CIS 604
Techniques in Artificial Intelligence
Introduction

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Credits for slides: Dr. Iyad Rahwan

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The Instructor

Education

- B.Sc.* Computer Science, Århus, Denmark
- M.Sc. Computational Logic, TU Dresden, Germany
- Ph.D. BioTec TU Dresden, Germany

Research

- **Bioinformatics:** Classification of Protein-Protein Interactions, Computational Miocrobial Ecology/Metagenomics, Phenotype prediction from genotype
- **Text mining:** Ontologies, Information Retrieval, Technology Forecasting

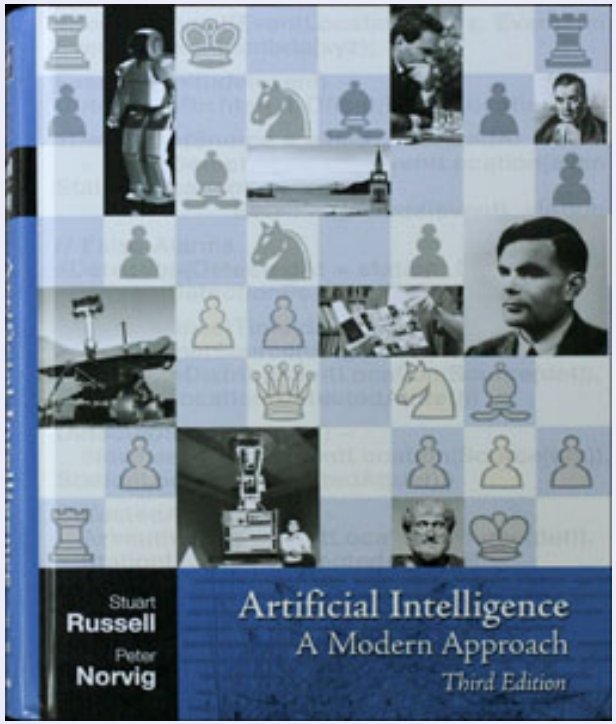
More Details

Masdar Faculty website, `www.masdar.ac.ae`

Material

Literature

- Main Textbook: Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach. Prentice Hall 3rd Edition, 2010



- Various handouts

Further Reading

... and watching ⌣̈

- AIMA web site: `http://aima.cs.berkeley.edu/`
- Online book on Artificial Intelligence `artint.info`
- Stanford Online course by Norvig and Thrun `www.ai-class.com`
- Online classes by S. Thrun `www.udacity.com` (Robotics, Search Engine)
- `bernardwelt.blogspot.com/2011/08/human-body-is-machine-which-winds-its.html`

Assessment

Teaching philosophy

- Interactive, personalized classroom
- Detailed study at home

Assessment

- 20% Assigment 1
- 20% Mid-term exam (in class)
- 20% Assigment 2
- 30% Final exam
- 10% Participation: class, moodle, quizzes

Assignment	Handed	Due
1	Week 4	Week 10
2	Week 8	Week 14

Getting Help

- Office hours: 1.30pm-2.30pm on class days (prior appointment required)
- Outside office hours:
  - Post questions on "the Source" (course management system) `https://source.masdar.ac.ae`
  - Other students who answer will get "participation credit"

Schedule

Week	Topic (tentative)	Chapter
1	Introduction, search techniques	1,2,3
2	More search techniques	3,4
3	Adversarial Search + Constraint Satisfaction Problems	5,6
4	Propositional Logic	7
5	First Order Logic	8,9
6	Planning	10,11
7	Ontologies	12
8	Revision + Mid-term exam	-
9	Uncertainty	13
10	Probabilistic Reasoning with Bayesian Networks	14
11	Probabilistic Reasoning over Time	15
12	Decision Theoretic Agents	16
13	Sequential Decision Making & Markov Decision Processes	17
14	Reinforcement Learning	21
15	Hidden Markov Models and NLP	
16	Revision + Final Exam	-

Prerequisites

Math

- Basic set theory and discrete mathematics
- Basic probability theory

Algorithms

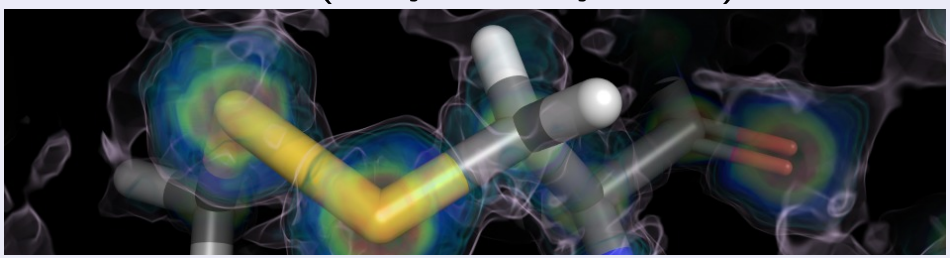
- Basic data structures (lists, queues, trees, graphs)
- Basic algorithmic techniques (loops, conditions, recursion)

You can learn these things as we go!

