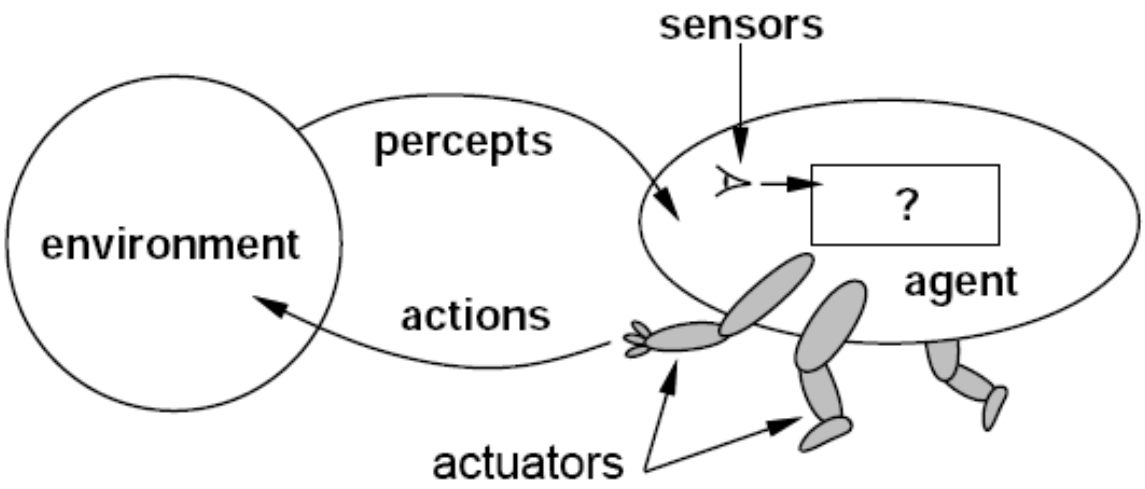
COMP702: Classical Artificial Intelligence

2: Authored Behaviour

Agents

Agents



An **agent** is anything which perceives an **environment** through **sensors**, and acts upon that environment through **actuators**.

Performance

- An "intelligent" agent moves towards some kind of **goal**
- The goal is an **environment state** (or a set of states)
- A **performance measure** evaluates a given state for how well it fits the goal

PEAS

For each example of an agent, what are the Performance measure, Environment, Actuators and Sensors?

- A Roomba
- A self-driving car
- A chatbot
- A factory robot
- An enemy in an FPS game
- A chess AI
- A human

Types of environment

- Environments come with many different properties
- These properties influence the choice of AI architecture we use to build agents

Observability

- **Fully observable**: the agent's sensors give it full information about the state of the environment
- **Partially observable**: some aspects of the environment state are not visible to the agent's sensors
- E.g. a chess game is fully observable, a poker game is partially observable

Number of agents

- **Single agent**: our agent is the only one in the environment
- **Multi-agent**: there is more than one agent
- **Cooperative**: all agents share the same performance measure
- **Competitive**: agents' performance measures are in opposition to each other (i.e. if one agent "wins", another "loses")

Determinism

- **Deterministic**: the next state of the environment is completely determined by the current state and by the agent's action
- **Stochastic**: there is some aspect of randomness in determining the next state
- E.g. chess is deterministic; any board game involving dice rolls or random card draws is stochastic

Dynamicity

- **Static**: the environment does not change while the agent is deliberating
- **Dynamic**: the environment changes constantly
- E.g. most board games are static, most (non turn-based) video games are dynamic

Discreteness

- **Discrete**: time, percepts and actions are all discrete (from a finite set of possibilities or "integer valued")
- **Continuous**: at least one of these is not discrete ("float valued")
- Continuous problems are hard so we sometimes **discretise** them

Known or unknown

- Are all the details of the environment **known** to the AI designer?
- For a game or simulation: probably **yes** (unless someone else made it and we don't have the source code)
- For the real world: technically **no** (but we have physics, sociology, economics etc to give us good approximations)

Agents and AI

- The ideas of agents and environments are a useful frame for designing AI
- All(?) AI problems can be expressed in terms of creating an agent that optimises some performance measure in some environment
- Agent design boils down to: given a **percept** (and possibly some **memory** of past percepts/actions), choose the best **action** to take now

Rule-based AI

Rule-based AI

- Generally **reactive** to the state of the world
- Based on **if-then** triggers, basic **calculations**, etc.
- Generally hand-coded and only modifiable by a programmer

Case study: Ghosts in Pac-Man

- Full details: `http://gameinternals.com/understanding-pac-man-ghost-behavior`
- Each ghost has 3 states
  - Chase: head for a specific position (see next slide)
  - Scatter: head for a specific corner of the level
  - Frightened: move randomly

Ghost “personalities”

