# 1

# Intelligent Agents and their Environments

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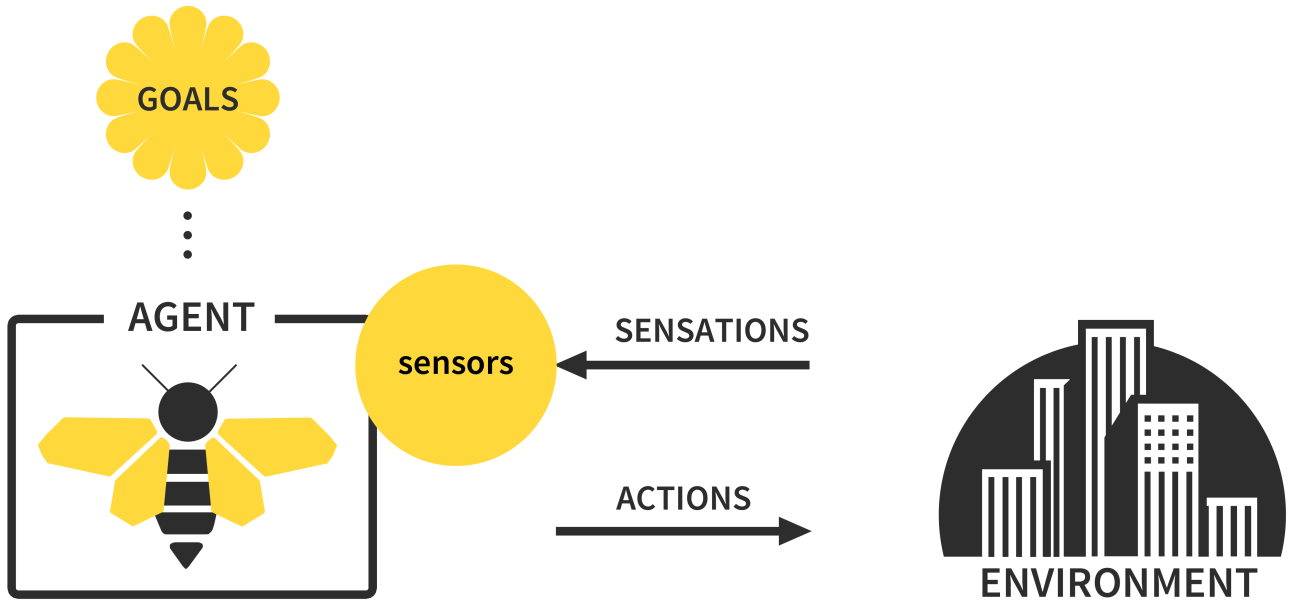
Based on slides by: Jacques Fleuriot, Michael Rovatsos, Michael Herrmann, Vaishak Belle

# 1.a

## What Is an Intelligent Agent?

# INTELLIGENT AGENTS



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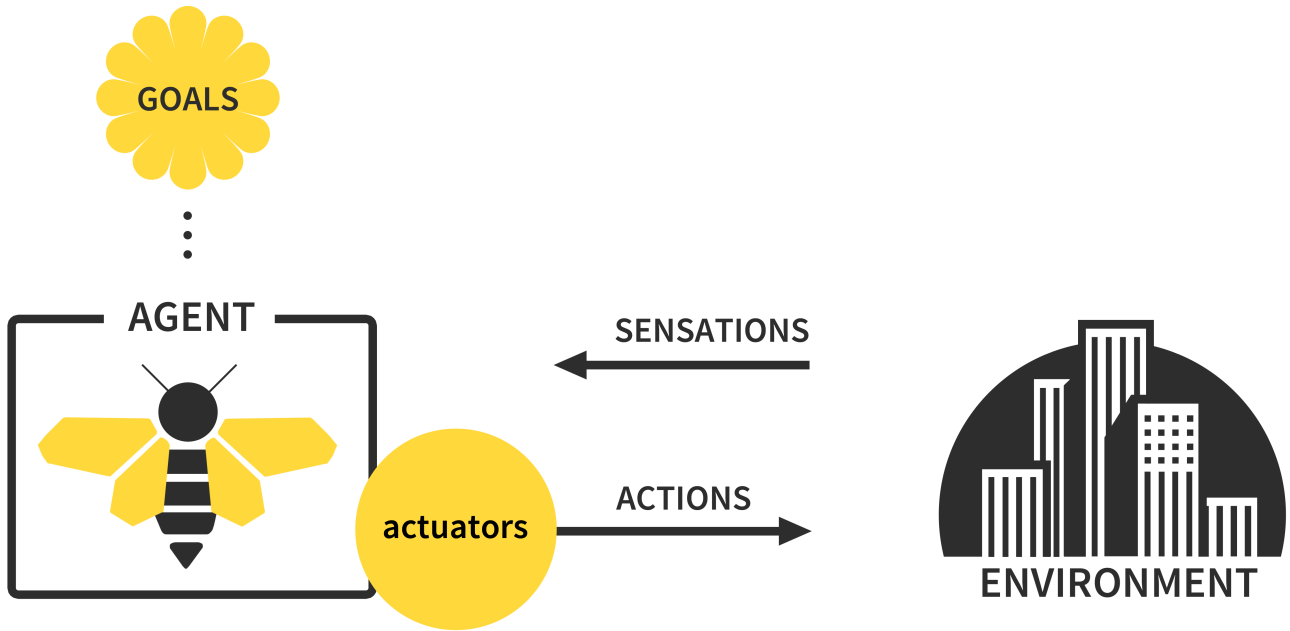