Programming

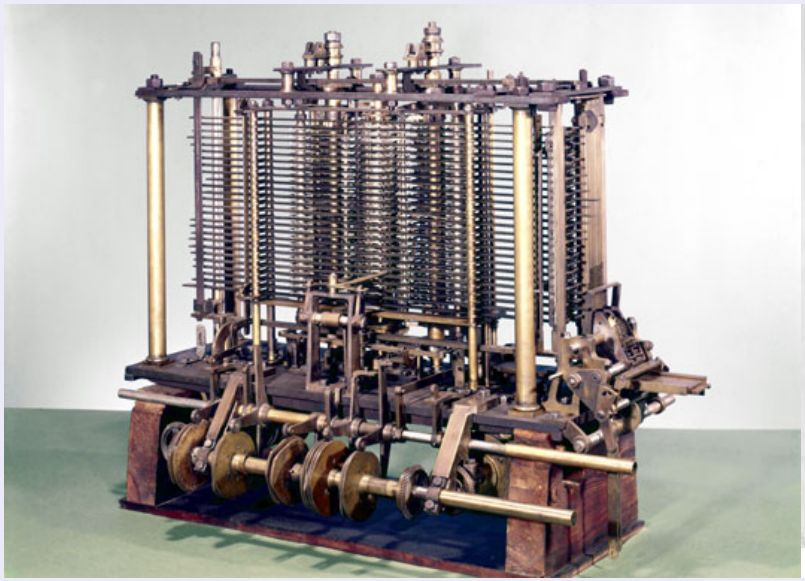
Python

- Easy-to-learn, easy-to-read
- Interpreted language, interactive (slow, but...)
- Widespread (also in AI, see Further Material), multi-purpose
- AIMA pseudo code uses similar syntax
- Extensive libraries:
  - Scientific computing (NumPy, SciPy, matplotlib)
  - NLP: NLTK
  - Graph theory (networkx)
  - Visualization (MayaVi, PyMOL)



AI Milestones

Babbage's mechanical computer



Library of Congress

AI Milestones

Rodney Brooks Robotics

http://www.youtube.com/watch?v=Uqt_pRbR8rI&feature=player_embedded#!

AI Milestones

IBM's Deep Blue beats Garry Kasparov in 1997

May 11th, 1997

Computer won world champion of chess

(Deep Blue) (Garry Kasparov)

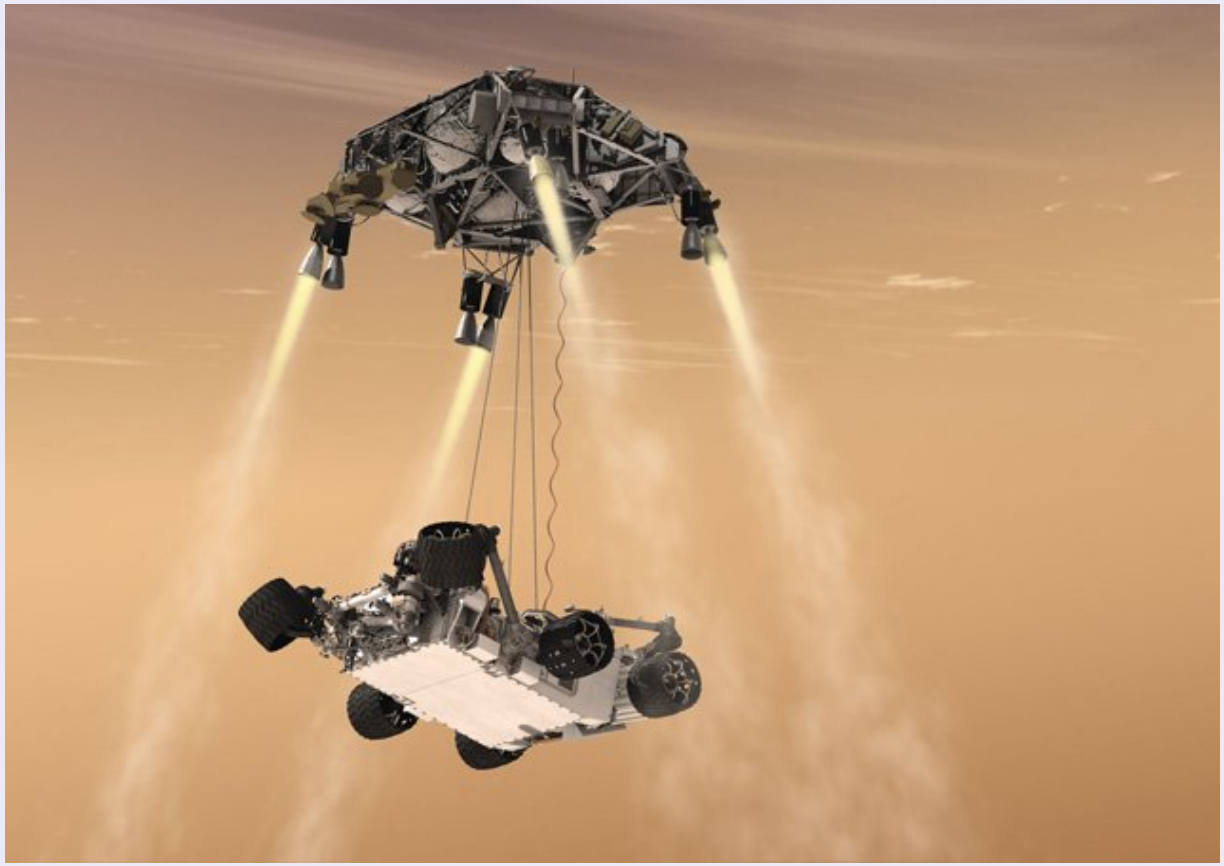
(Reuters = Kyodo News)