- Red ghost: aim for Pac-Man
- Pink ghost: aim for 2 spaces ahead of Pac-Man
- Blue ghost: aim for position on the line between red ghost and 2 spaces ahead of Pac-Man
- Orange ghost: aim for Pac-Man until 8 spaces away, then aim for corner

Ghost movement

- No pathfinding — greedily move towards target
- Can only change direction at an intersection
- Can't reverse or stay still
- Therefore can't get stuck, despite imperfect pathfinding

Ghost behaviour

- Behaviour rules are very simple
- However, the combination of them leads to interesting gameplay and illusion of personality

Design lessons

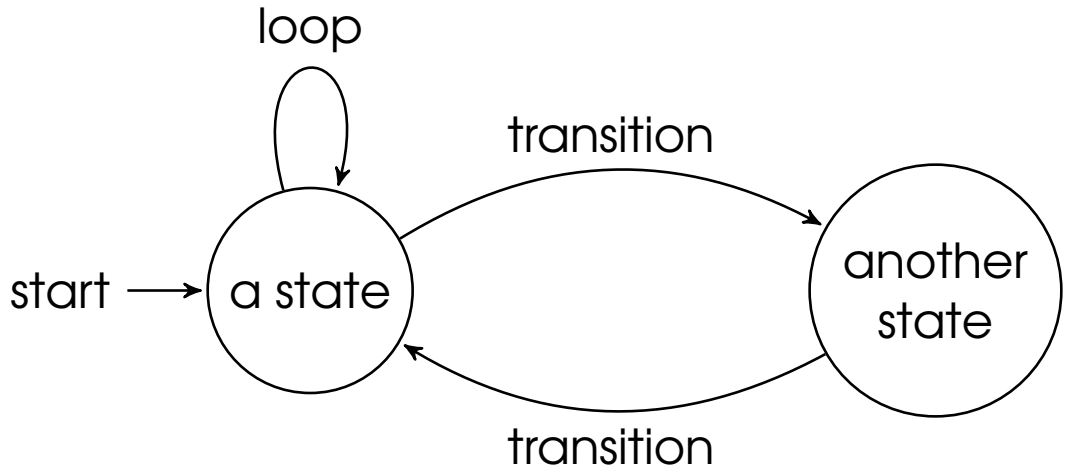
- AI doesn't have to be complicated
- Simple AI, when interacting with a player and each other, can give engaging results
- Bugs in AI don't always matter...

Finite state machines

Finite state machines

- A **finite state machine (FSM)** consists of:
  - A set of **states**; and
  - **Transitions** between states
- At any given time, the FSM is in a **single state**
- **Inputs** or **events** (**percepts**) can cause the FSM to transition to a different state
- Which state the FSM is in dictates what **actions** the agent takes

State transition diagrams



- FSMs are often drawn as **state transition diagrams**
- Reminiscent of **flowcharts** and certain types of **UML diagram**

Other uses of FSMs

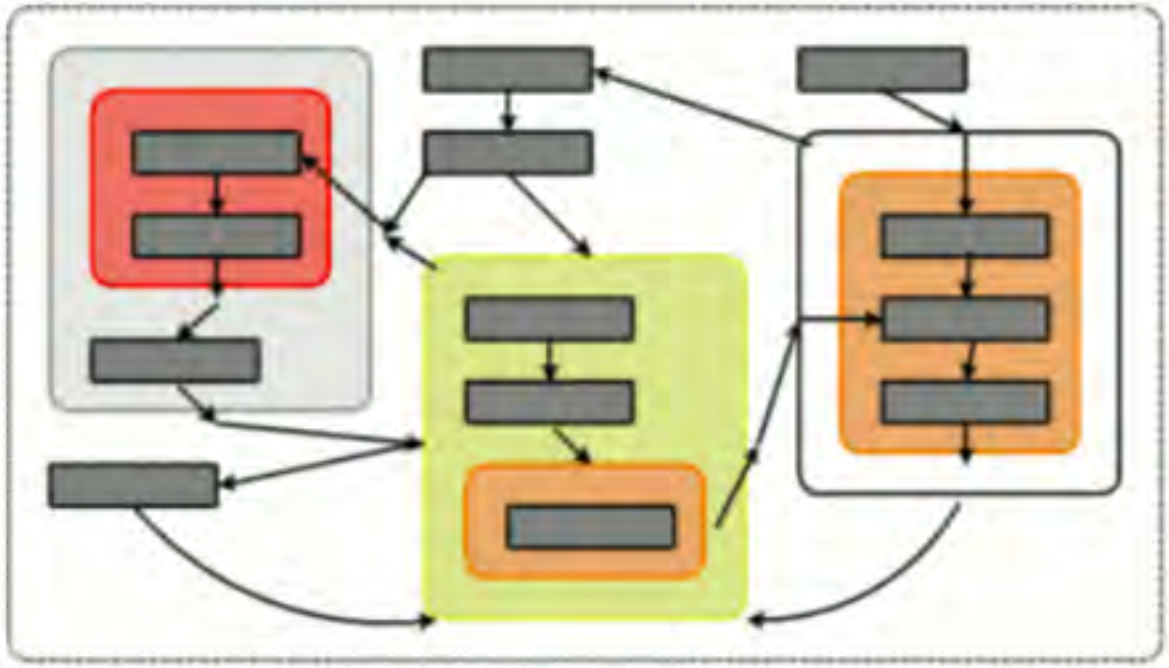
As well as AI behaviours, FSMs may also be used for:

- Animation
- UI menu systems
- Dialogue trees
- Token parsing
- ...

Implementing FSMs

- Implementation needs to keep track of current state, and execute some code dependent on the state (this code itself possibly changing the current state)
- Most common approach: a big **`switch`**–**`case`** statement, with an **`enum`** type for the state
- Object-oriented approach: a `State` class, which your FSM states inherit from
- Functional approach: represent state by a function delegate
- Coroutine approach: encode your FSM logic as a procedure which runs as a coroutine (requires either refactoring logic into structured loops, or using **`goto`**...)

Hierarchical FSMs



- An FSM with N states has potentially N^2 transitions
- Designing complex behaviour with FSMs quickly gets unwieldy
- Hierarchical FSMs allow to group states into **super-states** to simplify defining transitions

Should you use FSMs?

- FSMs are useful for designing simple AI behaviours
- Historically an important technique for game AI
- However other techniques such as behaviour trees are more flexible and better suited to designing complex behaviours

Behaviour Trees

Behaviour trees (BTs)

- A **hierarchical** model of decision making
- Allow **complex behaviours** to be built up from **simple components**
- Allow for **more complex** behaviours than FSMs
- First used in Halo 2 (2005), now used extensively
- Also used in robotics and other non-game AI applications

Using BTs

- Fairly easy to implement; plenty of resources online
- **Unreal**: an advanced BT system is built in
- **Unity**: numerous free and paid options on the Asset Store e.g. Behavior Machine, Behavior Designer, Behave, RAIN

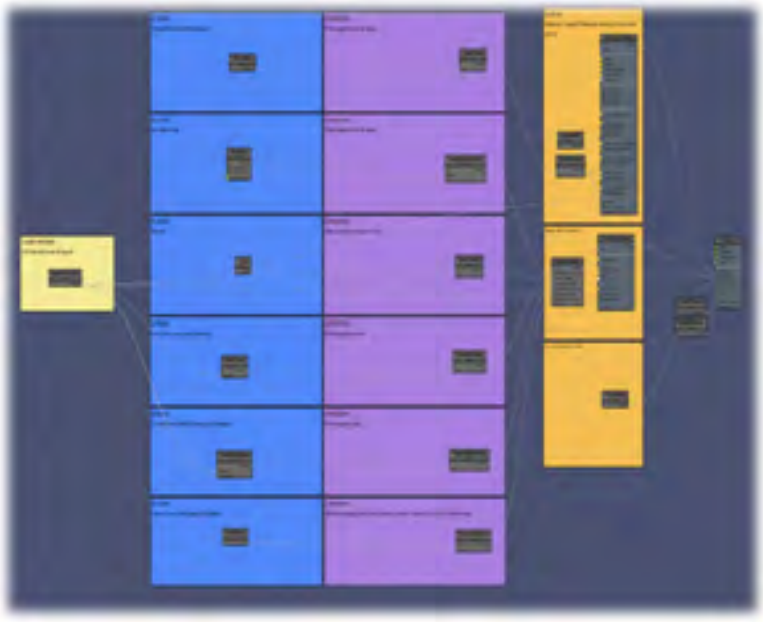
BT basics

- A BT is a **tree** of **nodes**
- On each game update (i.e. each frame), the root node is **ticked**
  - When a node is ticked, it might cause some or all of its **children** to tick as well
  - So ticks propagate down the tree from the root
- A ticked node returns one of three **statuses**:
  - Success
  - Running
  - Failure
- "Running" status allows nodes to represent operations that **last multiple frames**

Blackboard

- It is often useful to **share** data between nodes
- A **blackboard** (sometimes called a **data context**) allows this
- Blackboard defines **variables**, which can be **read** and **written** by nodes
- Blackboard can be **local** to the AI agent, **shared** between several agents, or **global** to all agents
- (Shared blackboards mean that your AI has "telepathy" — this may or may not be desirable!)

BTs in The Division



http://www.gdcvault.com/play/1023382/AI-Behavior-Editing-and-Debugging