COMP250: Artificial Intelligence

2: Designing AI behaviours

Learning outcomes

- **Explain** how finite state machines and behaviour trees are used in AI
- **Design** character behaviours using behaviour trees
- **Implement** an AI system based on behaviour trees

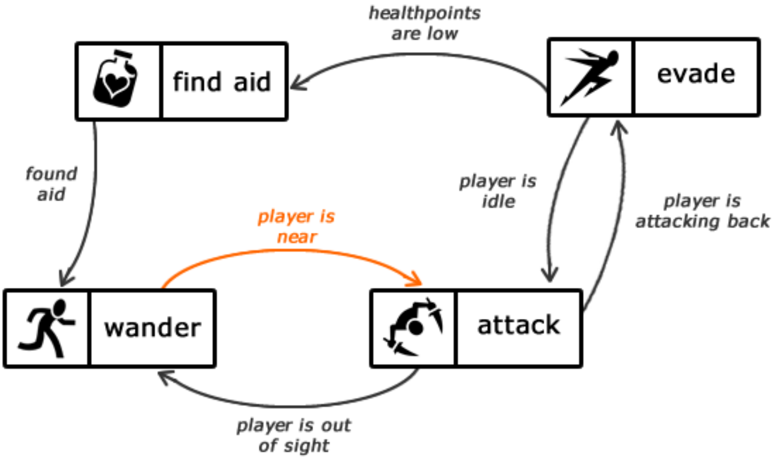
Research journal check-in

AI architectures

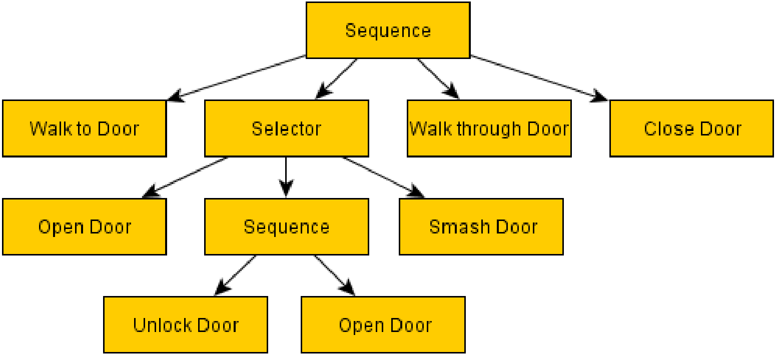
Rule-based AI

Generally implemented as `if` statements or event-based triggers

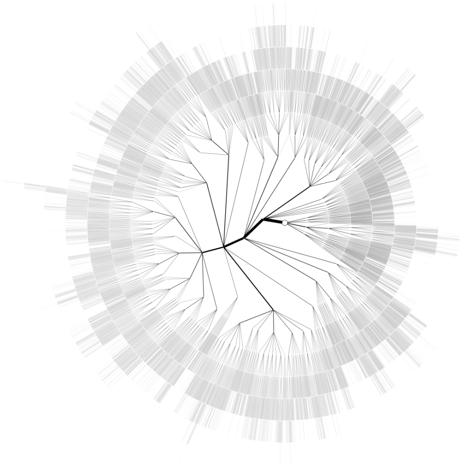
Finite state machines



Behaviour trees

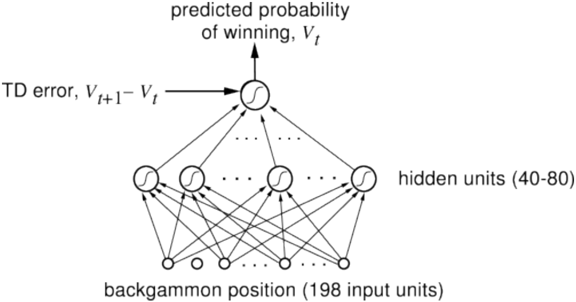


Game tree search



Multi-agent approaches (e.g. flocking)

