Environments

Sensing, Characterising, Acting and Goals for AI Agents

An Agent's Environment

- An agent interacts with its environment
  - It is situated in an environment.
- It collects data from the environment via sensors
- It acts in/on its environment via actuators (the output of something: movement, data, power, etc.) towards some goal
- It might change its environment as it acts
- It might learn from its environment too

Environment, Sense, Act, Goal

- These four concepts are central to AI theory
- One book uses the acronym, PEAS
  - Performance indicator (goal)
  - Environment
  - Actuators
  - Sensors
- This lecture covers them all

Sensing the Environment

- Typical sensors include
  - Camera, light detector, IR sensor, etc. for light
  - Microphone for sound
  - Keyboard / mouse / buttons for typed input
  - Touch sensors for impact
  - Heat sensor / stress gauge / pressure sensor / accelerometer for physical measurements
  - Many other sensors are possible.

Understanding Senses

- Many text book examples assume that the meaning of what is sensed is easily accessible
  - This is NOT the case.
- Logic, for example, deals with truth or falsity – facts are simply stated
- In reality, converting what is sensed into useful, meaningful knowledge can be very difficult

Understanding Senses Examples

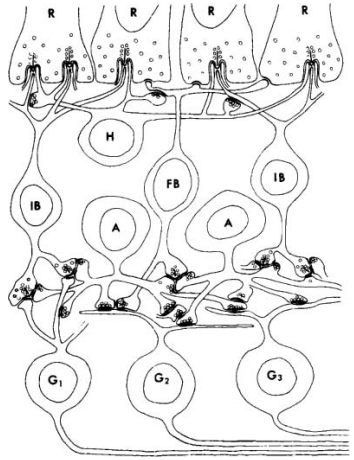
- Vision
  - Object recognition. A camera just provides a matrix of colour values, it can't tell you what it can see. Spotting objects in an image and recognising them is a challenge
  - Invariance under illumination.
- Sound
  - Voice recognition – what is being said, who is saying it
  - Sound location and isolation – which of several sources of sound in an environment made each of the different sounds you can hear?
  - Invariance under reverberation.
    - Not forgetting additional noise
- Invariances and context.

What is invariance?

- Adjusting perception to reality
  - Interpreting as the same, things which are the same, even when they appear different
  - Invariant visual perception
    - under varying illumination, varying distance (size), differing orientation
  - Invariant auditory perception
    - Varying loudness, varying reverberation levels, in the presence of background "noise"

How is invariance implemented?

- ***Invariance*** is tied to specific modalities
  - Invariance under …
  - In animal perception it is often at the sensor
  - Visually:
    - Retinal architecture
    - Lots of processing on the retina, before it is transmitted to the cortex
  - Invariance under varying illumination
    - Overall, and local changes



… and in audition

- Processing takes place in brainstem nuclei
- Before transmission to the auditory midbrain, and thence to the cortex
- Very similar across a large range of animals
- Invariance under level, reverberation changes,
  - Also sound source separation
  - …

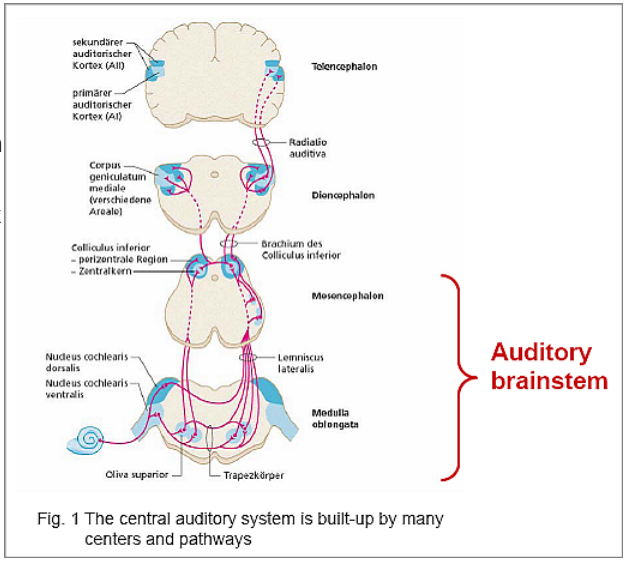


Fig. 1 The central auditory system is built-up by many centers and pathways

Characteristics of the Environment

- Fully observable (accessible) vs. partially observable (inaccessible)
- Deterministic vs. stochastic (non-deterministic)
- Episodic vs. sequential
- Discrete vs. continuous
- Static vs. dynamic
- Single agent vs. multi agent

