Fast and Optimal Pathfinding on Grid Maps

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1 The Problem
Pathfinding in modern video games often involves exploring highly regular environments such as cities, sewers or dungeons – see for example Figure 1. These locations are usually symmetric in the sense that many optimal length paths exist between arbitrary pairs of locations. Symmetry is undesirable as it increases the size of the search space and forces search algorithms to waste time.

In this work we speed up pathfinding by identifying and eliminating symmetry in 4-connected grid maps. Our method is fast, optimal, memory efficient and readily combined with any existing pathfinding system.

Figure 1: Typical examples of highly regular video game environments.

2 The Big Idea
We propose the following offline symmetry breaking technique:
1. Decompose the grid map into a set of empty rectangular rooms.
2. Prune all tiles not on the perimeter of an empty room.
3. Connect tiles on opposite sides of the perimeter.

Sometimes a tile which has been pruned is later required; for example as a start or goal location. To handle such cases we use an online re-insertion procedure. Figure 2 shows a concrete example.

Figure 2: We speed up search by decomposing a 4-connected map into empty rectangular rooms which can be traversed without visiting any tiles from their interior. This method is both fast and provably optimal.

3 Results
Figure 3 summarises our main result while Figure 4 and Figure 5 show the amount of improvement we can regularly obtain. We evaluate performance by running the well known A* algorithm on a range of realistic and synthetic benchmarks:
- **Adaptive Depth**: 12 maps of size 100×100 which are composed of rectangular rooms and large open areas.
- **Baldur’s Gate**: 120 maps from BioWare’s Baldur’s Gate II: Shadows of Amn. Sizes vary from 50×50 to 320×320.
- **Rooms**: 300 maps of size 256×256 which are divided into 32×32 rectangular areas.

Figure 4: Tiles explored before symmetry elimination.
Figure 5: Tiles explored after symmetry elimination.

4 Future Work
We are investigating a number of extensions:
- Stronger symmetry breaking techniques to prune more tiles.
- An analogous algorithm for 8-connected grid maps.
- Hybrid algorithms that combine our speedup technique with existing methods to achieve further performance increases.

5 More Information
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