AI Milestones

IBM's Watson beats Jeopardy ! champions

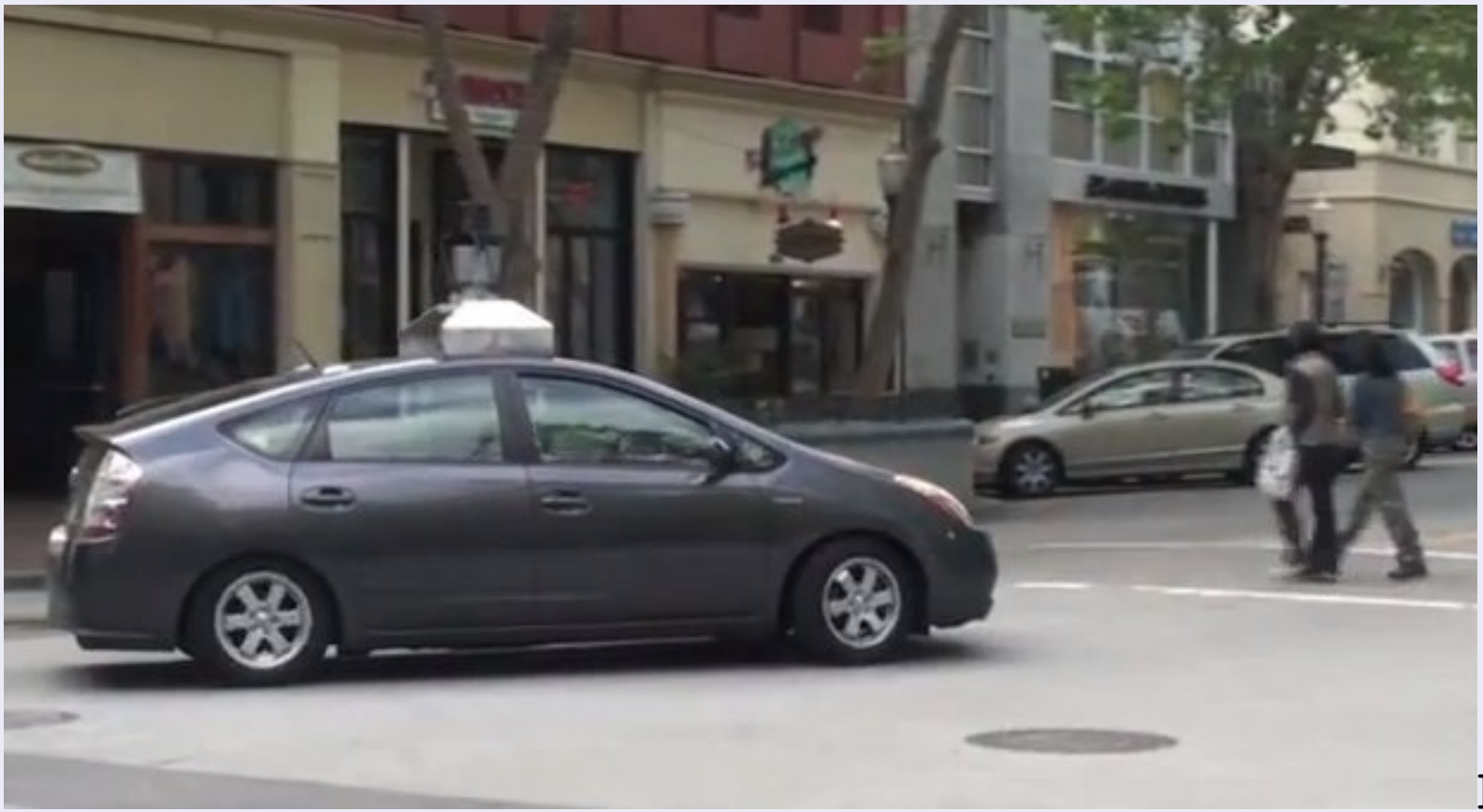
AI Milestones

"Curiosity" spectacularly lands on Mars



AI Milestones

Driverless cars



http://www.youtube.com/watch?v=C9p8B7-5MTI

Roots of AI

Fields of relevance

Philosophy logic, methods of reasoning, mind as physical system foundations of learning, language, rationality,

