Summer 2020
Lecture 1
CSE 351: Artificial Intelligence

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Why Study AI?

- AI makes computers more useful
- Intelligent computer would have huge impact on civilization
- AI cited as “field I would most like to be in” by scientists in all fields
- Computer is a good metaphor for talking and thinking about intelligence

Why Study AI?

- Turning theory into working programs forces us to work out the details
- AI yields good results for Computer Science
- AI yields good results for other fields
- Computers make good experimental subjects
- Personal motivation: mystery

What is the definition of AI?

What do you think?

What is the definition of AI?

Systems that think like humans	**Systems that think rationally**
Systems that act like humans	Systems that act rationally

What is the definition of AI?

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Bellman, 1978

"[The automation of] activities that we associate with human thinking, activities such as decision making, problem solving, learning"

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Charniak & McDermott, 1985

“The study of mental faculties through the use of computational models”

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Dean et al., 1995

“The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent”

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Haugeland, 1985

“The exciting new effort to make computers think *machines with minds*, in the full and literal sense”

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Kurzweil, 1990

"The art of creating machines that perform functions that require intelligence when performed by people"

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Luger & Stubblefield, 1993

"The branch of computer science that is concerned with the automation of intelligent behavior"

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Nilsson, 1998

“Many human mental activities such as writing computer programs, doing mathematics, engaging in common sense reasoning, understanding language, and even driving an automobile, are said to demand intelligence. We might say that [these systems] exhibit artificial intelligence”

What is the definition of AI?

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Rich & Knight, 1991

"The study of how to make computers do things at which, at the moment, people are better"

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Schalkoff, 1990

"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes"

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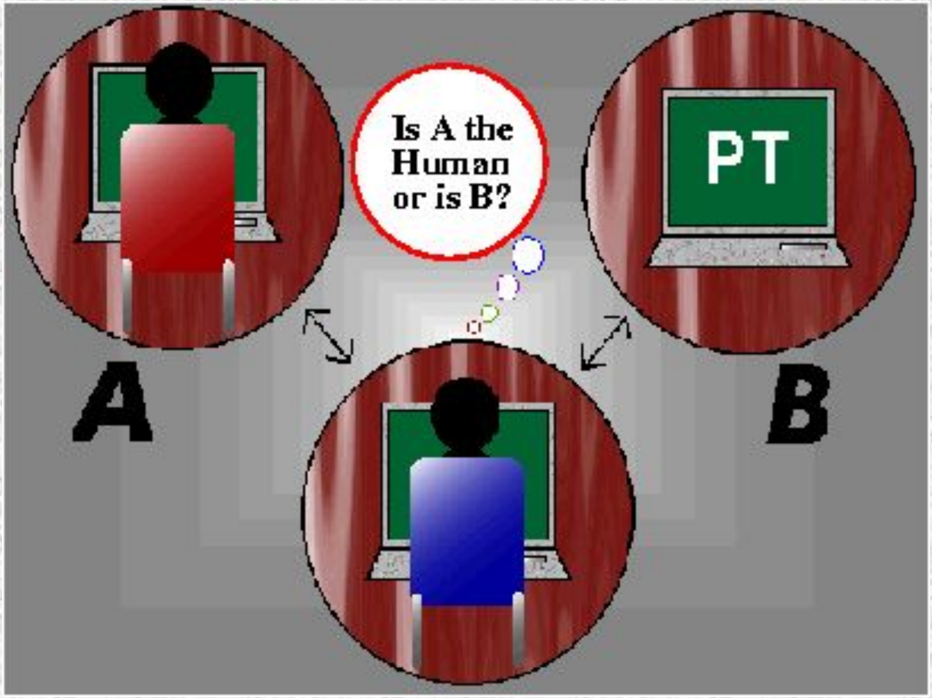
Winston, 1992

“The study of the computations that make it possible to perceive, reason, and act”

Approach 1: Acting Humanly

- Turing test: ultimate test for acting humanly
  - Computer and human both interrogated by judge
  - Computer passes test if judge can’t tell the difference



How effective is this test?