# EXAMPLE · MAIL SORTING ROBOT

**Environment** · conveyor belt of letters

**Goals** · route letter into correct bin

**Percepts** · array of pixel intensities

**Actions** · route letter into bin

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 Wikipedia entry on mail sorters

# EXAMPLE · INTELLIGENT HOUSE

**Environment**
- occupants enter and leave house
- occupants enter and leave rooms
- daily variation in outside light & temperature

**Goals**
- occupants are warm
- room lights are on when room is occupied
- house energy efficient

**Percepts**
- signals from temperature sensor, movement sensor, clock, sound sensor

**Actions**
- room heaters on/off
- lights on/off

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Smarthus — a plea for simplicity

Wikipedia entry on home automation

# EXAMPLE · AUTONOMOUS CAR

**Environment** · streets, other vehicles, pedestrians, traffic signals, lights, signs

**Goals** · safe, fast, legal trip

**Percepts** · camera, GPS signals, speedometer, sonar

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The ethical dilemma of self-driving cars – Patrick Lin

Wikipedia entry on autonomous cars

# 1.b

## Types of Intelligent Agents

# SIMPLE REFLEX AGENTS

- Action depends only on immediate percepts.
- Implement by **condition-action rules**.

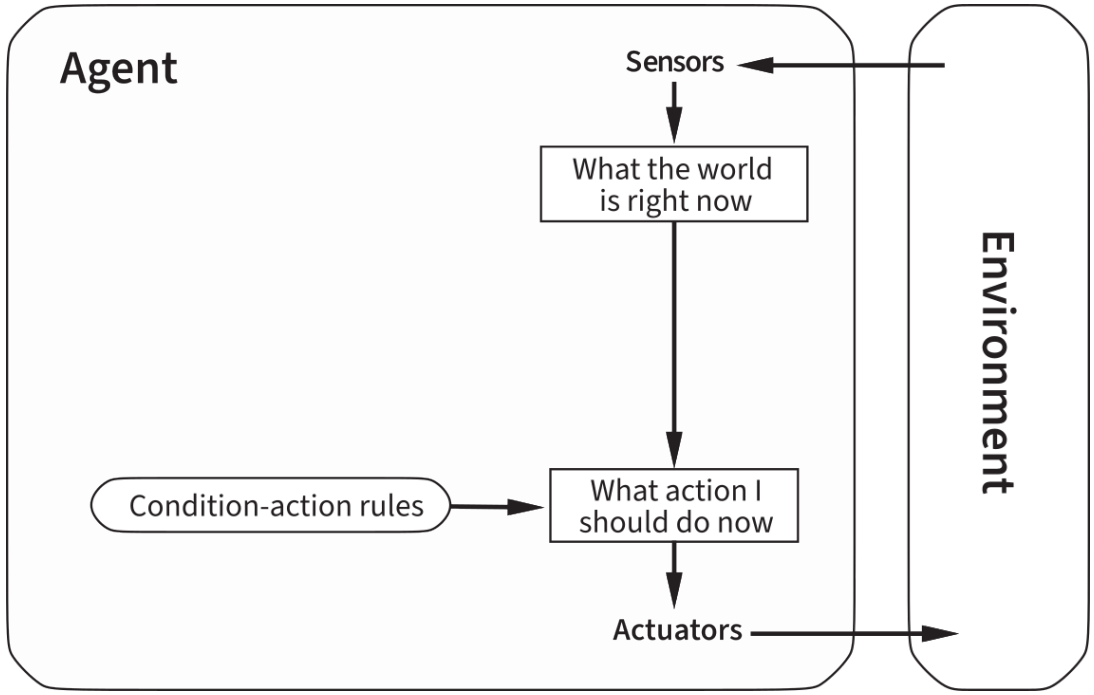
