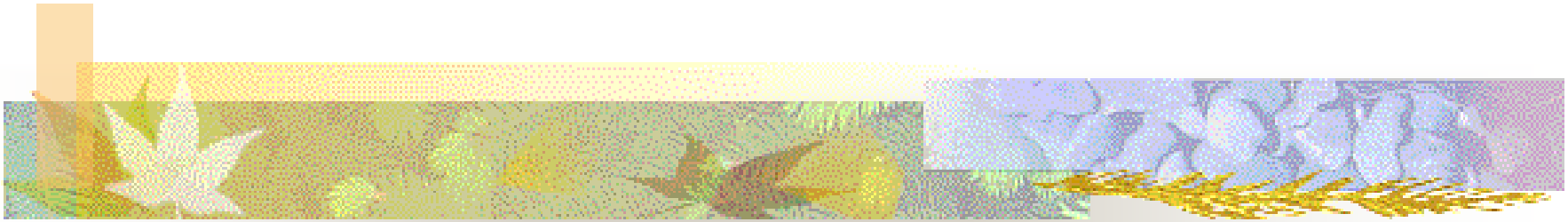
Intro to AI

6 lectures

Mária Markošová



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Conditions

1. Attend the exercises; Mgr Pocos and Mgr Beckova. All about exercises is in his competence.
2. All lectures, slides in English will be on Teams.
3. Evaluation: 50 percent exercises, 50 percent exam. You need to have 25 percent on exercises (detailed information will be given by Mgr Pocos and Mgr Beckova) in order to absolve exams.
4. Exam is written, based on the problem solving, not on the definitions.

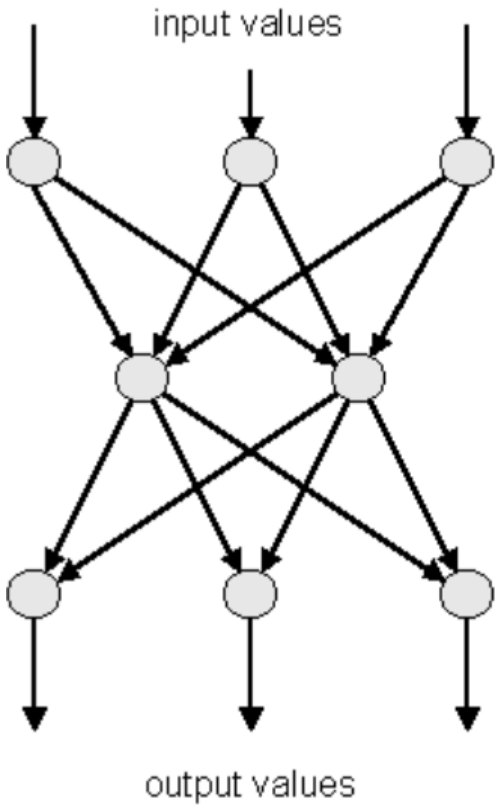
What to expect

1. Basic concepts, intelligence, AI, definitions, agent, agent example. Simple reflex agent. Environments.
2. Goal based agent and searching, tree search, graph search, blind search, informed search.
3. Heuristics and how to find a good heuristics, local search (hill climbing, genetic algorithm).
4. CSP problem, definition, backtracking search, heuristis.
5. Games, MinMax and alpha beta pruning, Expectiminimax, KB agent, example.
6. Logical agent, inference in propositional KB, forward, backward chaining, CNF form of KB, resolution.

Second half: nature-inspired computing in AI (prof. Beňušková)

http://dai.fmph.uniba.sk/w/Course:Introduction_to_artificial_intelligence

- 07.11. Introduction, learning in AI agents, some basic math.
- 14.11. Learning of a single perceptron (model of a neuron).
- 21.11. Learning in a multi-layer neural network.
- 28.11. Unsupervised learning: Self-organized neural net.
- 05.12. Practical applications of neural nets for (visual, sound) signal classification and robot navigation.
- 12.12. Quo vadis AI? Problems and visions of future AI methods (gaming, social nets, chatbots, etc.).



What is intelligence?

1. Definitions from dictionary.

   a) Intelligence is an ability to gain and process knowledge .

   b) Intelligence is an ability to think and derive new knowledge.

   c) Intelligence is

   -the ability to learn or understand or to deal with new or trying situations

   -the skilled use of reason

   -the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests) (online webster)

2. Technological definition

Intelligence is an ability to process an information (processing capability)

3. Definition from Encyclopedia (Columbia Univerzity Press)

It is a power of the mind which includes calculation, inference, reasoning, learning, classification and generalization.

4. Definition of psychologists

a) Binet's definition (Binet, fr. psychológ): Intelligence is a totality of mental processes, which leads to the adaptation.

b) Callel's definition (Raymond Callel, psychológ): Intelligence has two parts: fluid ability is a basic mental power to do conclusions and : crystalized ability are all knowledges gained by experience in a cultural environment.

5. Medical definition

Intelligence is an ability to gain and process knowledges for a certain goal..

6. Legg a Hutter (2007): Intelligence measures an agent's ability to achieve goals in a wide range of environments.

What is AI ?

Kelemen a kol. (Základy umelej inteligencie, Alfa, 1992) :

a) AI is an artificial phenomenon resembling a human intelligence.

b) AI is a wide spectrum of methods trying to realize AI defined under a)

c) AI is an area of research which looks for the limits of symbolic representation of the reality.

Návrat a kol. (Umelá inteligencia, Vydavateľstvo STU, 2001)

The goal of AI is to realize an intelligent objects and to understand their behavior. The goal of AI is not to find an answer what is intelligence in general.

Šefránek (Inteligencia ako výpočet, IRIS, 2000):

The core of AI is an afford to model an intelligent behavior and thinking with a help of computation and information processing.