Mathematics formal representation and proof, algorithms, computation, (un)decidability, (in)tractability probability

Psychology adaptation, phenomena of perception and motor control, experimental techniques (psychophysics, etc.)

Economics formal theory of rational decisions

Linguistics knowledge representation, grammar

Neuroscience plastic physical substrate for mental activity

Control theory homeostatic systems, stability, simple optimal agent designs

AI History

1943	McCulloch & Pitts: Artificial Neuron
1950	Turing's "Computing Machinery and Intelligence"
1950s	Early AI programs, Checkers, Backgammon "General Problem solver"
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural networks return to popularity
1988–	Resurgence of probability; Genetic Algorithms, ALife, soft computing
1995–	Agents, agents, everywhere ...
2003–	Human-level AI back on the agenda

AI Technologies

Technologies invented in AI labs

- Time Sharing
- GUIs + mouse
- Rapid development environments
- The linked list data type
- Automatic storage management
- Symbolic programming (e.g. PROLOG)
- Functional programming (e.g. LISP)
- Object-oriented programming
- Dynamic programming

AI Technologies Today

- Knowledge representation and reasoning
- Search Algorithms, Constraint Processing
- Machine Learning
- Natural Language Processing
- Planning and Scheduling
- Computer Vision
- Robotic Control
- Multi-agent systems (distributed AI)

Applications of AI

- Finance
- Medicine
- Electrical Engineering
- Security
- Bioinformatics
- Military

What is AI?

Traditional views

	human-centered	**rationality-centered**
Think	think like humans	think rationally
Act	act like humans	act rationally

Thinking humanly

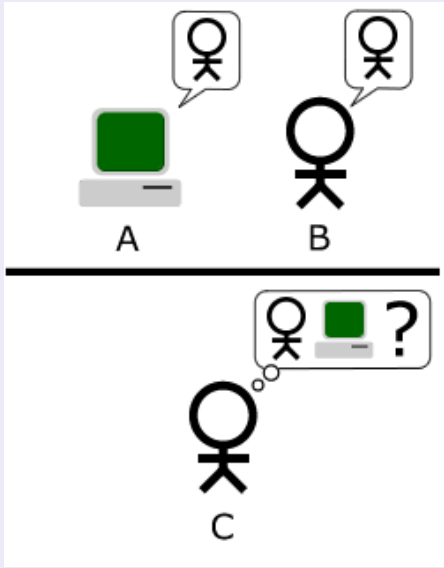
Cognitive Science

- based on information-processing psychology (1960s)
- Validation requires scientific theories of internal activities of the brain
  - Cognitive Science (predicting and testing behavior of human subjects)

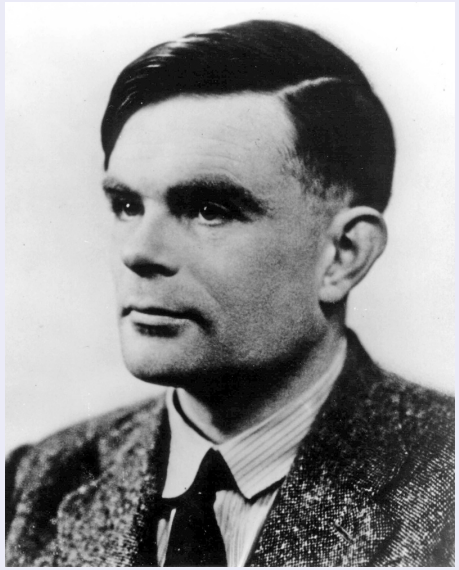
  - Cognitive Neuroscience (Neurological data)
  - Both fields nowadays distinct from AI

Acting humanly

Turing Test



Turing Test



Alan M. Turing (1950)

- Turing's prediction: By 2000, a bot can fool 30% of judges
- 2014 - Eugene Goostman: simulating an Ukrainian boy could fool 33% of judges, considered the first "pass", disputed
- Problem: Turing test is not *reproducible*, *constructive*, or amenable to *mathematical analysis*

Thinking rationally

"Laws of thought" approach

- Logic: precise notation for statements about all kinds of objects
- Problems:
  - Formalization
  - Uncertainty
  - Computable often only for small instances

Acting rationally

- An agent is an entity that can perceive and act
- This course is about designing rational agents
- Rational behavior: doing the right thing
- The right thing: what is expected to maximize goal achievement, given available information, doesn't necessarily involve thinking

Environment Types

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)
  - Next state determined by current state and agent's action
  - If environment is deterministic except for the actions of other agents: environment is strategic
- Episodic (vs. sequential)
  - Agent's experience divided into atomic "episodes": each episode consists of the agent perceiving and then performing a single action, choice of action in each episode depends only on current episode

Environment Types cont.