- Agent must:
  - Have command of language
  - Have wide range of knowledge
  - Demonstrate human traits (humor, emotion)
  - Be able to reason
  - Be able to learn
- Loebner prize competition is modern version of Turing Test
  - Example: Alice, Loebner prize winner for 2000 and 2001

Chinese Room Argument

Imagine you are sitting in a room with a library of rule books, a bunch of blank exercise books, and a lot of writing utensils. Your only contact with the external world is through two slots in the wall labeled ``input'' and ``output''. Occasionally, pieces of paper with Chinese characters come into your room through the ``input'' slot. Each time a piece of paper comes in through the input slot your task is to find the section in the rule books that matches the pattern of Chinese characters on the piece of paper. The rule book will tell you which pattern of characters to inscribe the appropriate pattern on a blank piece of paper. Once you have inscribed the appropriate pattern according to the rule book your task is simply to push it out the output slot.

By the way, you don't understand Chinese, nor are you aware that the symbols that you are manipulating are Chinese symbols.

In fact, the Chinese characters which you have been receiving as input have been questions about a story and the output you have been producing has been the appropriate, perhaps even "insightful," responses to the questions asked. Indeed, to the outside questioners your output has been so good that they are convinced that whoever (or whatever) has been producing the responses to their queries must be a native speaker of, or at least extremely fluent in, Chinese.

Do you understand Chinese?

- Searle says NO
- What do you think?
- Is this a refutation of the possibility of AI?
- The Systems Reply
  - The individual is just part of the overall system, which does understand Chinese
- The Robot Reply
  - Put same capabilities in a robot along with perceiving, talking, etc. This agent would seem to have genuine understanding and mental states.

Approach 2: Thinking Humanly

- Requires knowledge of brain function
- What level of abstraction?
- How can we validate this
- This is the focus of Cognitive Science

Approach 3: Thinking Rationally

- Aristotle attempted this
- What are correct arguments or thought processes?
- Provided foundation of much of AI
- Not all intelligent behavior controlled by logic
- What is our goal? What is the purpose of thinking?

Approach 4: Acting Rationally

- Act to achieve goals, given set of beliefs
- Rational behavior is doing the “right thing”
  - Thing which expects to maximize goal achievement
- This is approach adopted by Russell & Norvig

Foundations of AI

- Philosophy
  - 450 BC, Socrates asked for algorithm to distinguish pious from non-pious individuals
  - Aristotle developed laws for reasoning
- Mathematics
  - 1847, Boole introduced formal language for making logical inference
- Economics
  - 1776, Smith views economies as consisting of agents maximizing their own well being (payoff)
- Neuroscience
  - 1861, Study how brains process information
- Psychology
  - 1879, Cognitive psychology initiated
- Linguistics
  - 1957, Skinner studied behaviorist approach to language learning

History of AI

- CS-based AI started with “Dartmouth Conference” in 1956
- Attendees
  - John McCarthy
    - LISP, application of logic to reasoning
  - Marvin Minsky
    - Popularized neural networks
    - Slots and frames
    - The Society of the Mind
  - Claude Shannon
    - Computer checkers
    - Information theory
    - Open-loop 5-ball juggling
  - Allen Newell and Herb Simon
    - General Problem Solver

AI Questions

- Can we make something that is as intelligent as a human?
- Can we make something that is as intelligent as a bee?
- Can we make something that is evolutionary, self improving, autonomous, and flexible?
- Can we save this plant $20M/year by pattern recognition?
- Can we save this bank $50M/year by automatic fraud detection?
- Can we start a new industry of handwriting recognition agents?

Which of these exhibits intelligence?

- You beat somebody at chess.
- You prove a mathematical theorem using a set of known axioms.
- You need to buy some supplies, meet three different colleagues, return books to the library, and exercise. You plan your day in such a way that everything is achieved in an efficient manner.
- You are a lawyer who is asked to defend someone. You recall three similar cases in which the defendant was guilty, and you turn down the potential client.
- A stranger passing you on the street notices your watch and asks, “Can you tell me the time?” You say, “It is 3:00.”
- You are told to find a large Phillips screwdriver in a cluttered workroom. You enter the room (you have never been there before), search without falling over objects, and eventually find the screwdriver.