Russel, Norvig (Artificial Intelligence; a modern approach, Prentice – Hall 2006):

a) AI is the exciting new afford to make computers think, to make machines with minds in the full and literal sence (Haugeland, 1985)

b) AI studies mental faculties through the use of computational models (Charniak and Mc Dermott, 1985). It is the study of the computations that make it possible to perceive, reason and act.(Winston, 1992)

c) AI is a field of study that seeks to explain and emulate intelligent behavior in terms of computational processes. (Schalkoff, 1990)

d) AI is the branch of computer science that is connected with the automatization of intelligent behavior“ (Luger and Stubblefield, 1993)

Nils J. Nilsson, Artificial intelligence: A new synthesis (1998)

AI concerns with intelligent behavior in artifacts. Intelligent behavior involves perception, reasoning, learning, communicating and acting in complex environments.

Long term goal of AI: Developement of machines, that can do these things as human can.

Categories of AI

1. Symbolic AI (the oldest part of AI based on symbols and logic as the language for the agents)

2. Subsymbolic AI (neural nets, genetic algorithma, inspired by human thinking)

Symbolic AI

1. Based on the Newel a Simon hypothesis, 1976:

   Physical symbolic system is a machine able to process the symbols.

2. The concept of **agent** is crucial.
3. We use a **knowledge base** written in a language of logic, knowledges are represented as a logical sentences.
4. Domain of the agent's activity should be well described.

Agent example: robotic fish

Toy robotic fish: percepts water and this percept is mapped to the action - movement.

Complex robotic fish developed at MIT: http://news.mit.edu/2014/soft-robotic-fish-moves-like-the-real-thing-0313

Agent

Let us call the robotic fish an agent. What should agent designer do to make robotic fish perform as an alive animal?

1. The fish must have some **senzors** to percept the environment.
2. The must have an **actuators** (tail, fin) to perform a task in the environment.
3. The robotic fish must have **a agent program,** which maps the percept into an appropriate action**.** This program is a realization of the **agent function.**

Agent: definition

Agent is a system (robot, man, softbot...), which percepts its environment with a help of sensors and acts in the environment with a help of actuators.

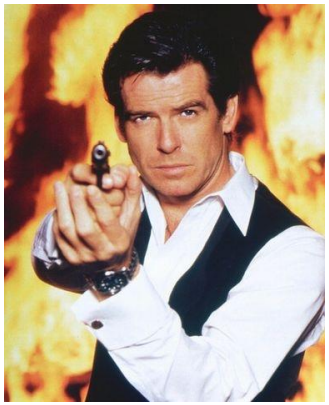
Sensors: camera, infrared sensor, temperature sensor

Actuators: tail, fin in robotic fish, artificial hand, wheels

} *Robotic agents*

Senzors: eyes, nose, ears …

Efektory: hands, feet, pistol ….



} *Agent 001*

Percept: State of the environment seen by the agent at certain time.

Percept sequence: History of percepts in time.

Action: Agent 's intervention into the environment based on the current percept or percept sequence. The environment is then changed by a defined way.

How to design an agent:

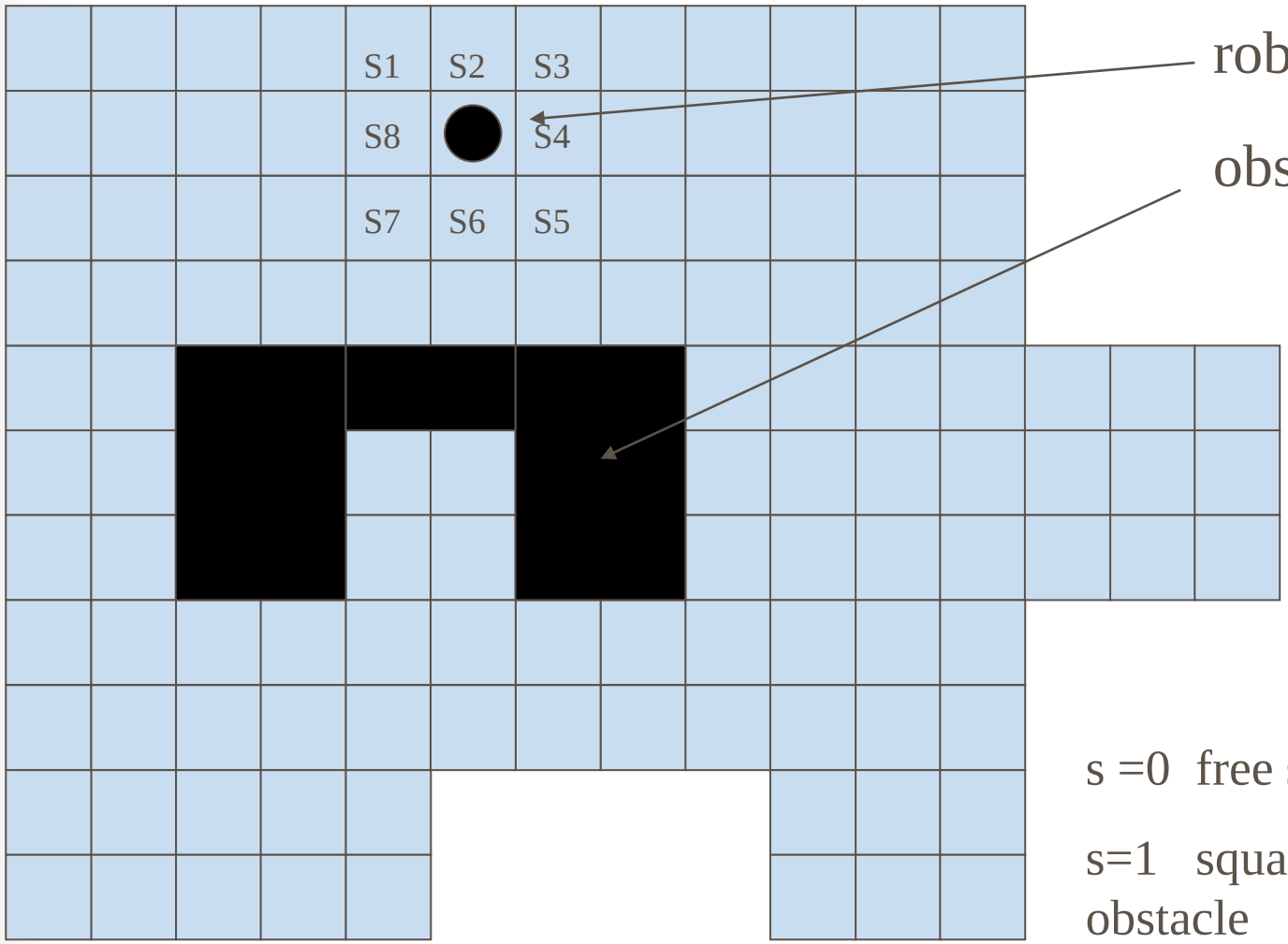
A designer should specify an agent function and make an agent program as a realization of the agent function.