**EXAMPLE**

**Agent** · mail sorting robot

**Environment** · conveyor belt of letters

**Rule** · *city = Edinburgh* $\longrightarrow$ *put in Scotland bag*

# SIMPLE REFLEX AGENTS




**function** SIMPLE-REFLEX-AGENT(*percept*)
returns *action*
  **persistent**: *rules* (set of condition-action rules)
    *state* ← INTERPRET-INPUT(*percept*)
    *rule* ← RULE-MATCH(*state*, *rules*)
    *action* ← rule.ACTION
**return** *action*

# MODEL-BASED REFLEX AGENTS

- Action may depend on history or unperceived aspects of the world.
- Need to maintain **internal world model**.

**EXAMPLE**

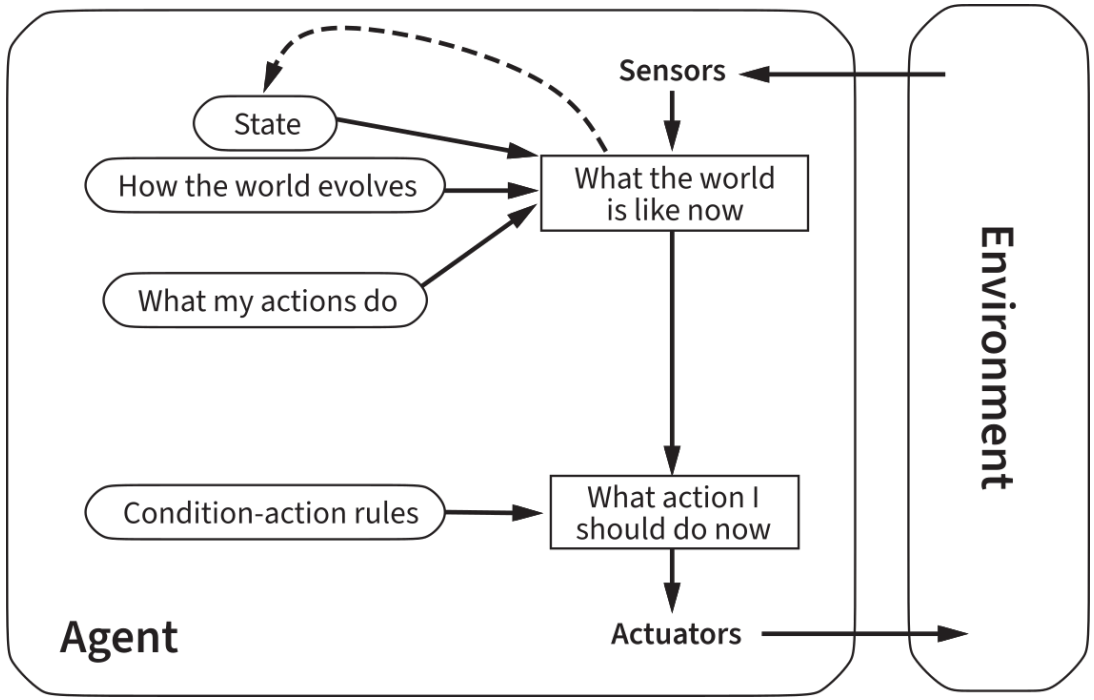
**Agent** · robot vacuum cleaner

**Environment** · dirty room, furniture

**Model** · map of room, which areas already cleaned

Sensor/model trade-off.

# MODEL-BASED REFLEX AGENTS




**function** REFLEX-AGENT-WITH-STATE(*percept*)
  **returns** *action*
  **persistent**: *state*, description of current world state
    *model,* description of how the next state depends on current state and action
    *rules*, a set of condition-action rules
    *action,* the most recent action, initially none
  *state* ← UPDATE-STATE(*state, action, percept, model*)
  *rule* ← RULE-MATCH(*state, rules*)
  *action* ← rule.ACTION
  **return** *action*

# GOAL-BASED AGENTS

- The agents so far had fixed, implicit goals.
- We want agents with **variable goals**.
- Forming plans to achieve goals is a topic for later.

