COMP9414: Artificial Intelligence

Lecture 1b: Agents

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This Lecture

- Agents
- Agent Architectures and Programs
- Layered Architectures and Programs
  - Example – Delivery Robot
- Rational Agents

Three Definitions of *Agent*

- Agent as actor
  - Acts autonomously in the world to achieve goals
  - Rational – may have beliefs, desires and intentions
- Agent as helper, representative
  - Performs some task on behalf of another agent
  - Collaborates with some "user" on a (complex) task
  - May or may not be an "agent as actor"
- Agent as catalyst
  - Cause of a chemical reaction

Textbooks combine the first two types, then say AI is about "agents"

Agent – Intuitive Definition

- An entity that perceives its environment through sensors and acts on its environment through effectors
- Example – human agent

  sensors – eyes, ears, touch, etc.
  effectors – hands, legs, etc.
- Example – robotic agent

  sensors – ultrasonic, infrared range finder, video input, etc.
  effectors – motors, manipulators, etc.

Agents according to Poole and Mackworth: person, robot, dog, worm, lamp, computer program that buys and sells, corporation?

What is an Agent?

An entity

- situated: operates in a dynamically changing environment
- reactive: responds to changes in a timely manner
- autonomous: can control its own behaviour
- proactive: exhibits goal-oriented behaviour
- communicating: coordinate with other agents??

Examples: humans, dogs, ..., insects, sea creatures, ..., thermostats?

Where do current robots sit on the scale?

Situatedness

What does the frog know?

What are the implications for agent design?

Robocup Soccer

Specifying Agents

- percepts: inputs to the agent via sensors
- actions: outputs available to the agent via effectors
- goals: objectives or performance measure of the agent
- environment: world in which the agent operates

Most generally, a function from percept sequences to actions

Ideally rational agent does whatever action is expected to maximize some performance measure – the agent may not know the performance measure (Russell and Norvig 2010)

Resource bounded agent must make "good enough" decisions based on its perceptual, computational and memory limitations (design tradeoffs)

Example Agents

Agent Type	Percepts	Actions	Goals	Environment
Medical diagnosis system	Symptoms, findings, patient responses	Questions, tests, treatments	Healthy patient, minimise costs	Patient, hospital
Satellite image system	Pixels of varying intensity, colour	Print categorisation of scene	Correct categorisation	Images from orbiting satellite
Automated taxi driver	Cameras, speedometer, GPS, sonar, microphone	Steer, accelerate, brake, talk to passenger	Safe, fast, legal, comfortable trip, maximise profits	Roads, other traffic, pedestrians, customers
Robocup robot	Camera images, laser range finder readings, sonar readings	Move motors, "kick" ball	Score goals	Playing field with ball and other robots

Based on Russell and Norvig (2010) Figure 2.5.

Agent Programs and Architectures

- Program – function implementing mapping from percept sequence to actions, using an internal representation of the percept history
- Architecture – hardware and software components, and their organization, on which agent program executes

Agent = Architecture + Program

Representation

Example – Chess

- States – one way the world could be
  - e.g. 2^{43} distinct states
- Features – state with basic information
  - e.g. State has feature f if there is a passed pawn
- Propositions – state with logical structure
  - e.g. State divided into positions, pieces and relations

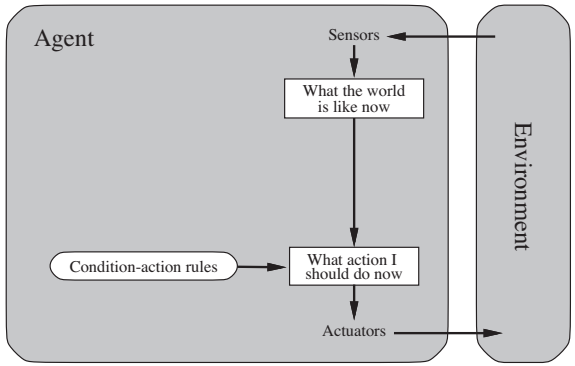
More complex representations need more complex inference procedures, but are more expressive – another tradeoff

Representation

- Rich enough to express knowledge needed (to solve the problem)
- As close to the problem as possible: compact, natural, maintainable
- Amenable to efficient computation
  - Able to express features of the problem that can be exploited for computational gain
  - Able to trade off accuracy and computation time and/or space
- Able to be acquired from people, data and past experiences