Machine learning



AI architectures

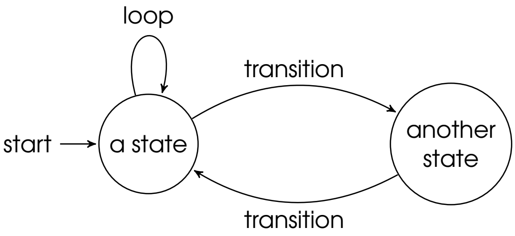
- Can roughly be divided into **hand-authored**...
  - Rule-based, FSM, behaviour trees
- ... and **computational intelligence**
  - Search, multi-agent, machine learning
- Do you want to **design** the AI behaviours yourself, or do you want them to **emerge** from the system?
- Predictability and authorial control versus adaptability and novelty
- Can also combine the two, e.g. use a rule-based system to constrain a CI system

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** can cause the FSM to transition to a different state

State transition diagrams

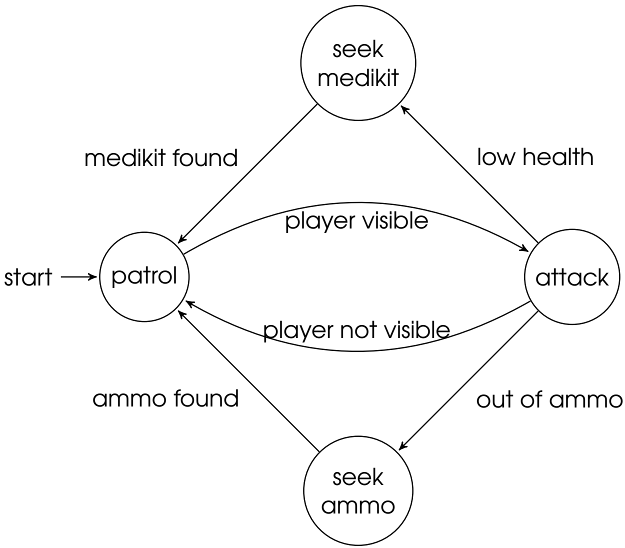


- FSMs are often drawn as **state transition diagrams**
- Reminiscent of **flowcharts** and certain types of **UML diagram**

FSMs for AI behaviour

The next slide shows a simple FSM for the following AI behaviour, for an enemy NPC in a shooter game:

- By default, patrol (e.g. along a preset route)
- If the player is spotted, attack them
- If the player is no longer visible, resume patrolling
- If you are low on health, run away and find a medikit. Then resume patrolling
- If you are low on ammo, run away and find ammo. Then resume patrolling


seek
medikit
medikit found
low health
player visible
start
patrol
attack
player not visible
ammo found
out of ammo
seek
ammo

Other uses of FSMs

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

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

Beyond FSMs

Some topics for you to research, for when plain old FSMs aren't enough...

- Hierarchical FSMs
- Nested FSMs
- Stack-based FSMs
- Hierarchical task networks
- ...

Plus the topic we will be looking at today: **behaviour trees**

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**

Node types

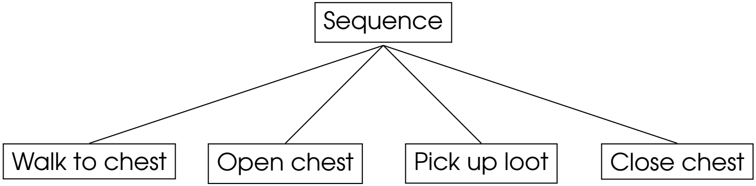
- There are **three main types** of BT node
- **Leaf** nodes
  - No children
  - Represent actions (i.e. the AI agent actually doing something)
- **Decorator** nodes
  - One child
  - Modify the execution of the child
- **Composite** nodes
  - Control which of the children are executed on each tick

Leaf nodes

- Represent **atomic actions**
  - I.e. actions which can't sensibly be broken down into smaller actions
- E.g. walk to, crouch, attack, open door
- Status:
  - Success means "the action is done"
  - Failure means "the action cannot be done"
  - Running means "the action is still in progress"
- Leaf nodes can also be used to represent **conditions**
  - E.g. "is my health below 10%?"
  - Returns success for true, failure for false
- Leaf nodes often have **parameters** to allow for reuse in different situations