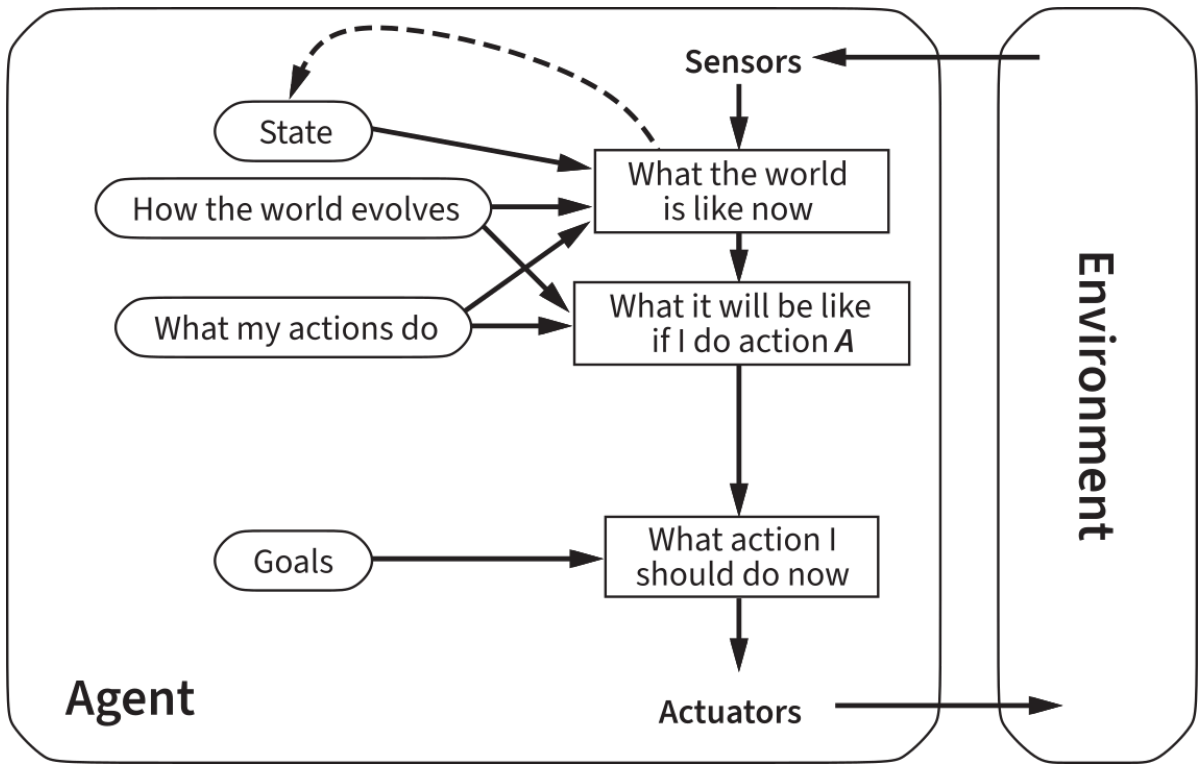
**EXAMPLE**

**Agent** · household service robot

**Environment** · house & people

**Goals** · clean clothes, tidy room, table laid

# GOAL-BASED AGENTS



# UTILITY-BASED AGENTS

- The agents so far had a single goal.
- Agents may have to juggle **conflicting goals**.
- Need to optimise utility over a range of goals.