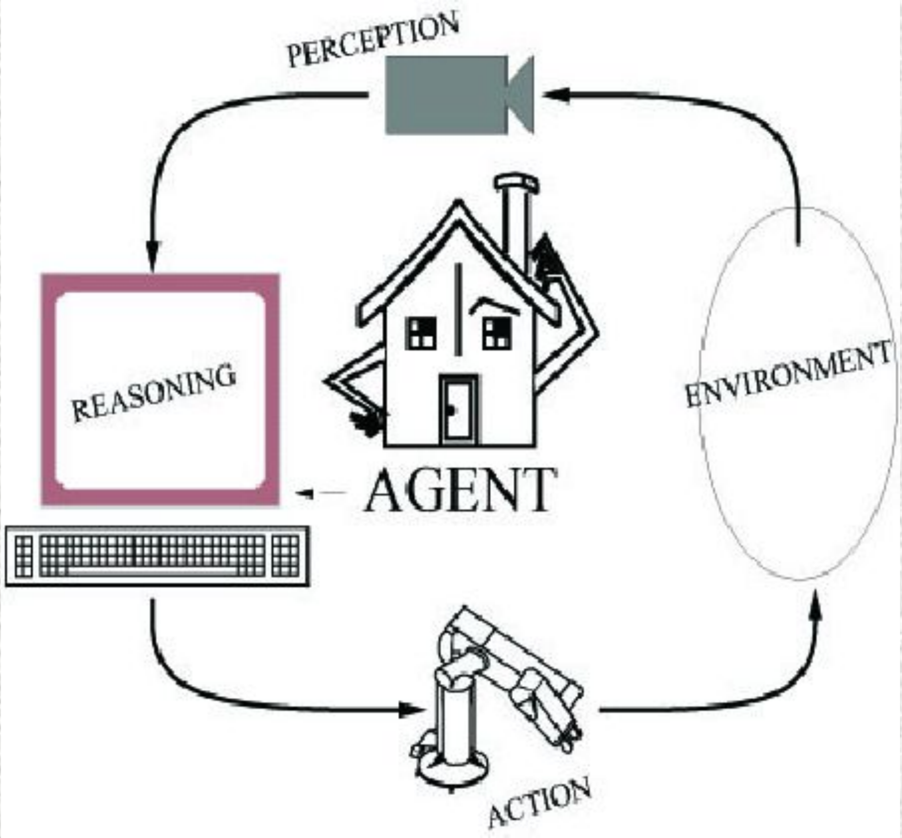
Which of these exhibits intelligence?

- You are a six-month-old infant. You can produce sounds with your vocal organs, and you can hear speech sounds around you, but you do not know how to make the sounds you are hearing. In the next year, you figure out what the sounds of your parents' language are and how to make them.
- You are a one-year-old child learning Arabic. You hear strings of sounds and figure out that they are associated with particular meanings in the world. Within two years, you learn how to segment the strings into meaningful parts and produce your own words and sentences.
- Someone taps a rhythm, and you are able to beat along with it and to continue it even after it stops.
- You are some sort of primitive invertebrate. You know nothing about how to move about in your world, only that you need to find food and keep from bumping into walls. After lots of reinforcement and punishment, you get around just fine.

Which of these can currently be done?

- Play a decent game of table tennis
- Drive autonomously along a curving mountain road
- Drive autonomously in the center of Cairo
- Play a decent game of bridge
- Discover and prove a new mathematical theorem
- Write an intentionally funny story
- Give competent legal advice in a specialized area of law
- Translate spoken English into spoken Swedish in real time
- Plan schedule of operations for a NASA spacecraft
- Defeat the world champion in chess

Components of an AI System



An agent perceives its environment through sensors and acts on the environment through actuators.

Human: sensors are eyes, ears, actuators (effectors) are hands, legs, mouth.

Robot: sensors are cameras, sonar, lasers, ladar, bump, effectors are grippers, manipulators, motors

The agent's behavior is described by its function that maps percept to action.

Rationality

- A rational agent does the right thing (what is this?)
- A fixed performance measure evaluates the sequence of observed action effects on the environment

PEAS

- Use PEAS to describe task
  - Performance measure
  - Environment
  - Actuators
  - Sensors

PEAS

- Use PEAS to describe task environment
  - Performance measure
  - Environment
  - Actuators
  - Sensors
- Example: Taxi driver
  - Performance measure: safe, fast, comfortable (maximize profits)
  - Environment: roads, other traffic, pedestrians, customers
  - Actuators: steering, accelerator, brake, signal, horn
  - Sensors: cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors

Environment Properties

- Fully observable vs. partially observable
- Deterministic vs. stochastic / strategic
- Episodic vs. sequential
- Static vs. dynamic
- Discrete vs. continuous
- Single agent vs. multiagent