Designing intelligent agents:

- **Knowledge acquisition level:** programmer specifies which knowledges are necessary to describe the world in which an agent acts. Simplification of the world is necessary. Designer creates a task environment – a simplification of the real world.

- **Symbol level:** representation of the knowledges with a help of symbolic structures, operators above these structures are defined.
- **Level of implementation:** implementation of the inference methods for a new knowledges derivation and best agent's action derivation, implementation of the agent program, realization of the agent.

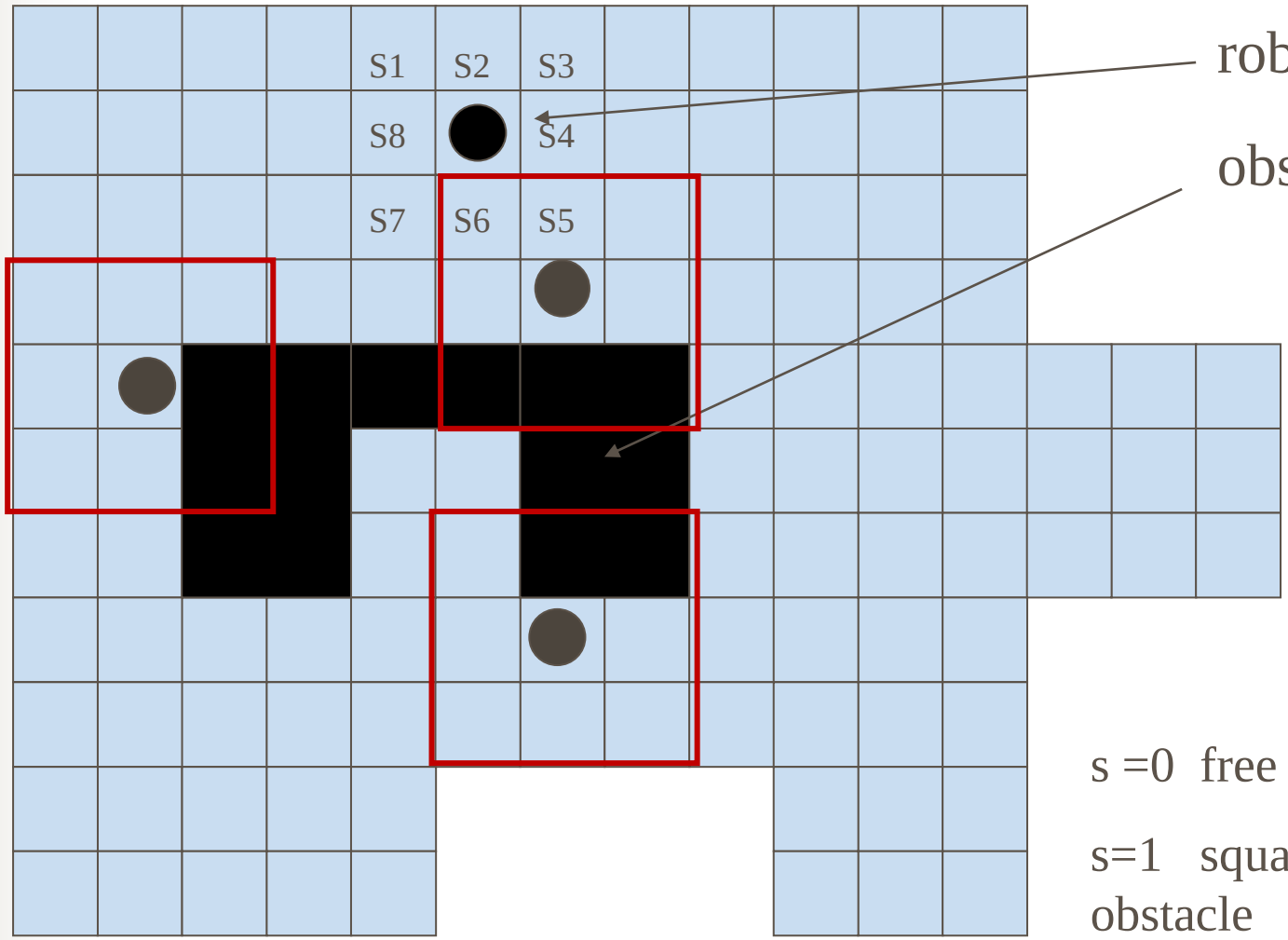
Paradigmatic example



s =0 free square

s=1 square with obstacle

Paradigmatic example



s =0 free square

s=1 square with an obstacle

Robot: let us call him agent.

What should robot – agent know to fulfill the task?