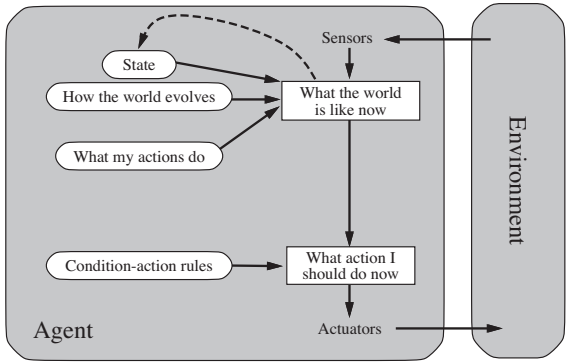
A Taxonomy of Agent Programs

Reflex (reactive) agent – applies condition-action rules to each percept



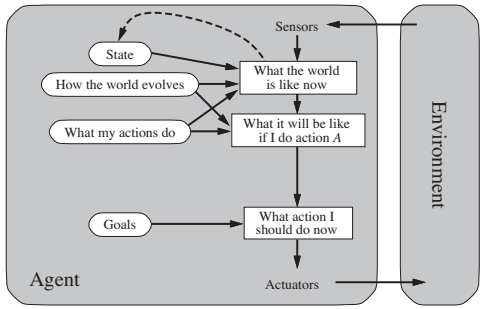
A Taxonomy of Agent Programs

Agent with internal state – keeps track of world



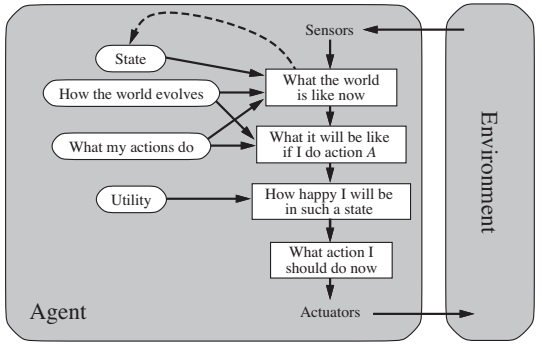
A Taxonomy of Agent Programs

Goal-based (teleological) agent – state description often not sufficient for agent to decide what to do so it needs to consider its goals (may involve searching and planning)



A Taxonomy of Agent Programs

Utility-based agent – considers preference for certain world states over others



Environment Types

Fully Observable vs Partially Observable
: Agent's sensors give access to complete (relevant) state of environment (no internal state required)

Deterministic vs Stochastic
: Next state of environment determined only by current state and agent's choice of action

Episodic vs Sequential
: Agent's experience divided into "episodes"; agent doesn't need to think ahead in episodic environment

Static vs Dynamic
: Environment changes while agent deliberates

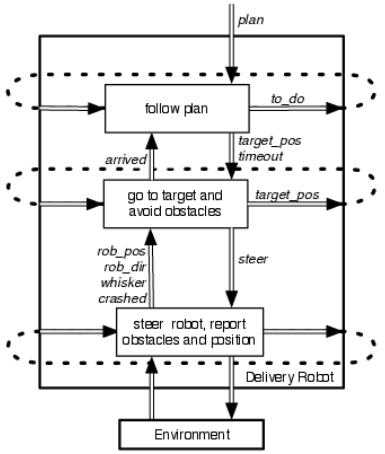
Discrete vs Continuous
: Limited number of distinct, clearly defined percepts and actions

Layered Architecture

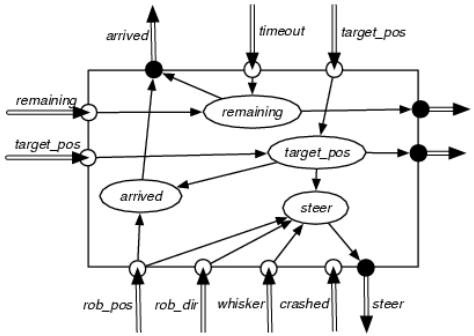
Hierarchy of controllers

- Controller gets percepts from and sends commands to the lower layer
  - Abstracts low level features into higher level (perception)
  - Translates high level commands into actuator instructions (action)
- The controllers have different representations, programs
- The controllers operate at different time scales
- A lower-level controller can override its commands