Types

- Static (vs. dynamic):
  - The environment is unchanged while an agent is deliberating.
  - The environment is semidynamic: if environment does not change but performance score does
- Discrete (vs. continuous):
  - A finite number of distinct, clearly defined percepts and actions
- Single agent (vs. multi-agent)
  - An agent operating by itself in an environment

Environment Types cont.

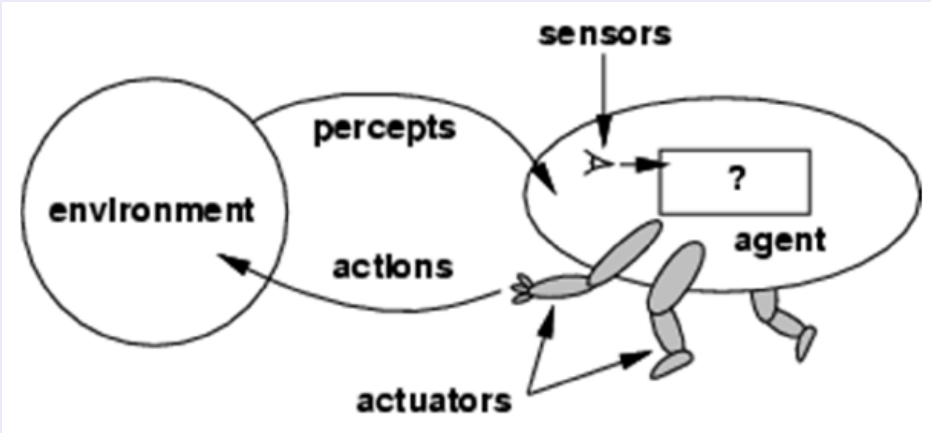
Examples

	Chess	Taxi drive
Fully observable		
Deterministic		
Episodic		
Static		
Discrete		
Single agent		

What is an Agent?

Agent Terminology

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



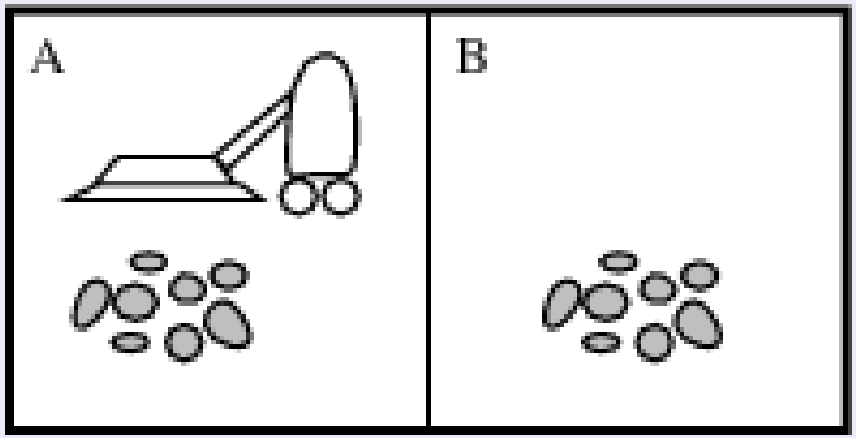
- Autonomous: Actions $\mathcal{A}$ determined by Percepts $\mathcal{P}$

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

- We want: best performance for every environment $\rightarrow$ requires performance measure