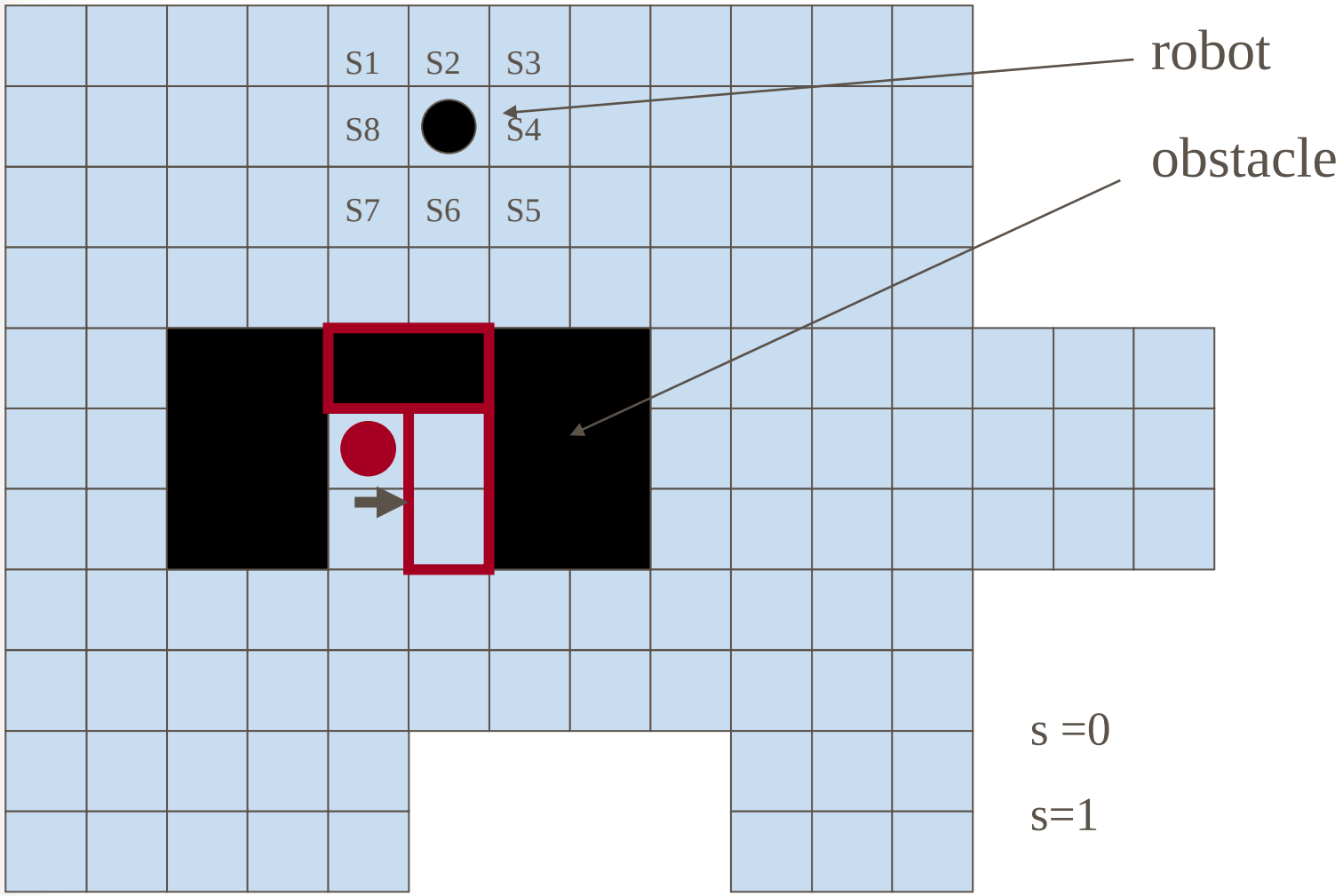
1. To percept the environment
2. To process the percepts
3. On the basis of the previous percepts to choose the best action

