Fast and Optimal Pathfinding on Grid Maps

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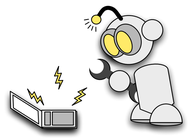
1 The Problem



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.

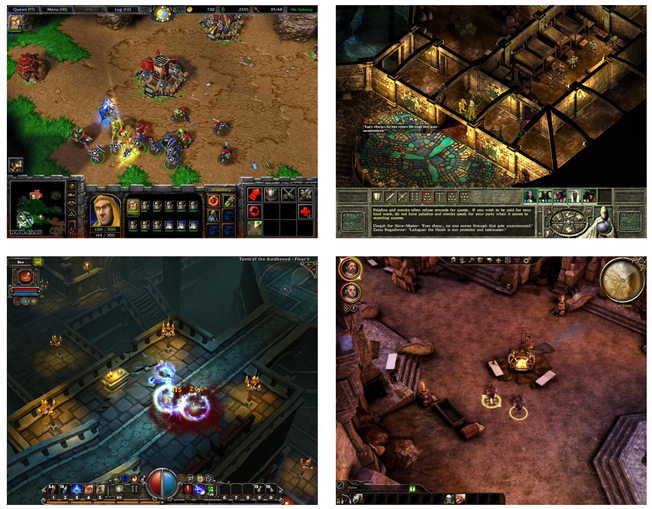
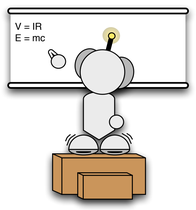


Figure 1: Typical examples of highly regular video game environments.

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.

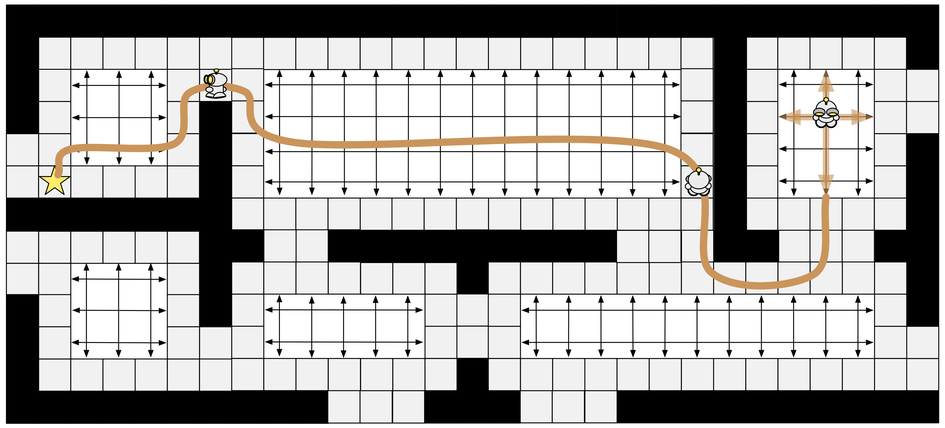
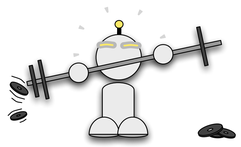


Figure 2: We speed up search by decomposing a 4-connected map into empty rectangular rooms which can be traversed without visiting any tiles from their interior. This method is both fast and provably optimal.

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.



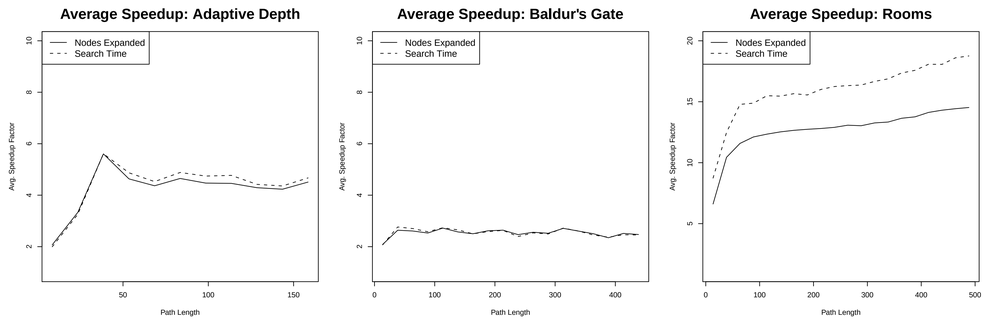


Figure 3: Using symmetry elimination A* runs between 3 to 20 times faster on a range of synthetic and realistic benchmarks. The best results are achieved on maps with large open areas where we eliminate many symmetric paths.

Figure 4: Tiles explored before symmetry elimination.

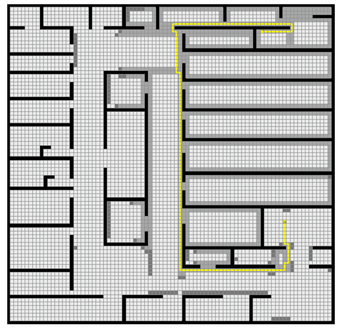


Figure 5: Tiles explored after symmetry elimination.

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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