Example Agent

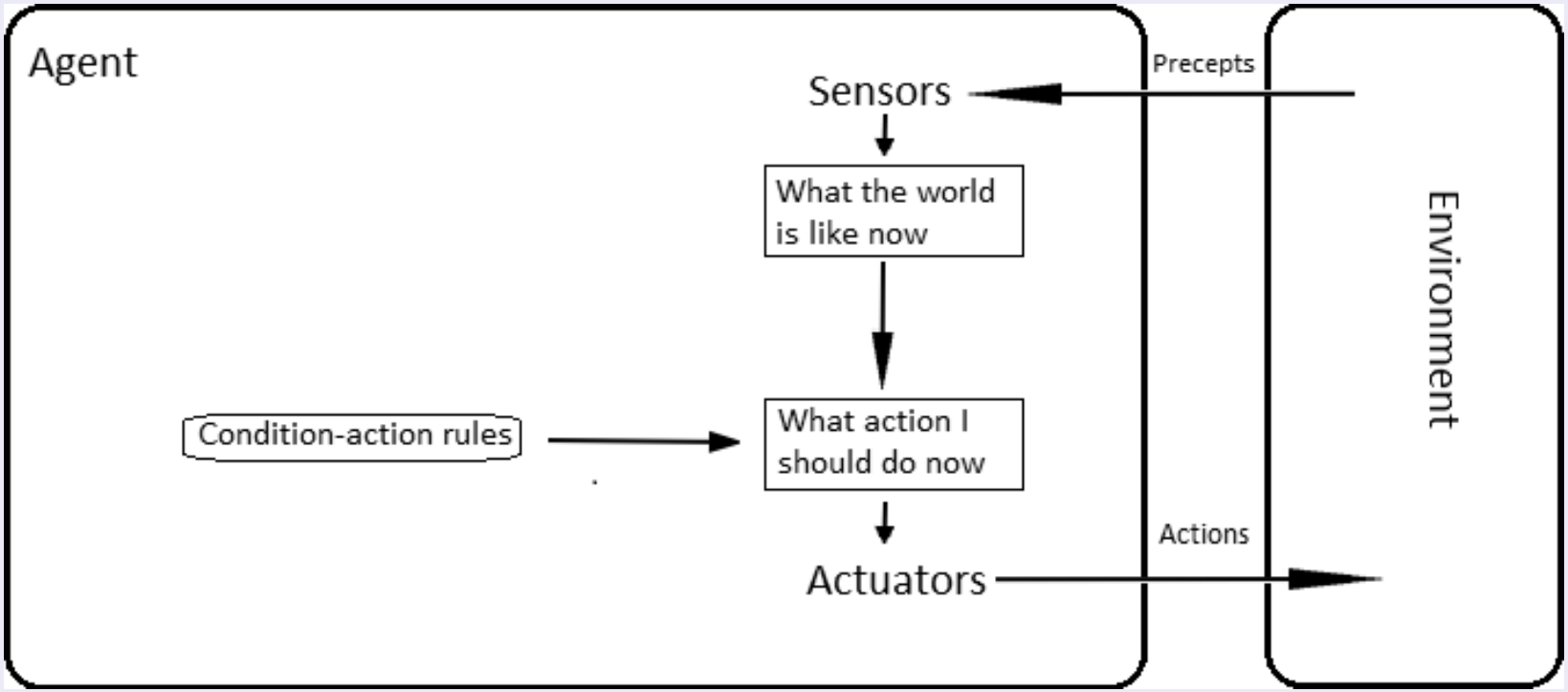
Vacuum cleaner



- $\mathcal{P}$: location, dirty/clean `[A, dirty]`
- $\mathcal{A}$: *GoLeft*, *GoLeft*, *Clean*, *Idle*
- Question: Size of State space?
- for 10 rooms, 5 levels of dirt?

Simple Reflex Agent

Simple reflex agent

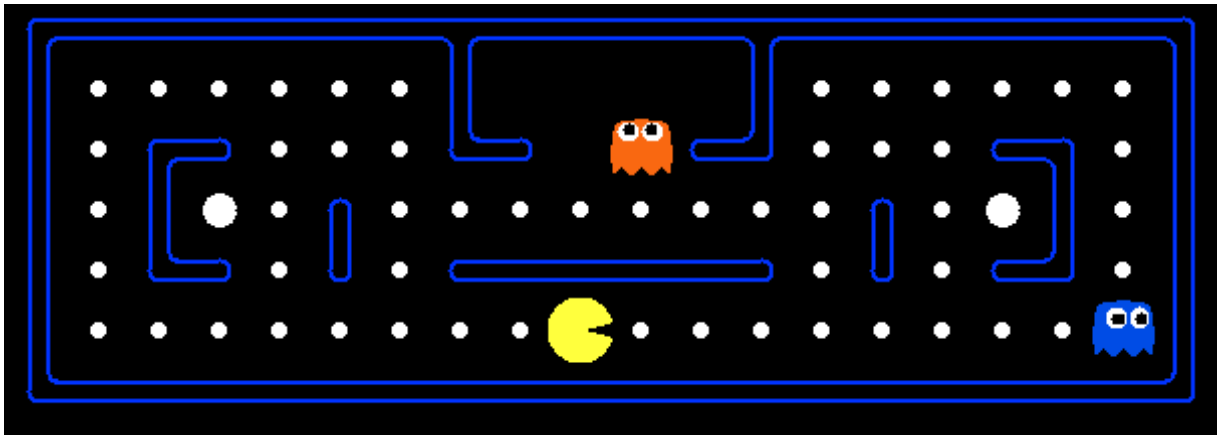


Reflex agents cont.