Percept? Binary vector: (00000000), (00011100), etc

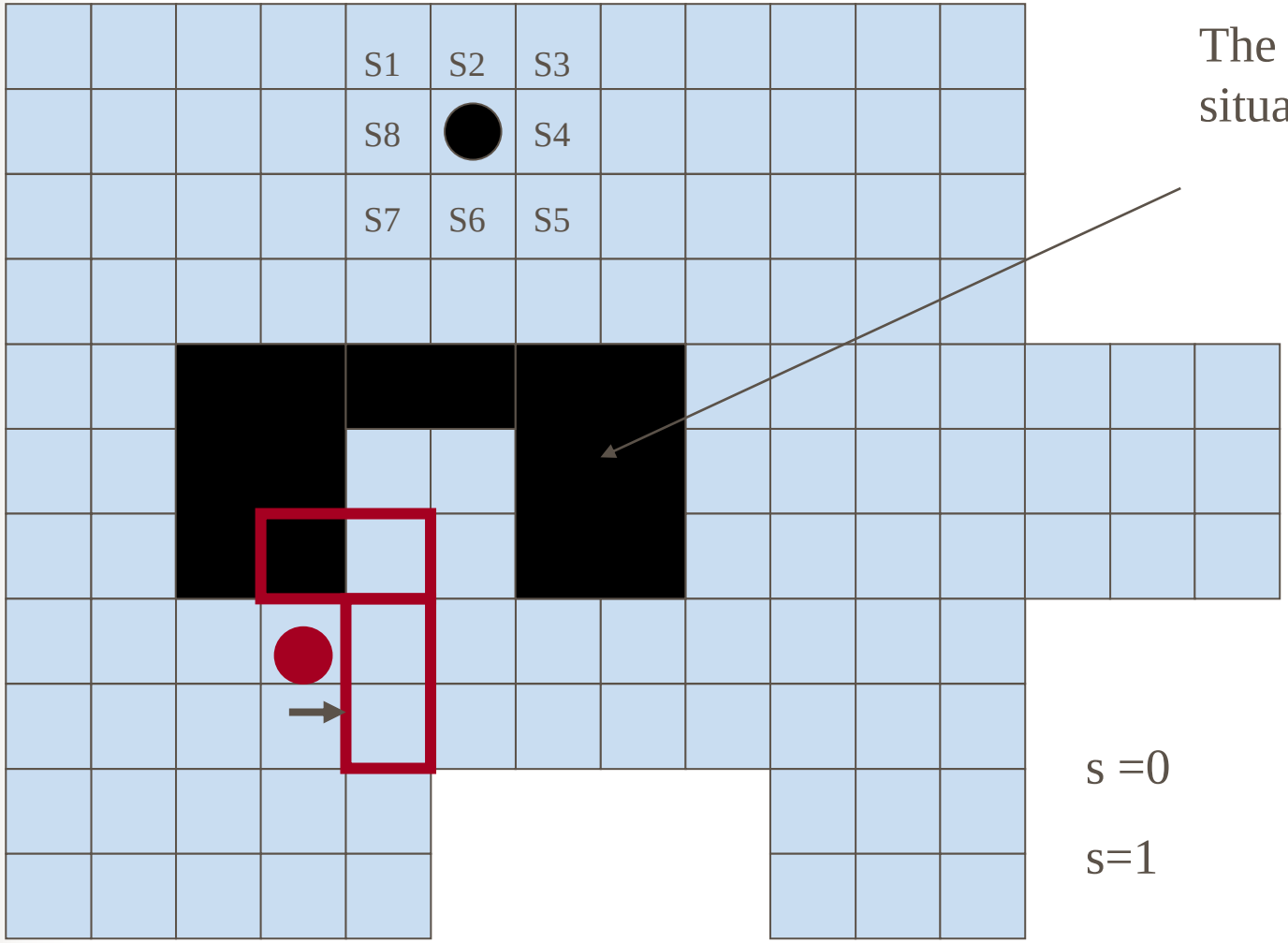
Agent function? Action ← *f(percept)*

Agent program? For each percept we have a rule:
if (percept) then (action)