Environment Examples

Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Chess with a clock						
Chess without a clock						

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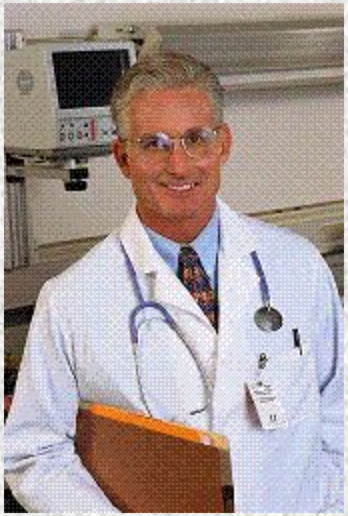

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Medical diagnosis						

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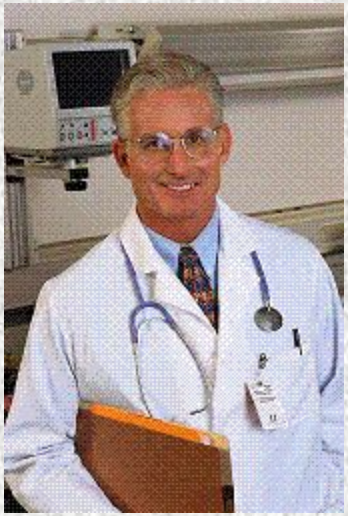

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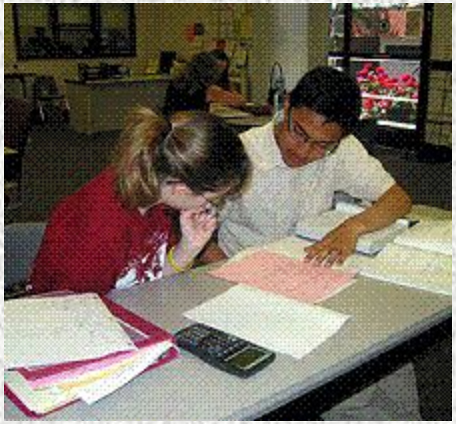

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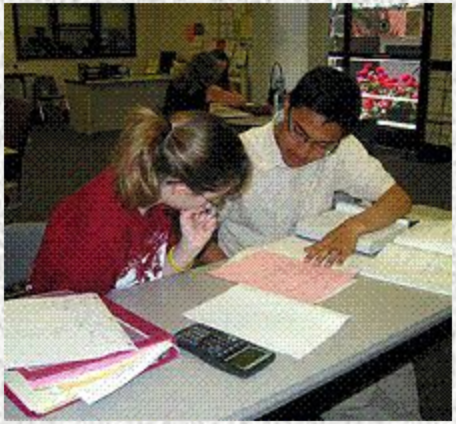

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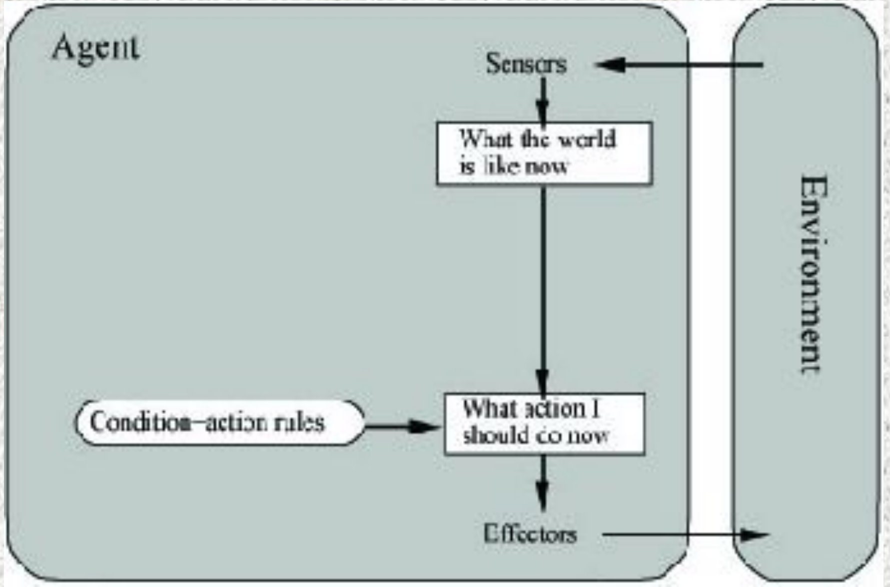
Agent Types

