Behaviour Trees
Seminar

Pascal Folleher
Universität Hamburg

27.10.2014
Outline

1. Behaviour Trees
2. Extensions
3. vs HFSM
4. Handling Complexity in the Halo 2 AI
Motivation

- Behaviour Trees are reusable
- $\Rightarrow$ BTs scale well
- BTs are easily authored
Behaviour Trees

- Directed tree
- Nodes are either *composites* or *leaves*
- Root is *ticked* every time step
Behaviour Trees 2

- *Ticks* traverse down towards leaves
- Results traverse up towards the root
- Possible results: *Success, Failure, Running*
Composites

- Selector
- Sequence
- Parallel
- Decorator
Selector

- Behaves similar to logical OR
- Returns Success (Running) if any child returns Success
- Returns Failure if all children return Failure
Selector 2

Evade_Obstacles  Find_Path
Sequence

- Behaves similar to logical AND
- Returns Success if all children return Success
- Returns Failure (Running) otherwise
Sequence 2

Position_Hand -> Grasp
Parallel

- Allows parallel execution of behaviours
- Returns Success if $\geq S$ children succeed
- Returns Failure if $\geq F$ children succeed
- Returns Running in any other case
Decorator

- Can only have **ONE** child
- Manipulate return value of child
- e.g. Inverter, Counter, Timer ...
Decorator 2

? -> Recharge

! -> Search

Battery_Low
Leaves

- Actions
- Conditions
- Leave can be another BT
Behaviour Tree in Action

lelftandgrasp

righthandgrasp

bothhandgrasp
Behaviour Tree in Action 2

First Experiment (0:00 - 1:15)
http://www.youtube.com/watch?v=kEd2YxysBtI
Behaviour Tree in Action 3

\[
\text{squatdown} \rightarrow \text{positionarm} \rightarrow \text{grasp}
\]
~Decorator

- used to synchronize actions with other agents
- one agent broadcasts intended behavior
- other agents can respond if interested
Parametrized Behaviour Trees

- Subtrees can be parametrized
- SmartEvents contain parametrized Behaviour Tree
- Agents involved in SmartEvent will execute the BT once, then restart personal BT
HFSM

- Large FSM can be hard to handle
- HSFM allows to use FSM as nodes...
- ... but still has the same problems
HFSM Example
Implicit vs Explicit State Transitions

- BT state transition similar to procedure call
- (H)FSM state transition similar to GoTo
General Ideas

- Behaviour Trees are shared between characters
- Characters have a memory pool (e.g. Grenade Cooldown)
- Bitvectors represent characters world-knowledge and can lock behaviours
Impulses & Stimuli

- Impulses reference other parts of BT
- Stimuli are inserted into BT when certain events happen
- Because of priority sorting stimuli only interrupt certain behaviours
Orders

- Orders group Firing Positions
- Orders are assigned to Squads
- Trigger (e.g. Squadleader died) may assign new Orders
Styles

- Styles can be assigned to Orders
- Styles can block certain behaviours (e.g. aggressive style prevents fleeing behaviour)
The End

Thank you for your attention.
Any questions?
Michele Colledanchise and Petter Ögren.
How behavior trees modularize robustness and safety in hybrid systems.

Damian Isla.
Handling Complexity in the Halo 2 AI.
In Game Developers Conference, Mar 2005.

A. Johansson and P. Dell’Acqua.
Emotional behavior trees.
In Computational Intelligence and Games (CIG), 2012 IEEE Conference on, pages 355–362, Sept 2012.

Chong-U Lim, Robin Baumgarten, and Simon Colton.
Evolving behaviour trees for the commercial game defcon.

A. Marzinotto, M. Colledanchise, C. Smith, and P. Ogren.
Towards a unified behavior trees framework for robot control.

Petter Ogren.
Increasing Modularity of UAV Control Systems using Computer Game Behavior Trees.