Rodney Brooks - Behavioral Robotics

- One school of thought: "The world is its own best model"
- Cog Project ("Cockroach robotics")

Reflex Agent cont.



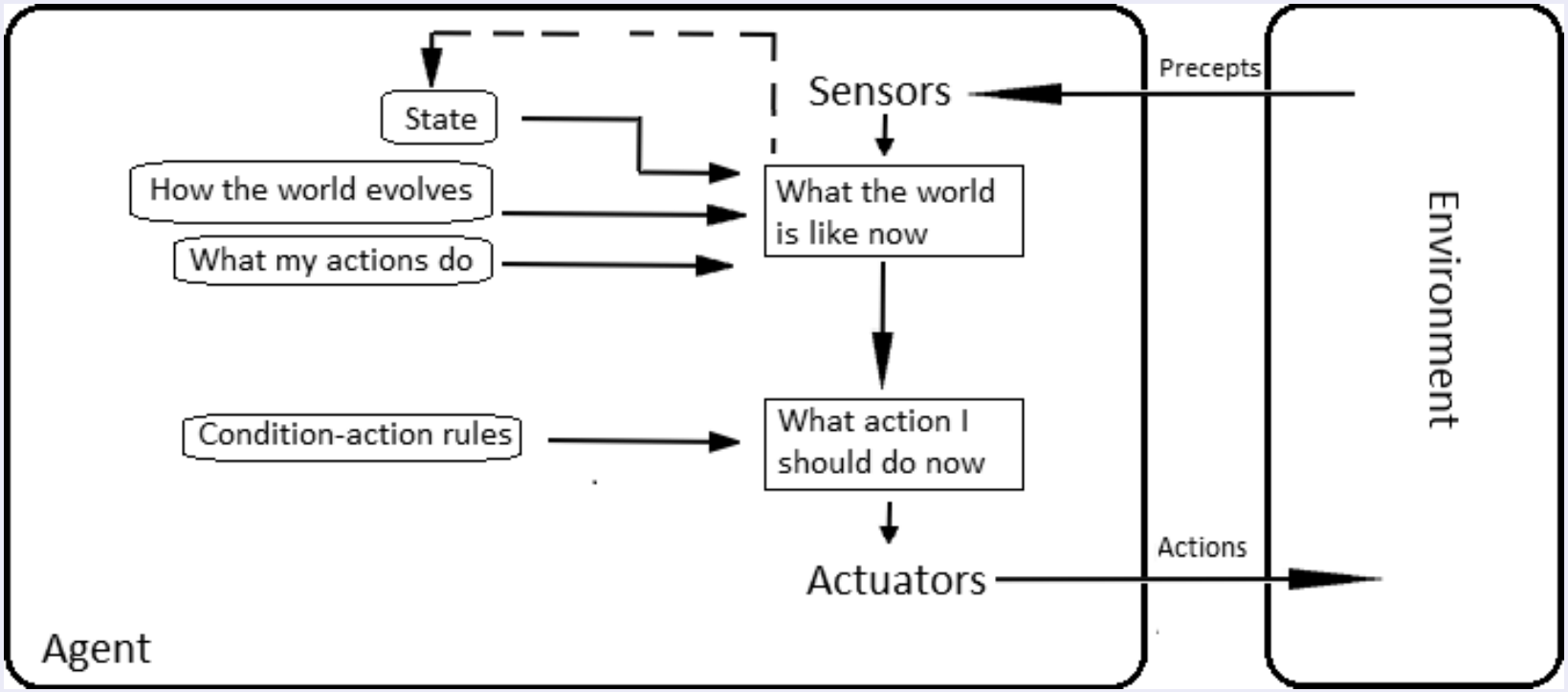
PacmanReflexAgent

if wall in front of me **then**
    turn right
else
    move forward
end if

Can a reflex agent be rational (optimal)?