- Types of agents (increasing in generality and ability to handle complex environments)
  - Simple reflex agents
  - Reflex agents with state
  - Goal-based agents
  - Utility-based agents
  - Learning agent

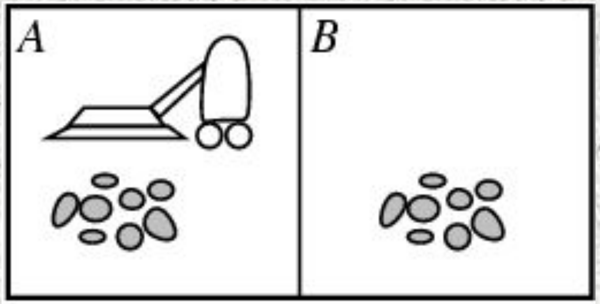
Simple Reflex Agent

- Use simple “if then” rules
- Can be short sighted




```
SimpleReflexAgent(percept)
  state   = InterpretInput(percept)
  rule    = RuleMatch(state, rules)
  action = RuleAction(rule)
  Return action
```

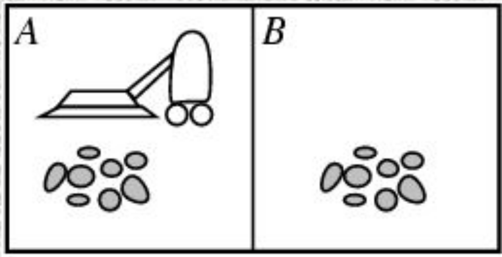
Example: Vacuum Agent



- Performance?
  - 1 point for each square cleaned in time T?
  - #clean squares per time step - #moves per time step?
- Environment: vacuum, dirt, multiple areas defined by square regions
- Actions: left, right, suck, idle
- Sensors: location and contents
  - [A, dirty]

- Rational is not omniscient
  - Environment may be partially observable
- Rational is not clairvoyant
  - Environment may be stochastic
- Thus Rational is not always successful

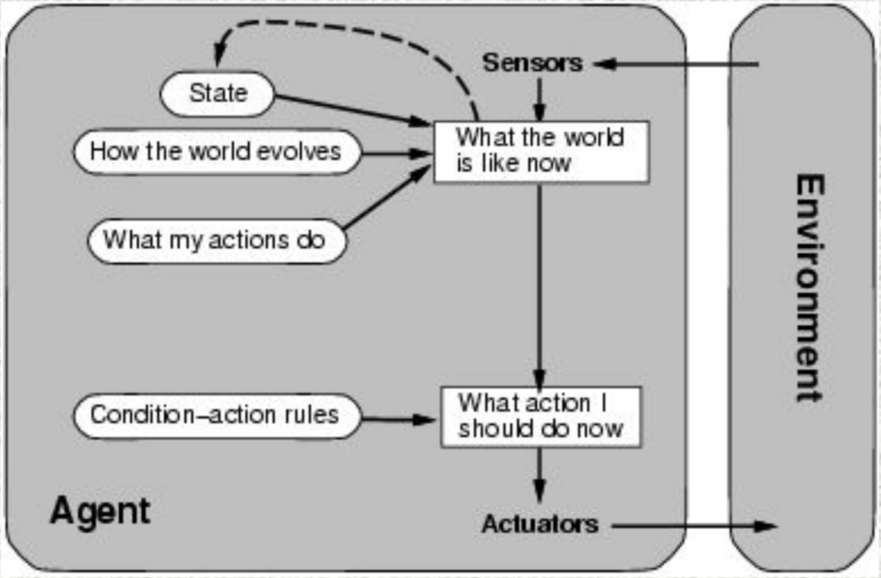
Reflex Vacuum Agent



- If status=Dirty then return Suck
  else if location=A then return Right
  else if location=B then right Left

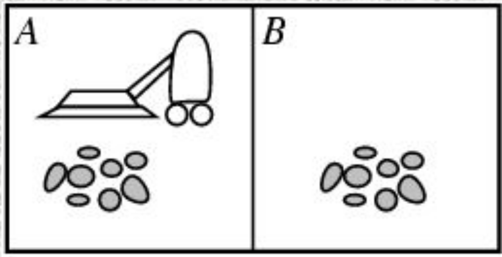
Reflex Agent With State

- Store previously-observed information
- Can reason about unobserved aspects of current state



