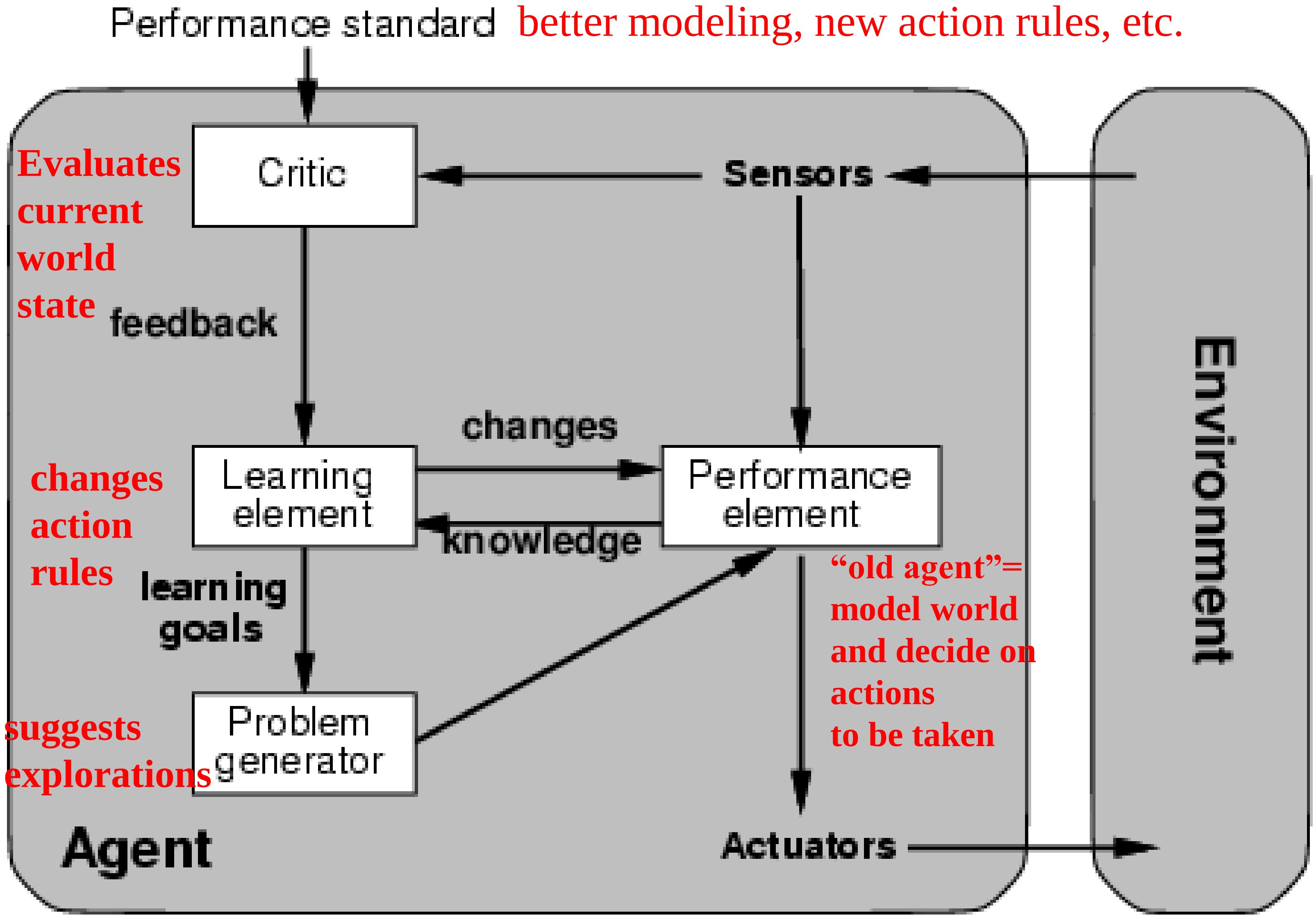
Utility-based agents

Some solutions to goal states are better than others.
Which one is best is given by a utility function.
Which combination of goals is preferred?



Learning agents

How does an agent improve over time?
By monitoring it's performance and suggesting
better modeling, new action rules, etc.



Summary

- **What is Artificial Intelligence**?
  - modeling humans thinking, acting, should think, should act.
- **History of AI**
- **Intelligent agents**
  - We want to build agents that act rationally

- **Real-World Applications of AI**
  - AI is alive and well in various “every day” applications
    - many products, systems, have AI components
- **Assigned Reading**
  - Chapters 1 and 2 in the text R&N