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Computer Games Technology
—Dynamic Skeleton-Based Path Finding—

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Origins

• Paul Shotbolt’s graduate project in 2003.

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Introduction

- Many existing computer-game wayfinding techniques favour mathematical or graphical approaches and ignore the possibility of knowledge re-use.

- Humans re-use knowledge to solve wayfinding problems.

- Due to the difference in approach, solutions obtained by humans and computers differ qualitatively.

A human prefers to re-use known routes (skeleton paths), and might adopt a semantically shorter path that translates to a longer real-world path.
Introduction

- In computer games, differences between simulated-human behaviour and actual human behaviour make characters less convincing.

- A goal of the game designer is the suspension of disbelief of the player. This is impeded by unconvincing character behaviour.

- Therefore, more human-like behaviour is needed to prevent onset of disbelief.

Some computer players unerringly opt for the shortest route to their goal.

Human players will often alternate between a number of skeleton paths.
Dynamic skeleton-based wayfinding

- A wayfinding system incorporating knowledge re-use. This involves aspects of case-based reasoning and inter-agent communication.

- Differs from most existing game wayfinding techniques which do not involve knowledge re-use.

- In effect, CBR principles applied to existing wayfinding techniques, to better simulate human wayfinding. Our test environment used A*, however other wayfinding systems should be equally appropriate.

- May lead to faster but less-optimal wayfinding.
Approach

- A set of known skeleton paths is gradually accumulated, and these paths are adapted to solve new wayfinding problems.

- Agents communicate path-knowledge to each other allowing cooperative problem-solving.
Skeleton-path selection

- Selecting a known skeleton path for adaptation to solve a new problem.

- An appropriate path $S$ is selected depending on:
  - Amount of prior use
    - By both this agent and known other agents
  - Path length
  - Orientation and curvature
  - Estimated adaptation distances
Skeleton-path adaptation

- Adapting a chosen skeleton path to solve a new problem.

- A chosen skeleton path $S$ is adapted by finding a route from the start to the skeleton path, and from the skeleton path to the goal.

- By introducing an intermediate subgoal, search complexity is reduced.

- The adapted path is retained in the skeleton-paths case-base, which grows dynamically.
In Vivo

- The Torque Game Engine from Garage Games was adapted.
- An inter-agent communication system using semantic networks was implemented.
- The skeleton-based wayfinding system was built over this both this communication system and a basic A* implementation.
Evaluation

- **Benefits:**
  - More human-like paths chosen.
  - More human-like cooperation between route-finding agents.
  - Wayfinding can be more efficient.
  - An emergent positive-feedback loop causes agents to prefer common routes and thus encounter each other more frequently.

- **Problems (classic CBR issues):**
  - The skeleton path case-base is difficult to maintain automatically, and can become degenerate if significantly sub-optimal paths are stored.
  - Skeleton-path selection is a non-trivial task that is compounded by a degenerating case-base.
Conclusions

- Overhaul to the approach is needed.
- Several intrinsic problems:
  - Path selection is functional but could be improved.
  - Degenerating case-base significantly detracts from performance. Storing only optimal and 1st level derivative paths may solve this, however.
- Many possible improvements:
  - Using skeleton-path case-base to predict peer and opponent movements.
  - Link skeleton paths together.
- Deeper simulation of wayfinding creates emergent gameplay aspects:
  - Agents that encounter each other once are more likely to do so again.
  - A preference for common principal routes is exhibited, which mimics human behaviour.
  - Wayfinding is faster over previously-traversed terrain.
  - All of these emergent aspects can contribute to immersive gameplay.
- More empirical testing needed:
  - However, noted critical problems need to be solved before testing becomes worthwhile.