Environment Types-I

- Fully observable (accessible) vs. partially observable (inaccessible):
  - Fully observable if agent's sensors detect all aspects of environment relevant to choice of action
  - Could be partially observable due to noisy, inaccurate or missing sensors, or inability to measure everything that is needed
  - Model can keep track of what was sensed previously, cannot be sensed now, but is probably still true.
  - Often, if other agents are involved, their intentions are not observable, but their actions are
  - E.g chess – the board is fully observable, as are opponent's moves. Driving – what is around the next bend is not observable (yet).

Environment Types-II

- Deterministic vs. stochastic (non-deterministic):
  - Deterministic = the next state of the environment is completely predictable from the current state and the action executed by the agent
  - Stochastic = the next state has some uncertainty associated with it
  - Uncertainty could come from randomness, lack of a good environment model, or lack of complete sensor coverage
  - Strategic environment if the environment is deterministic except for the actions of other agents

Environment types-III

- Episodic vs. sequential:
  - The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action)
  - and the choice of action in each episode depends only on the episode itself
  - Sequential if current decisions affect future decisions, or rely on previous ones
  - Examples of episodic are expert advice systems – an episode is a single question and answer
  - Most environments (and agents) are sequential
  - Many are both – a number of episodes containing a number of sequential steps to a conclusion

Environment types-IV

- Discrete vs. continuous:
  - Discrete = time moves in fixed steps, usually with one measurement per step (and perhaps one action, but could be no action). E.g. a game of chess
  - Continuous = Signals constantly coming into sensors, actions continually changing. E.g. driving a car

Environment types-V

- Static vs. dynamic:
  - Dynamic if the environment may change over time. Static if nothing (other than the agent) in the environment changes
  - Other agents in an environment make it dynamic
  - The goal might also change over time
  - Not dynamic if the agent moves from one part of an environment to another, though it has a very similar effect
  - E.g. – Playing football, other players make it dynamic, mowing a lawn is static (unless there is a cat…), expert systems usually static (unless knowledge changes)

Environment types-VI

- Single agent vs. multi agent:
  - An agent operating by itself in an environment is single agent!
  - Multi agent is when other agents are present!
  - A strict definition of an other agent is anything that changes from step to step. A stronger definition is that it must sense and act
  - Competitive or co-operative Multi-agent environments
  - Human users are an example of another agent in a system
  - E.g. Other players in a football team (or opposing team), wind and waves in a sailing agent, other cars in a taxi driver

Actions

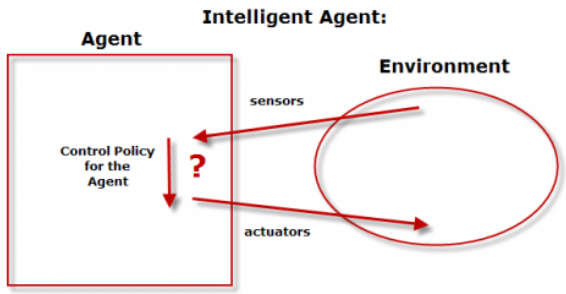
- Actions are controlled by actuators
- An actuator can be anything that causes any kind of output
  - Varying electrical current
  - Pumping hydraulic fluid, moving gears
  - Transmitting data, showing images / text
  - Changing a temperature / flow rate / pressure
  - Moving something!