Example – Delivery Robot



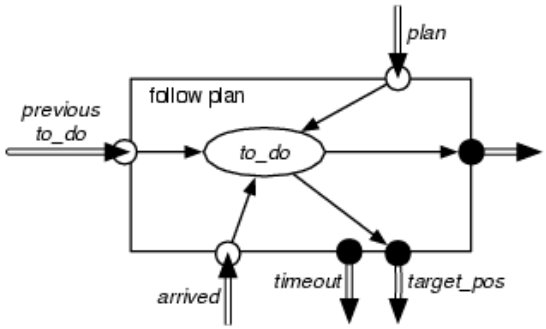
Delivery Robot – Middle Layer



Middle Layer Code

given timeout and target pos:
  remaining := timeout
  while not arrived() and remaining $\neq 0$
    if whisker_sensor = on
      then steer := left
    else if straight ahead(rob_pos; robot_dir; target_pos)
      then steer := straight
    else if left of (rob_pos; robot_dir; target_pos)
      then steer := left
    else steer := right
    do(steer)
    remaining := remaining – 1
  tell upper layer arrived()

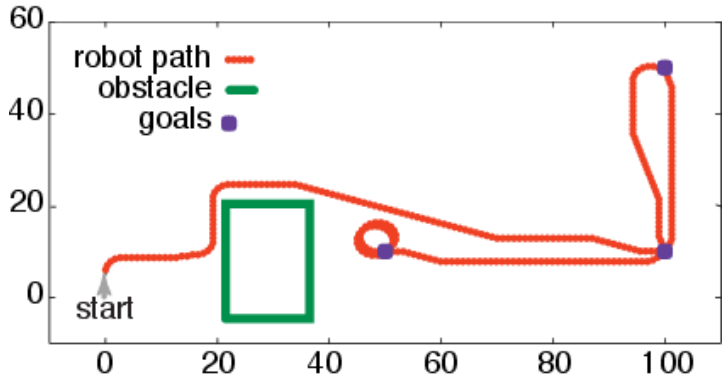
Delivery Robot – Top Layer



Top Layer Code

given plan:
  to_do := plan
  timeout := 200
  while not empty(to_do)
    target pos := coordinates(first(to_do))
    do(timeout; target_pos)
    to_do := rest(to_do)

Delivery Robot – Simulation



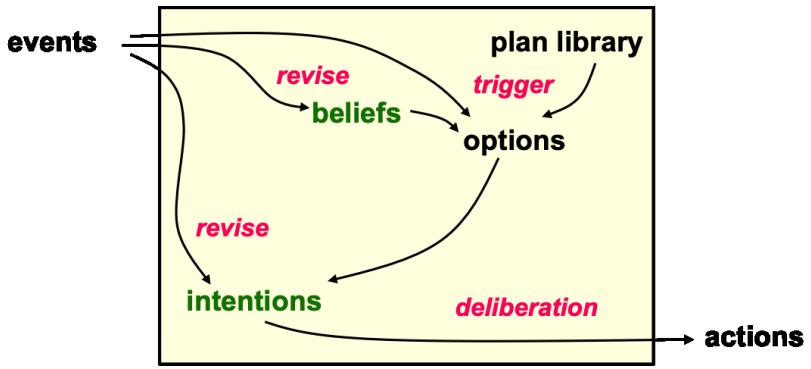
BDI Agents

- Beliefs: Explicit representation of the world
- Desires: Preferred states of the environment
- Goals: Desires the agent has chosen to pursue (must be consistent)
- Intentions: Actions the agent has chosen and committed to
  - Pose problems for deliberation (how to fulfil them)
  - Constrain further choices (must be compatible)
  - Control conduct (lead to future action)

All defined functionally – no X factor

"Intentions, Plans, and Practical Reason" (Bratman 1987)

BDI Agent Interpreter



PRS (Procedural Reasoning System)

Abstract PRS Interpreter:

initialize-state()
do
  options := option-generator(event-queue, B, G, I)
  selected-options := deliberate(options, B, G, I)
  update-intentions(selected-options, I)
  execute(I)
  get-new-external-events()
  drop-successful-attitudes(B, G, I)
  drop-impossible-attitudes(B, G, I)
until quit

PRS (Procedural Reasoning System)

- Useful in dynamic environments where
  - Reasonable plans can be formed in advance
  - Agent needs continuity of commitment
  - Agent needs to respond rapidly to situation
  - Agent's computational resources are limited
  - Agent can keep up with changes in the world

Summary

- Assumptions made about environment dictate nature of agent
  - Capabilities those needed to survive in the environment
  - Need not be “over-engineered” to handle more complexity
  - Agent + Environment can be thought of as a coupled system
- Specific architectures constrain agent’s computational power and limit behaviour: more efficient than general architectures