**UTILITY** – measure of *goodness* (real number).
Combine with probability of success to get *expected utility*.

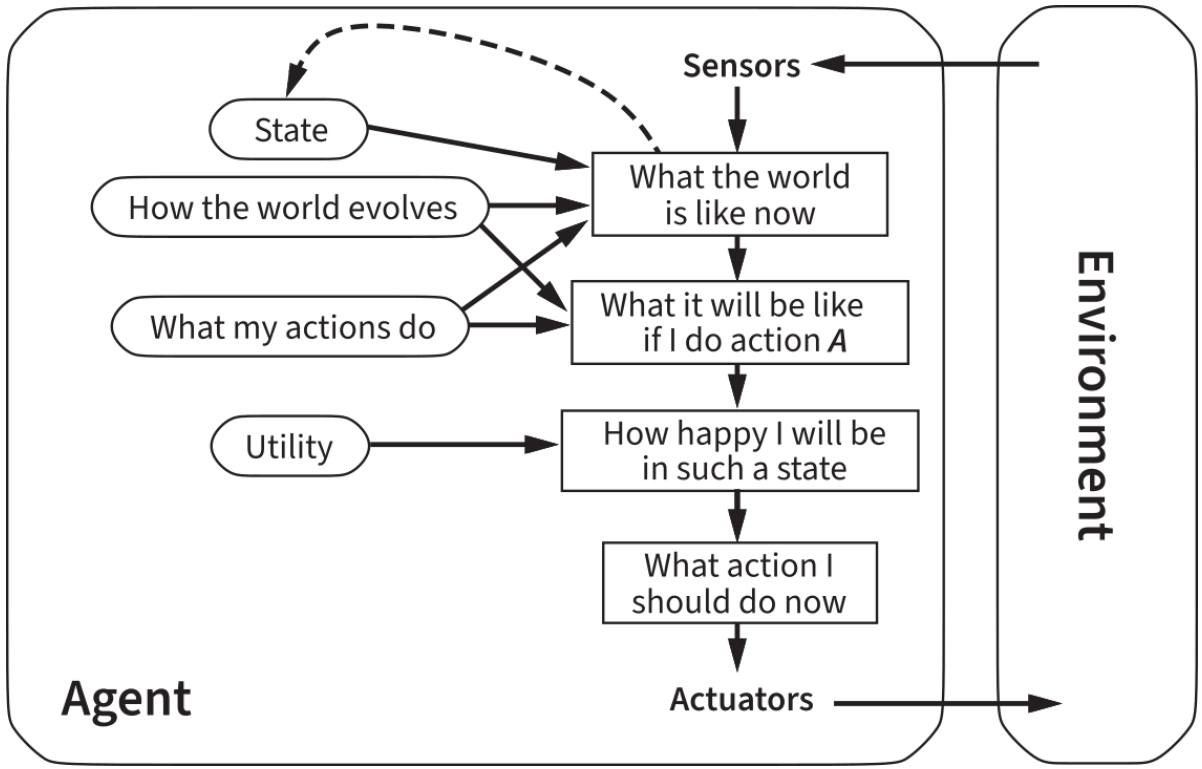
**EXAMPLE**

**Agent** · autonomous car

**Environment** · roads, vehicles, signs

**Goals** · stay safe, reach destination, be quick, obey law, save fuel

# UTILITY-BASED AGENTS



# LEARNING AGENTS

***How do agents improve their performance in light of experience?***

- Generate problems which will test performance.
- Perform activities according to rules, goals, model, utilities, etc.
- Monitor performance and identify non-optimal activity.
- Identify and implement improvements.

We will not be covering learning agents, but this topic is dealt with in several honours-level courses (see also R&N, Ch. 18-21).

# QUESTION TIME!

Consider a chess playing program.

What sort of agent would it need to be?

## ANSWER TIME!

Consider a chess playing program.
What sort of agent would it need to be?

**Might be...**

**Simple reflex** · but some actions require some memory
(e.g. castling)

**Model-based reflex** · but needs to reason about future

**Goal based** · but only has one goal

**Utility based** · might consider multiple goals with limited lookahead

**Learning** · learns from experience or self-play

# 1.c

## Types of Environments

# TYPES OF ENVIRONMENTS

A. FULLY OBSERVABLE vs. PARTIALLY OBSERVABLE

**Fullly** · agent's sensors describe the environment state fully

**Partially** · some parts of the environment not visible; noisy sensors

B. DETERMINISTIC vs. STOCHASTIC

**Deterministic** · next state fully determined by current state and agent's actions

**Stochastic** · random changes (can't be predicted exactly)

*An environment may appear stochastic if it is only partially observable.*

# TYPES OF ENVIRONMENTS

C. EPISODIC vs. SEQUENTIAL

**Episodic** · next action does not depend on previous actions

 mail-sorting robot *vs.* crossword puzzle

D. STATIC vs. DYNAMIC

**Static** · environment unchanged while agent deliberates

 crossword puzzle *vs.* chess
industrial robot *vs.* autonomous car

# TYPES OF ENVIRONMENTS

E. DISCRETE vs. CONTINUOUS

**Discrete** · percepts, actions and episodes are discrete

 chess *vs.* autonomous car

F. SINGLE AGENT vs. MULTI-AGENT

**Cardinality** · how many objects must be modelled as agents?

 crossword puzzle *vs.* poker

 *Element of choice over which objects are considered agents.*

# SUMMARY

An agent may have any combination of these properties:

from **benign** – fully observable, deterministic, episodic, static, discrete and single agent

to **chaotic** – partially observable, stochastic, sequential, dynamic, continuous and multi-agent.

What are the properties of the environments of:

- a mail-sorting robot?
- an intelligent house?
- a car-driving robot?