ReflexAgentWithState(percept)
 state = UpdateDate(state,action,percept)
 rule = RuleMatch(state, rules)
 action = RuleAction(rule)
 Return action

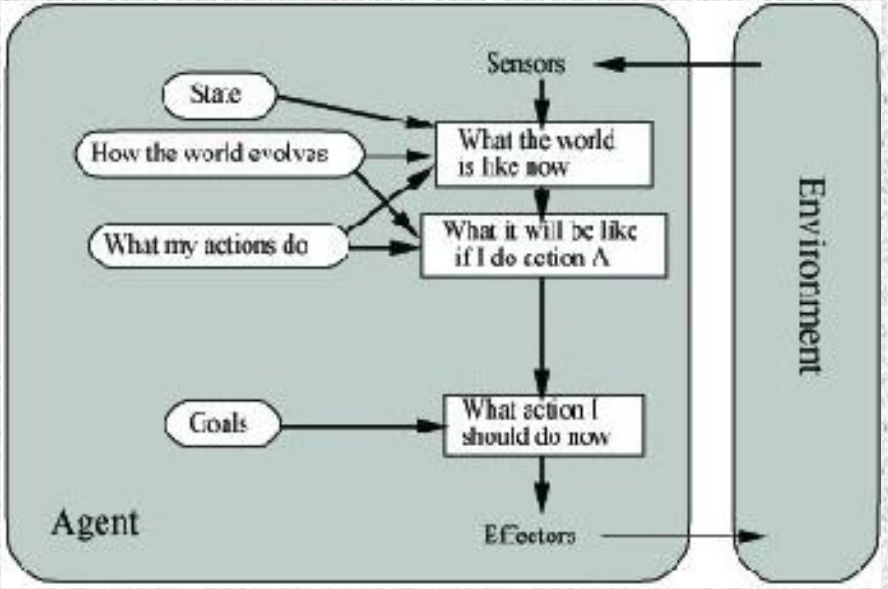
Reflex Vacuum Agent



- If status=Dirty then Suck
  else if have not visited other square in >3 time units, go there

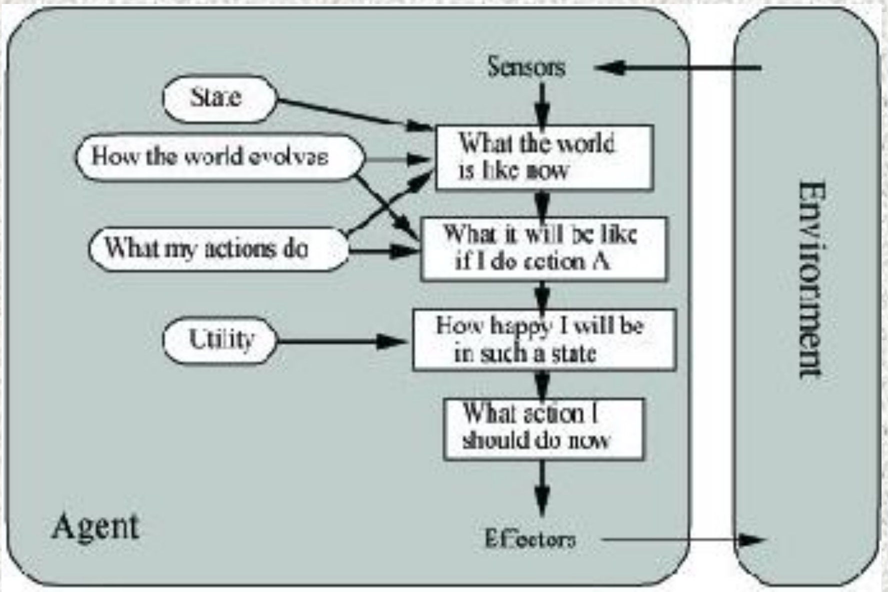
Goal-Based Agents

- Goal reflects desires of agents
- May project actions to see if consistent with goals
- Takes time, world may change during reasoning