Actions

- Actions may change things in the environment, or move the agent to a new part of the environment
  - Both of which alter what the sensors sense
  - Mine clearing robot moves from place to place, finds mines, detonates them, moves on to next
  - These actions change its local environment as it moves
  - They change the environment as they detonate mines
  - They change their own goals as they move to the next target
- Or they may just transmit information, like a recommendation in a decision support system

Feedback Loops

- There is a feedback loop from the environment, to sensor, to agent function, to action, to environment
- In episodic environments, this does not play a part (simple Q&A type systems)
- In most systems, however, it plays a very important role in agent behaviour



Goals

- An intelligent agent will generally exist for a reason – to perform some task
- This is generally known as the goal
- Needn't be a single action or outcome,
  - Often used to measure how well the agent is performing
- Sometimes the goal is at the end of a long series of actions, sometimes each action has a goal of its own
- Goals can be outcomes to achieve or to avoid (drive fast, don't crash)

Measuring Performance

- The agent needs to know if it has reached the goal or not
- Often, that means knowing how close to the goal it is
- Sometimes all an agent can know is whether it has reached the goal or not
  - and it may not know that until later
- When there is not a single goal where activity ends, a performance measure is more appropriate

Performance Measure

- An agent needs to know how to work towards a goal, but also to be told how well it is doing
- The performance measure can either be determined from the sensors, or given as an external input (perhaps to a specific sensor)
- It can be binary (yes, no) or a continuous score
  - And the feedback may be delayed.

Examples - Goals

- Finding the way out of a maze – 'yes' or 'no' feedback at each step – could be sensed from camera if the exit is recognisable or there could be a transmitter at the exit to send the 'yes' signal to the agent
  - Or (more likely) feedback only on reaching the maze's exit!
- Driving fast around a race track – current speed, whether or not you have crashed – speed sensor is there for goal tracking
- Up-selling on a web site – how many extra sales have been generated

Goals and Environment Types

- Episodic environments have simple goals – answer the question correctly, give the right advice, make the right decision
- Sequential environments can have a score as to how close to the goal you are at each step, or how well you are doing, but might also just have a final goal
- Dynamic environments may cause the goal to change
- Discrete environments might feedback a single score at each step, or after each action

Agent Motivation

- What will make your agent 'want' to act?
- Perhaps it is just programmed with rules that force it to act, but is that intelligence?
- Performance measure feedback is the 'emotions' of the agent
  - Hunger drives it to certain goals
  - Fear stops it acting dangerously
  - Happiness tells it how well it is doing
- Can a non-living entity have volition?

Agent Design

1. Identify the goal and a performance measure
2. Identify the environment and its characteristics
3. Decide what sensors are required to sense both the environment and the performance measure
4. Decide what actions the agent must perform and how they are to be made

Agent Design

- Ensure that the things you hope to catch with the sensors are available in the environment
  - Local processing at the sensor?
- Identify those things that you would like to sense, but can't – you may be able to predict them from the model (see later lectures!)
- Identify how your agent's actions impact on the environment

Agent Design - Goals

- How will you measure the performance of your agent?
- How will you tell it how well it is doing?
- Will it be able to work out how well it is doing from its sensors? Or will it need an extra input specially for feedback?
- Can you measure distance from the goal, or just whether or not it has been achieved?

Agent Design - Motivation

- Are there situations in the environment you want the agent to avoid?
- How does the performance measure reflect them?
- E.g. a robot lawn mower running over the cat.
- What makes the agent act? What stops it?

Questions for Tutorial 1

We are going to design a robot that can ride a normal, unmodified mountain bike down a red run. For the tutorial, please make some notes covering the following aspects of the task:

1. Characterise the environment. Obviously, it is a steep hill with rocks, roots, jumps and corners. It goes down most of the time, but there are some climbs. Describe it in terms of the six environment traits.
2. Choose some sensors – what will you need to measure, and how will you do it? Give some thought as to how easy it is to get the information you need from the sensors you choose.
3. Define a main goal, and some sub-goals (including what to avoid). How will you measure performance against these goals? What sensors are needed to measure performance?
4. Describe the actuators you will need. What will they do? How will they affect the environment? How will they feedback into the agent's own position? How will they move the agent towards the goal?