

Computing High-Quality Paths in Weighted Regions

Norman Jaklin, Mark Tibboel, Roland Geraerts

Motion in Games 2014

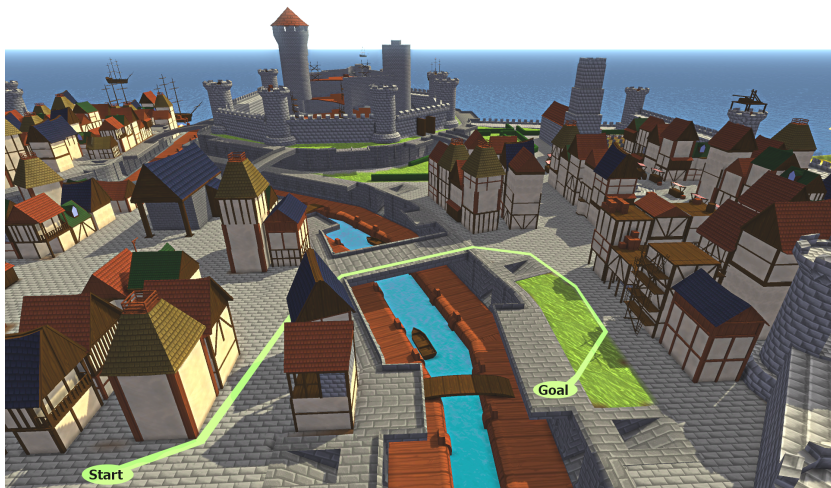


Universiteit Utrecht

November 7, 2014

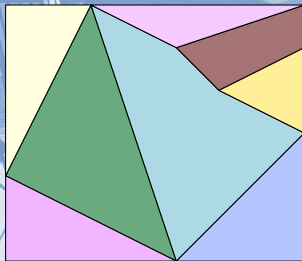
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Goal



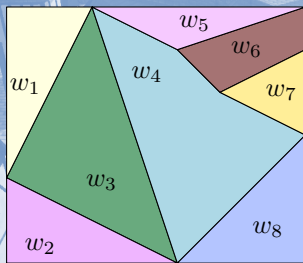
Weighted Region Problem

Introduced by Mitchell and Papadimitriou [6] in 1991



Weighted Region Problem

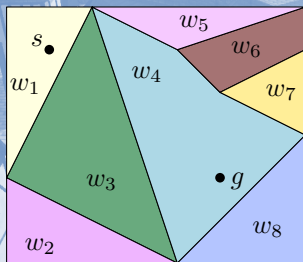
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Goal

Weighted Region Problem

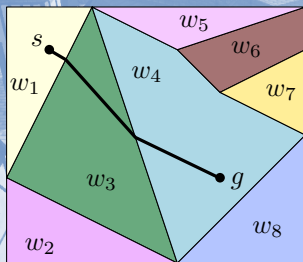
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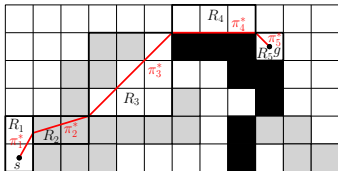
A blue-tinted 3D rendering of a medieval city. In the background, a large castle with multiple towers and battlements sits on a hill overlooking the sea. In the foreground, a path of white lines winds through the city's buildings and streets, leading towards a small blue oval labeled "Goal" on a rooftop. The overall scene is rendered in a clean, blocky style.

Proven to be unsolvable in $ACM\mathbb{Q}$ by Carufel et al. [2] in 2012

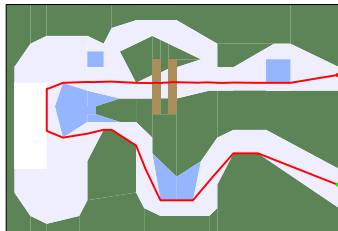
ϵ -approximation methods that work on the exact geometry exist
e.g. by Aleksandrov et al. [1] or Sun and Reif [8]

Our Contributions

Path-cost analysis proof:
8-neighbor grid paths in
weighted regions



Path planning method:
Vertex-based pruning (VBP)