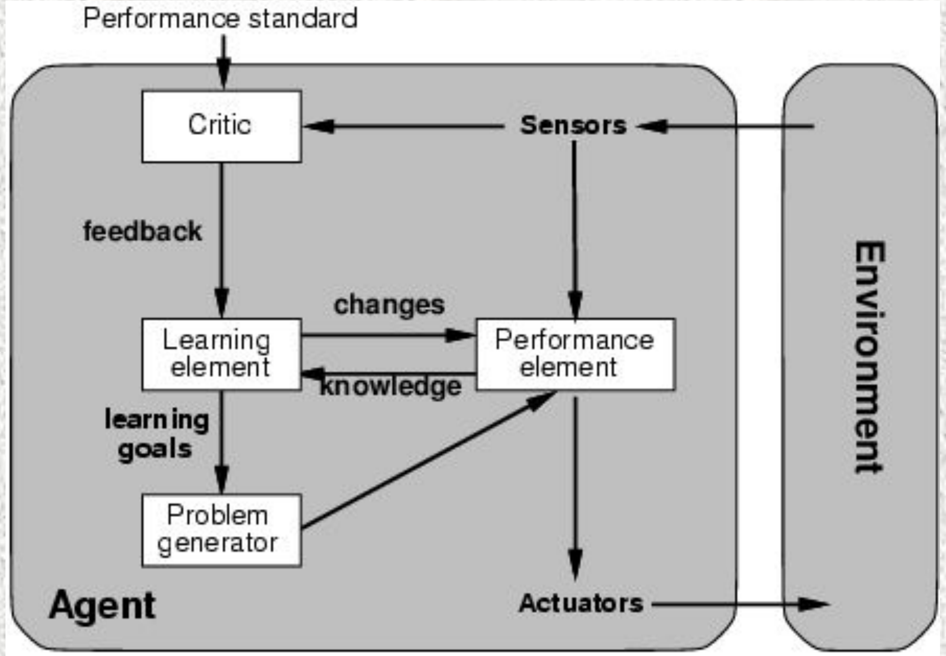


Utility-Based Agents

- Evaluation function to measure utility f(state) -> value
- Useful for evaluating competing goals

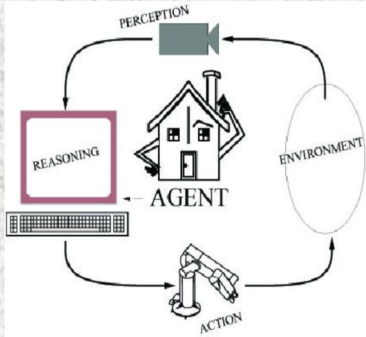


Learning Agents



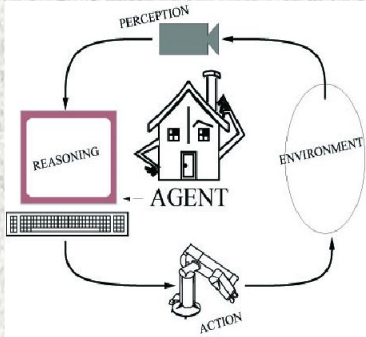
Xavier mail delivery robot

- Performance: Completed tasks
- Environment: See for yourself
- Actuators: Wheeled robot actuation
- Sensors: Vision, sonar, dead reckoning
- Reasoning: Markov model induction, A* search, Bayes classification



Pathfinder Medical Diagnosis System

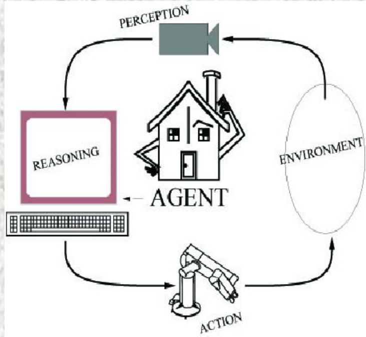
- Performance: Correct [Hematopathology diagnosis]
- Environment: Automate human diagnosis, partially observable, deterministic, episodic, static, continuous, single agent
- Actuators: Output diagnoses and further test suggestions
- Sensors: Input symptoms and test results
- Reasoning: Bayesian networks, Monte-Carlo simulations