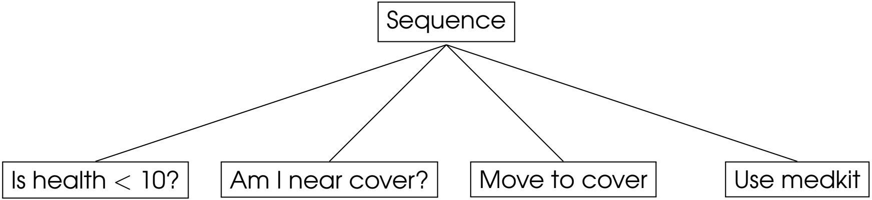
Composite nodes: sequence

- Run each child, in order
- If **any** child returns failure, stop and return failure
- If **all** children return success, stop and return success



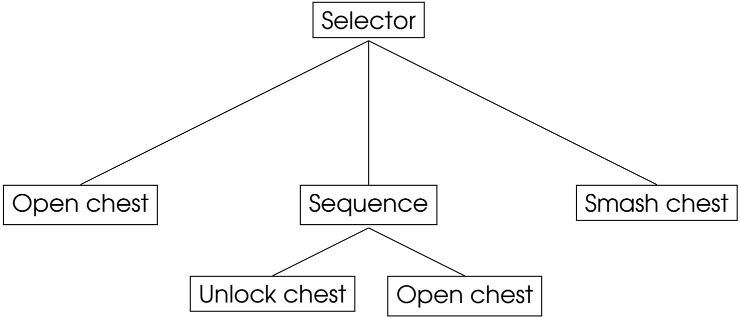
Sequence nodes and conditions

- A sequence node can be used like an `if (cond1 && cond2)` statement



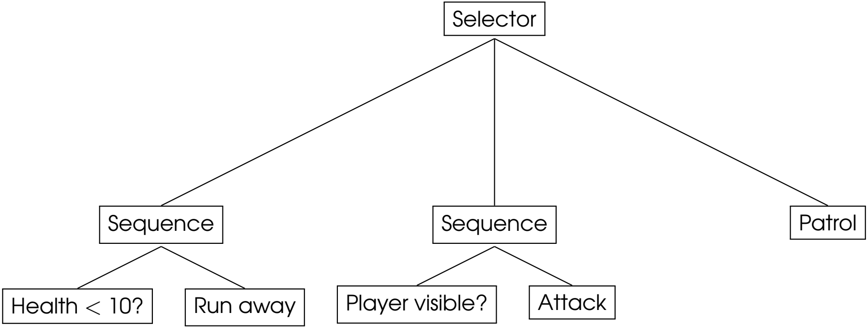
Composite nodes: selector

- Run each child, in order
- If a child returns failure, move onto the next one
- If **any** child returns success, stop and return success



Selectors and priority

- Order of selector children represents the **priority** of different alternatives



Sequence vs selector

- Sequence: perform a list of actions; if one of them fails then abandon the task
- Selector: try a list of alternatives; stop once you find one that works
- Sequence works like `and`, selector works like `or`

Other composite nodes

- Execute children in **random** order
- Execute children in **parallel**
- Most BT frameworks allow programmers to create custom composite nodes

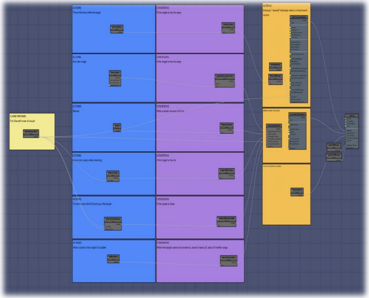
Decorator nodes

- **Inverter**: if child returns success then return failure, and vice versa
- **Repeater**: run the child a number of times, or forever
- Most BT frameworks allow programmers to create custom decorator nodes

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

Workshop

Follow the tutorial at

`https://docs.unrealengine.com/latest/INT/Engine/AI/BehaviorTrees/QuickStart/`