Paradigmatic example



Paradigmatic example

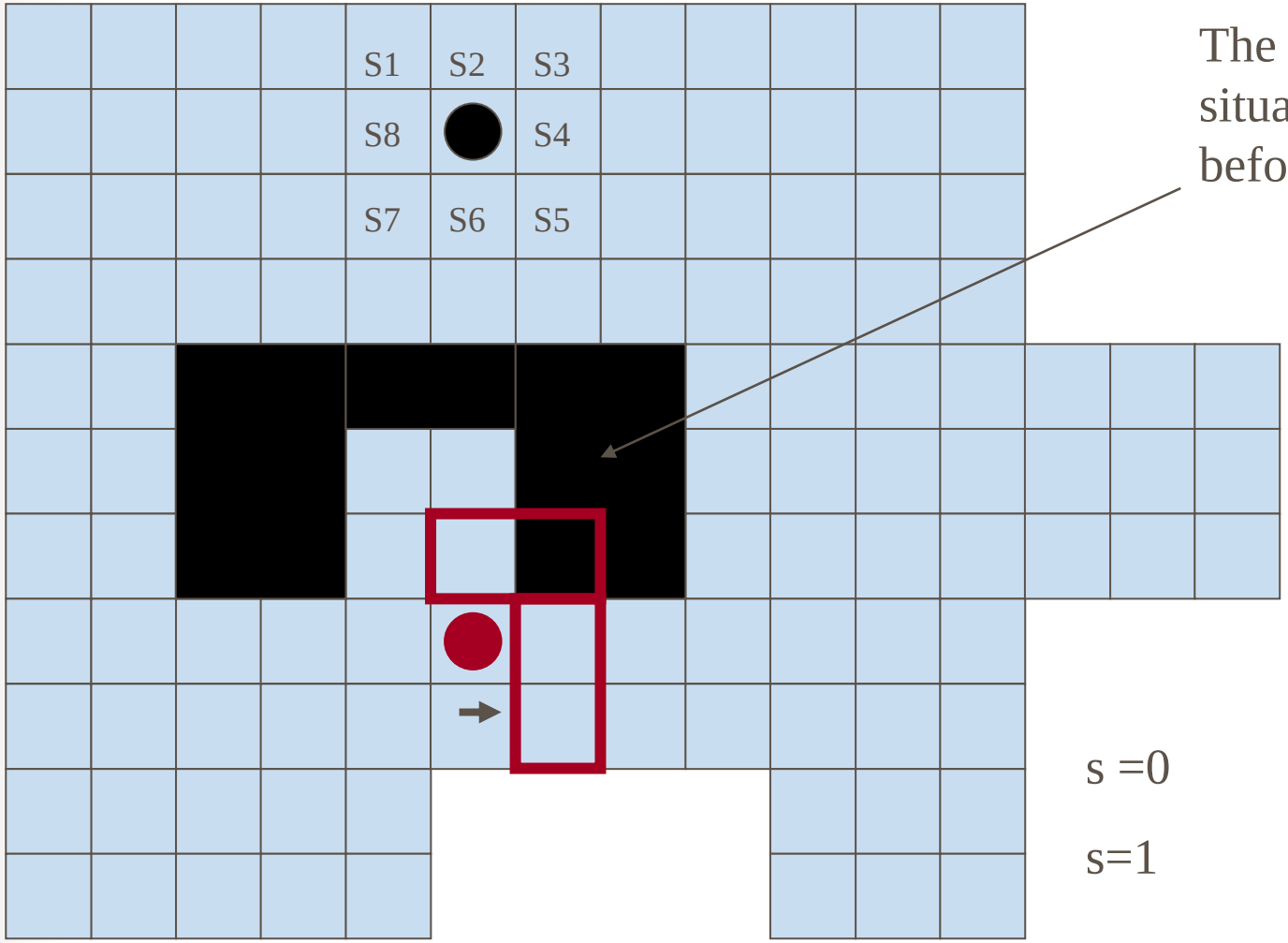


The same situation,

s =0

s=1

Paradigmatic example



Agent function: maps percepts to the action

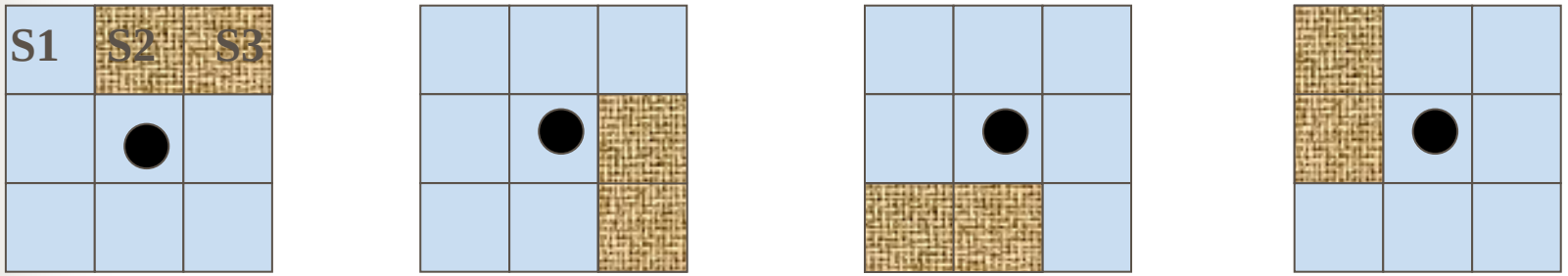
Effective representation of the agent function?

Binary vector is replaced by the feature vector. $x_1, x_2, \ldots, x_n$

Features: numerical features

categorial features (colour for example)

Extraction of features is based on the fact we do not have narrow spaces.



x_1 x_2 x_3 x_4

Each feature has a value 1 if at least one marked square is not free. Else, it has a value zero. For example $x_1 = 1$ if s2=1 or s3=1.

We have only few features.

Better agent function representation:

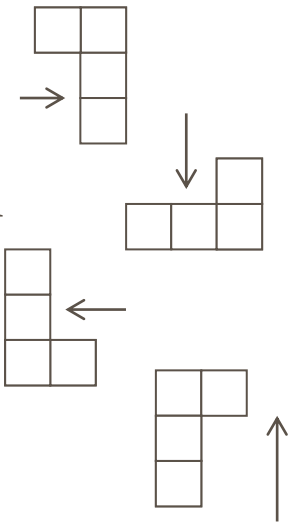
Situation on previous figs

if $x_1 = 1$ and $x_2 = 0$ then move east

if $x_2 = 1$ and $x_3 = 0$ then move south

if $x_3 = 1$ and $x_4 = 0$ then move west

if $x_4 = 1$ and $x_1 = 0$ then move north



Agent function of our robot:

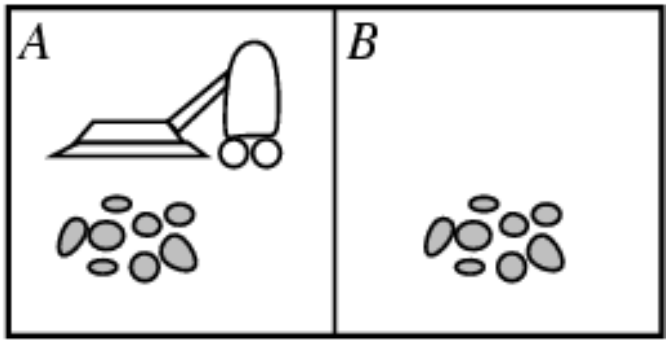
if $x_1 = 1$ and $x_2 = 0$ then move east

if $x_2 = 1$ and $x_3 = 0$ then move south

if $x_3 = 1$ and $x_4 = 0$ then move west

if $x_4 = 1$ and $x_1 = 0$ then move north

What is missing in these rules??
How to move robot distant from the obstacle..



Suggest percept representation ? What is an action ?

- Percept [A,Dirty]
- Actions: *Left*, *Right*, *Suck*, *NoOp*

Agent function ?

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
. . .	
[A, Clean] [A, Clean] [A, Dirty]	Suck

Agent program?

Agent program: implementation of the table

Performance measure

Performance measure: Measure which measures how well agent performs the given task.

Performance mesure is defined by designer, this measure depends on what is a suitable state of the environment.

What is the wish state of the environmetn for the agent automatic vaccum cleaner?

Performance measure possible definitions :

Example: rooms with automatic vacuum cleaner

1. ***choice:*** P.m. is measured by the amount of dirt cleaned in a time unit.
2. ***choice:*** P.m. is measured by a time during which the floor is clean.
3. ***choice:*** P.m. is measured by the number of steps in a time unit. We want to minimize this number.
4. ***choice:*** P.m. is measured by score (point for cleaned room, minus one point for each step, etc.) in a time unit.

Ideal rational agent: definition

Ideal **rational agent** acts by such a way, that for each possible percept sequence chooses an action, which maximizes the ‘performance measure’. Maximization is with respect to actual percept and knowledge of the agent.

Another properties of the ideal rational agent:

Autonomy and ability to learn.

Is the boundary following agent and the vacuum cleaner ideal rational agent?

PEAS description: aid for the agent designer

- PEAS: Performance measure, Environment, Actuators, Sensors

- Example of the agent: automatic taxi driver:
  - Performance measure
  - Environment
  - Actuators
  - Sensors

PEAS

Agent: Automatic taxi driver

- Performance measure: for example the number of transported people in time unit.
- Environment: streets
- Actuators: wheels, GPS
- Sensors: camera, transmitter

PEAS

Agent: Robot exploring the planet Mars

- Performance measure: Possibilities:
  1. Number of samples collected in a time unit.
  2. Number of photographs taken in one time unit. Etc.
  3. Or a combination of several weighted quantities.
- Environment: planet surface
- Actuators: Artificial hand, camera
- Sensors: camera, infrared sensor, transmitter…

PEAS

Agent: Agent selling the books on the internet

- Performance measure: Number of book sold in certain time unit. Gain during some time period. Etc.
- Environment: internet
- Actuators: display, robotic hand
- Sensors: automatic order reader

Environment of the agent

type of the environment → type of the agent

performance m. → task environment

Task environment ≠ environment

Task environment

Task environment: it is an abstraction, simplification of the real environment in which the agent acts. The environment is stripped of unimportant elements (from the task point of view).

Vacuum cleaner world:

Environment: Real empty rooms.