TDGammon

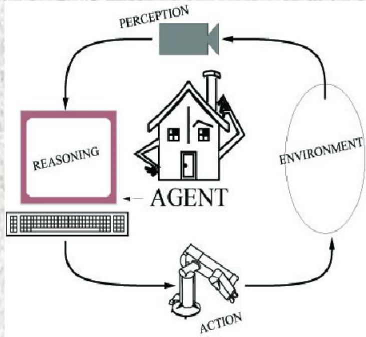
- Performance: Ratio of wins to losses
- Environment: Graphical output showing dice roll and piece movement, fully observable, stochastic, sequential, static, discrete, multiagent

  [World Champion Backgammon Player]
- Sensors: Keyboard input
- Actuator: Numbers representing moves of pieces
- Reasoning: Reinforcement learning, neural networks



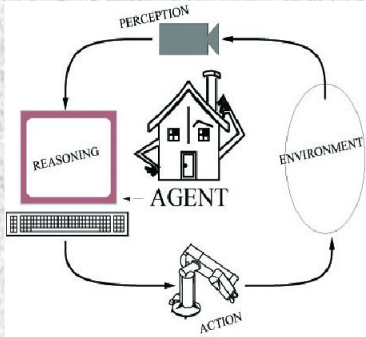
Factory Floor Scheduling

- Performance:
- Environment:
- Actuators: Ordering of tasks
- Sensors: Assembly tree, Bill of materials
- Reasoning: Constraint satisfaction, nonlinear and hierarchical planning, genetic algorithms, search



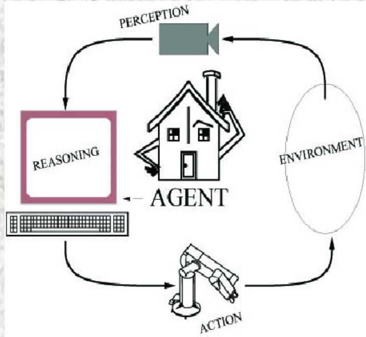
Alvinn

- Performance: Stay in lane, on road, maintain speed
- Environment: Driving Hummer on and off road without manual control (Partially observable, stochastic, episodic, dynamic, continuous, single agent), Autonomous automobile
- Actuators: Speed, Steer
- Sensors: Stereo camera input
- Reasoning: Neural networks



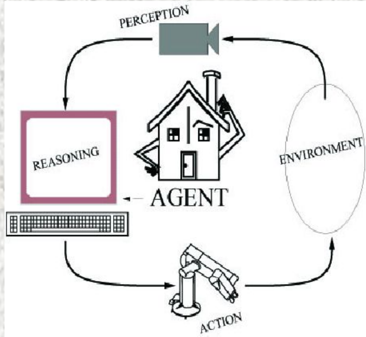
Talespin

- Performance: Entertainment value of generated story
- Environment: Generate text-based stories that are creative and understandable
  - One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe threatened to hit Irving if he didn't tell him where some honey was.
  - Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. Gravity drowned. Joe Bear was hungry. He asked Irving Bird where some honey was. Irving refused to tell him, so Joe offered to bring him a worm if he'd tell him where some honey was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was…
- Actuators: Add word/phrase, order parts of story
- Sensors: Dictionary, Facts and relationships stored in database
- Reasoning: Planning



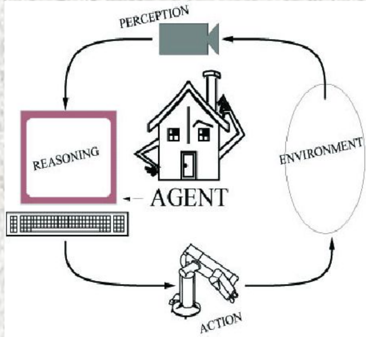
Robot Soccer

- Robot soccer competition
- Sensors: Camera image, messages from other players
- Reasoning: Planning, image processing
- Action: Robot 2D move or kick ball



Webcrawler Softbot

- Search web for items of interest
- Perception: Web pages
- Reasoning: Pattern matching
- Action: Select and traverse hyperlinks



Other Example AI Systems

- Translation of Caterpillar truck manuals into 20 languages
- Shuttle packing
- Military planning (Desert Storm)
- Intelligent vehicle highway negotiation
- Credit card transaction monitoring
- Billiards robot
- Juggling robot
- Credit card fraud detection
- Lymphatic system diagnoses
- Mars rover
- Sky survey galaxy data analysis

Other Example AI Systems

- Knowledge Representation
- Search
- Problem solving
- Planning
- Machine learning
- Natural language processing
- Uncertainty reasoning
- Computer Vision
- Robotics