Context: 5-Level Hierarchy for Path Planning

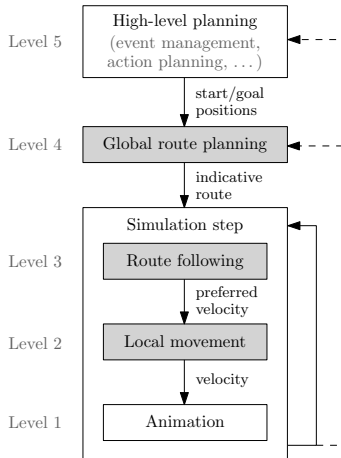


Figure: Taken from [5]

Context: 5-Level Hierarchy for Path Planning

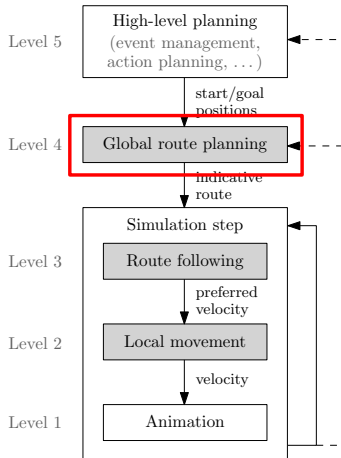


Figure: Taken from [5]

The background is a blue-tinted 3D rendering of a medieval city. In the foreground, a white path winds through the streets, starting from the bottom left and ending at a small blue oval labeled "Goal" on the right. The path navigates around buildings and a central courtyard with a boat. In the background, a large castle with multiple towers and crenellations sits on a hill, overlooking the sea. Several sailing ships are visible in the distance.

Contribution 1

Path-cost analysis of 8-neighbor grid paths in weighted regions

- Extensively studied for classical path planning without regions
- See e.g. Alex Nash, *Any-Angle Path Planning*, 2012 [7]
- Known upper bounds on path-costs for triangular grids, square grids, hexagonal grids, and cubic grids in 3D

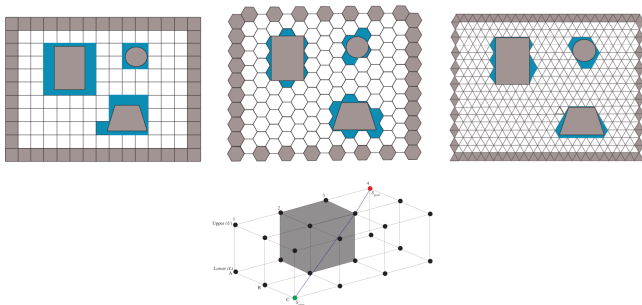
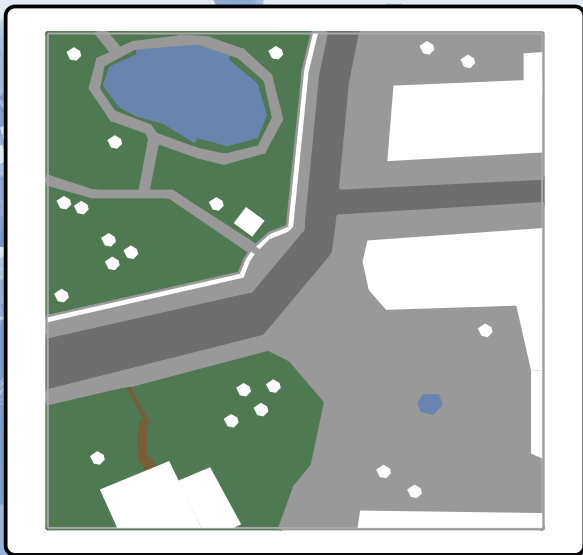
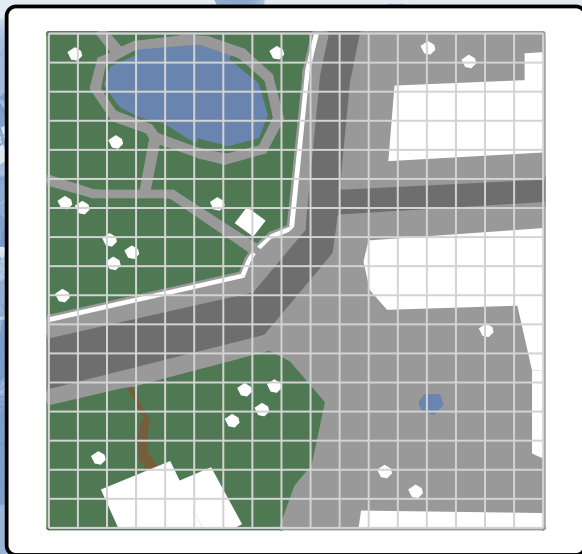
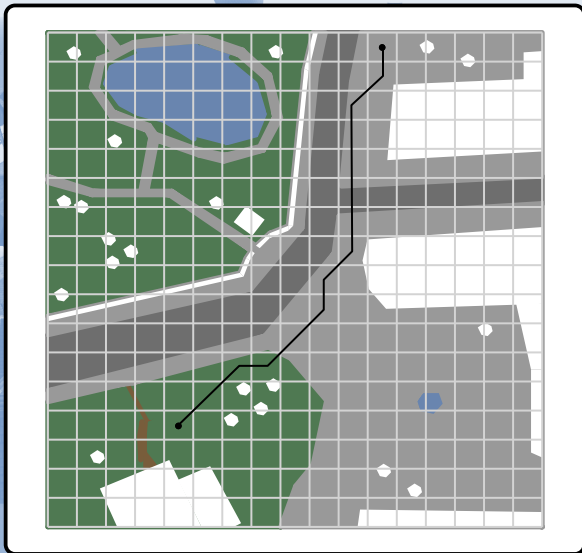