Task environment: Abstraction of real empty rooms, in which we do not care, for example, about the color of walls, pictures hanged on the walls, disposition of windows ....

Types of task environments

- Observable vs. unobservable, or partially observable: Sensors of the agent percept the environment as a whole if the environment is observable.
- Deterministic vs. undeterministic: If the next state of the environment is totally dependant on the actual state and the agent action, the environment is deterministic.
- Epizodic vs. unepizodic: Actual action depends only on the actual percept. Previous actions does not influence actual action. Agent's experience depends on episodes percept – action.
- Discrete vs. continuous: In the discrete environment the number of percepts and connected actions is limited and well defined (example: chess board).
- Static vs. dynamic: If the environment changes not only due to the agent action, it is a dynamic environment.
- Single agentové vs. multi agent:

Typs of simple agents

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents

Simple reflex agent

- input – output agent which chooses the action on the basis of the current percept

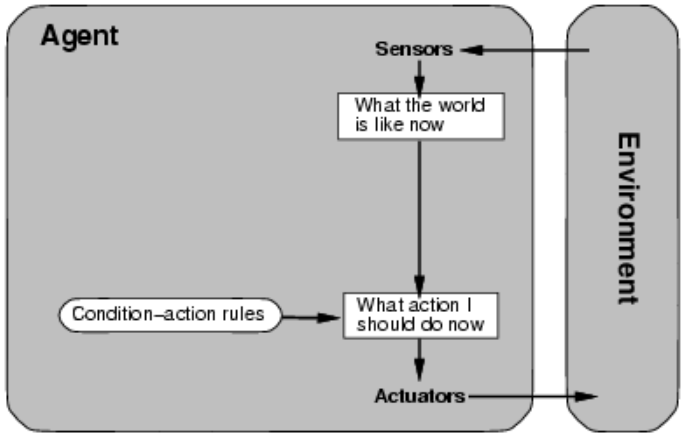
-For decision about the action uses condition – action (if – then) rules

- agent's usability and intelligence is very limited, often needs observable environment

- agent is often trapped in loops of actions (can be avoided by making random actions sometimes)

No memory, no planning.

Simple reflex agents



Model based reflex agent (often used in partly observable environments)

-Knows something about the environment, independently agent's own experience

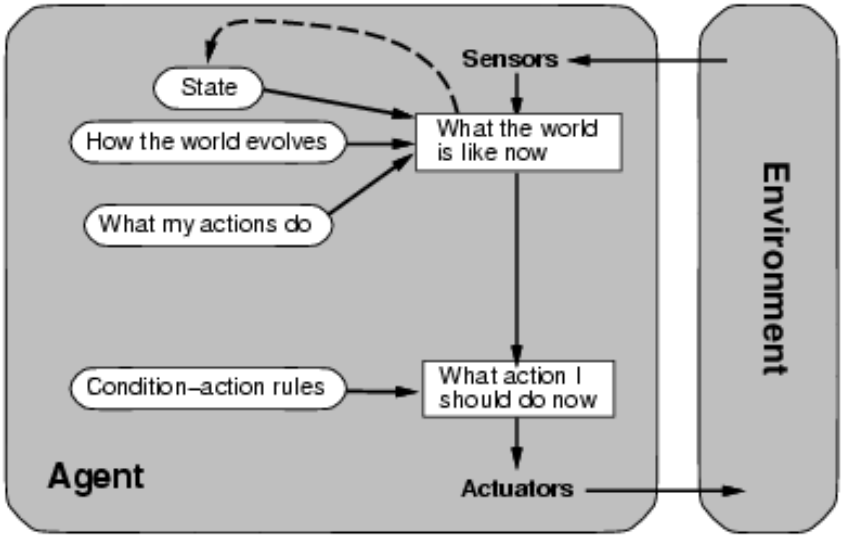
-Knows how the action influences this knowledges

-Knows something about the currently unobservable parts of environment

Has a **model** of the world in which the task is solved.

No longer term planning.

Model-based reflex agents

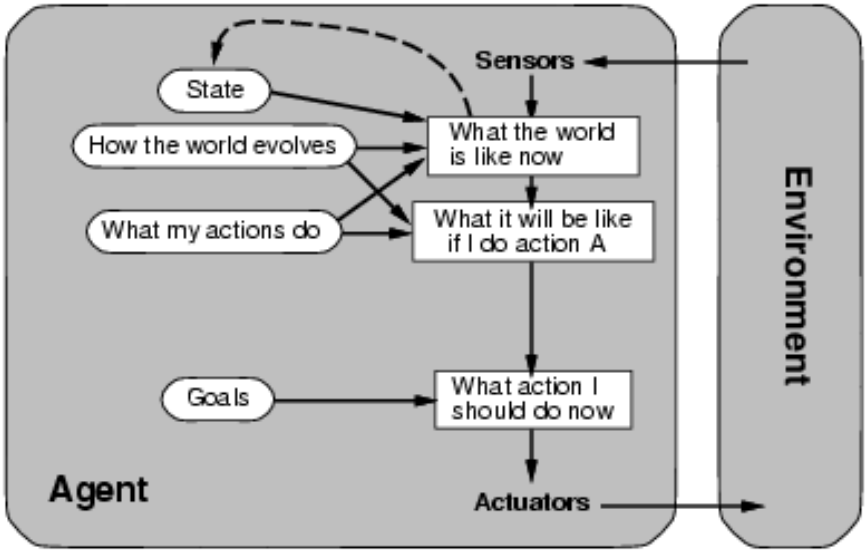


Goal – based – agent

-Has an information about the desirable goal states

- often uses ***searching*** and simple ***planning*** to reach the goal

Goal-based agents



Planning.