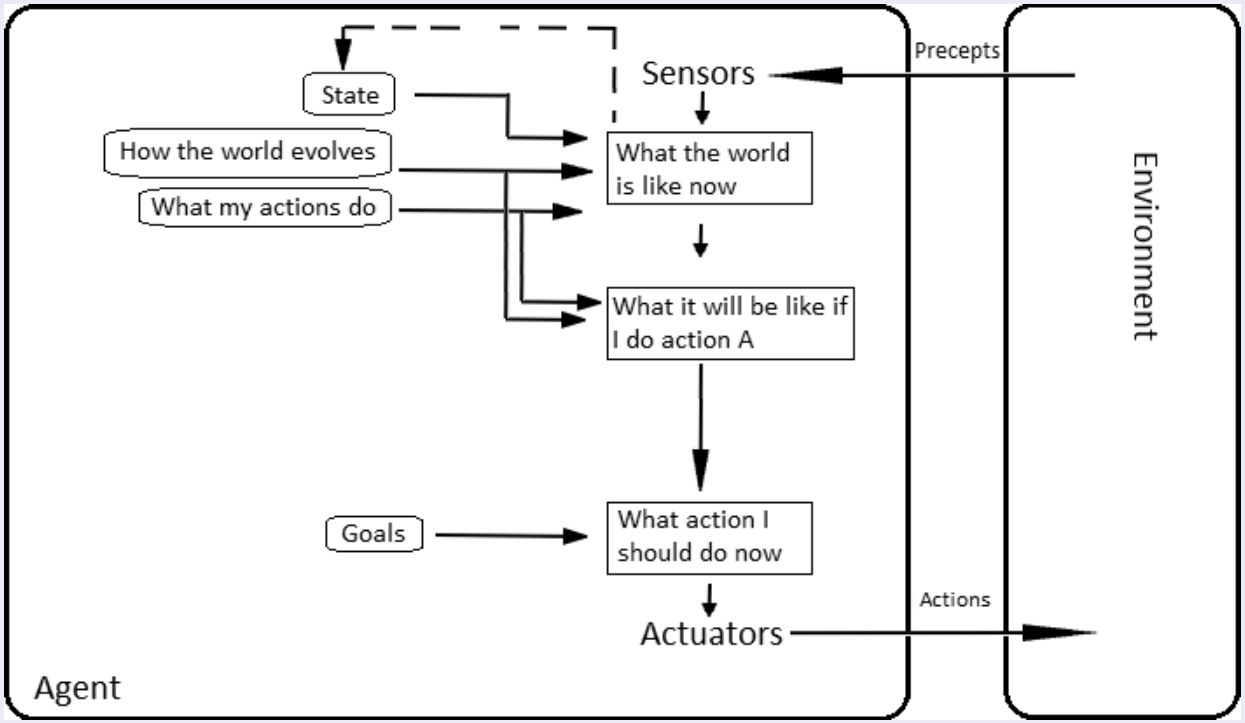
Model based reflex agent

Keeping state information



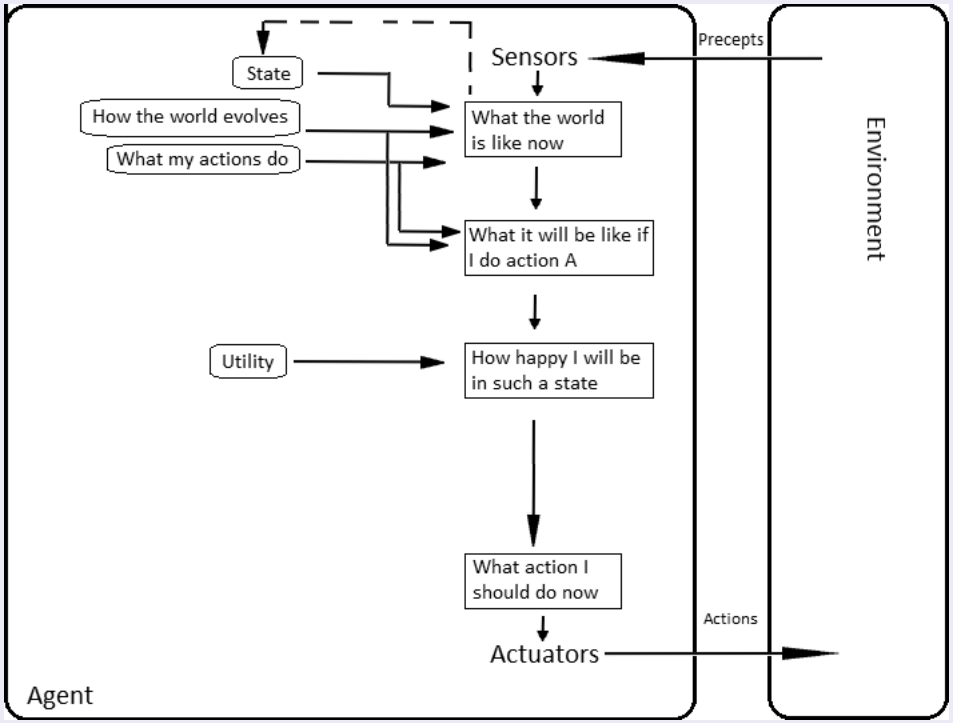
Model based goal based agent

Keeping state information, goal in mind



Utility based agent

"Happy" agents



Required Reading

Literature

- Stuart Russell and Peter Norvig. *Artificial Intelligence: A Modern Approach*. Prentice Hall, 3rd edition, 2010
  - Chapter 1
  - Chapter 2

"Education is the path from cocky ignorance to miserable uncertainty"

Mark Twain