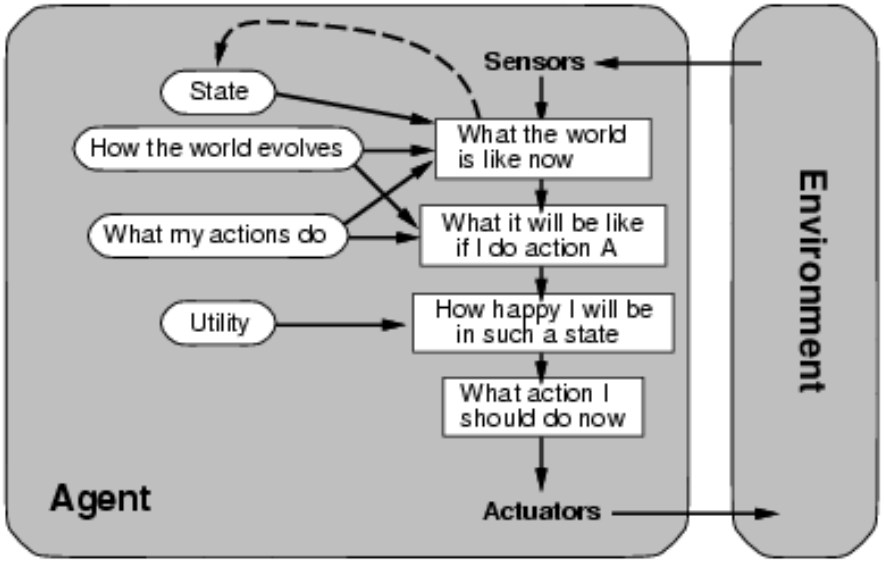
Utility – based agent

-For this agent not only goal is important. The cost of the way to the goal is also important.

- **Utility function** maps the state, or state sequence to a real number, which measures the cost.

- Utility function helps to choose between more possible ways to the desired goal.

Utility-based agents

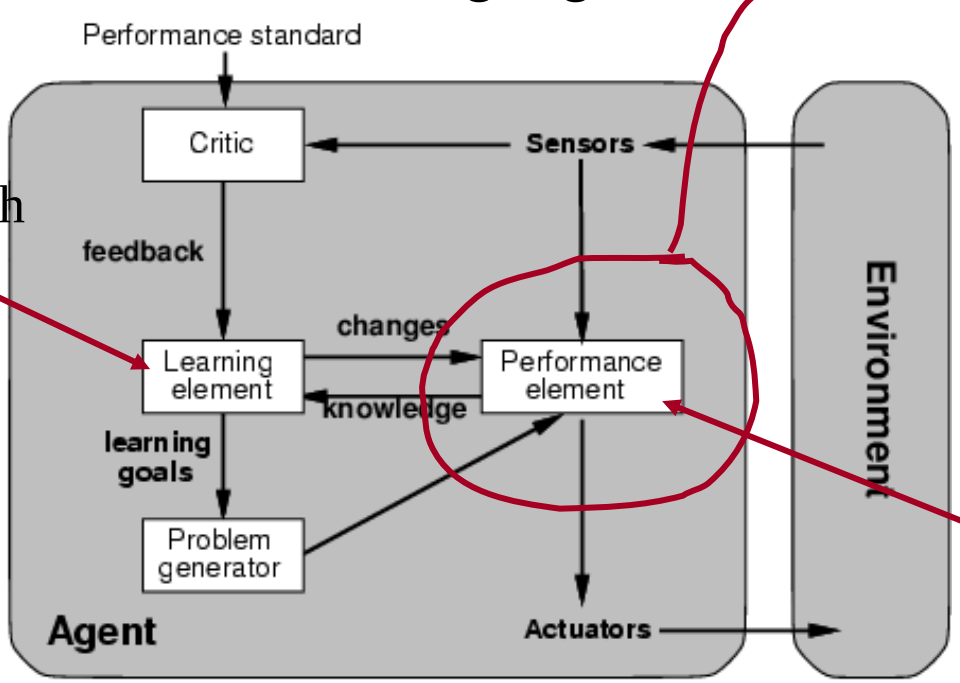


Utility versus performance measure – the difference

Performance measure: Measures the state of the environment, and how well the agent fulfills the task.

Utility function: Measures the state of the agent, the cost of the task fulfillment

More complex agents with the ability to learn



Simple agent

Learning elements cooperates with performance element

Percept and action selection

Example: automatic taxi driver

Reflex agent: 1. Percepts a car in front of him and slows down when this car slows .

Model based agent (agent with states):

1. Percepts a car in front of him and slows down when this car slows .
2. Has a model of the environment, for example knows what is the average possible velocity on the highway, second rate road, field path etc…and slows down also when the road quality changes.

Goal based agent:

1. Percepts a car in front of him and slows down when this car slows .
2. Has a model of the environment, for example knows what is the average possible velocity on the highway, second rate road, field path etc…and slows down also when the road quality changes.
3. Detects the goal state and stops when in this state.

Uutility based agent:

1. Percepts a car in front of him and slows down when this car slows .
2. Has a model of the environment, for example knows what is the average possible velocity on the highway, second rate road, field path etc…and slows down also when the road quality changes.
3. Detects the goal state and stops when in this state.
4. From various possibilities how to get to the goal chooses the cheapest one.

Problem solving agent

-it is a goal based agent with some model of the environment

-able to create a simple **plan**

-actions are first planned and simulated, then realized

Example: Agent searching for a way on a map.

What one needs to solve a problem? :

- exact formulation of the problem

  formultion of goal states – define a set of desirable states

  formultion of the problem (description of possible actions and states leading to the goal)

- looking for an appropriate searching strategy

- making a plan of actions

Tasks and questions

1. Suggest an appropriate „performance measure“ for an agent walking around a boundary.
2. What would be a rational behavior of the agent vacuum cleaner if he gets one good point for cleaning a room. He still have to fulfill the task and clean the rooms.
3. What would be a rational behavior if he gets one good point for each step. He still have to fulfill the task and clean the rooms.
4. What would be a rational behavior of the agent vacuum cleaner if he is penalized for each step?
5. Design an agent vacuum cleaner providing we do not know the geography of the environment. We only know that it consists of small squares becoming dirty in certain predefined time periods. Is it possible to solve the task using only one of the simple agents?