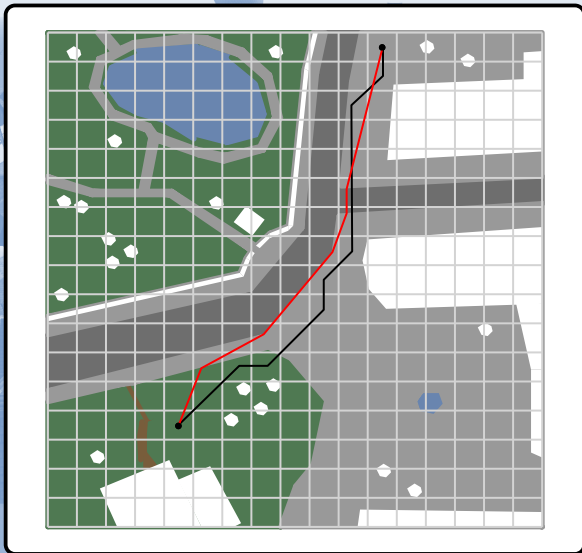
Figure: Taken from [7]



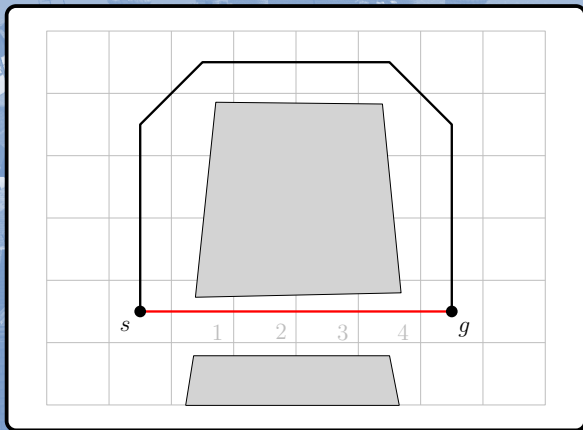


Goal





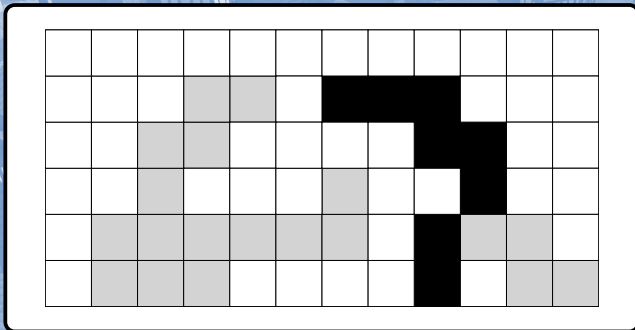
Arbitrary scene with arbitrary grid resolution



⇒ Grid path can be arbitrarily expensive

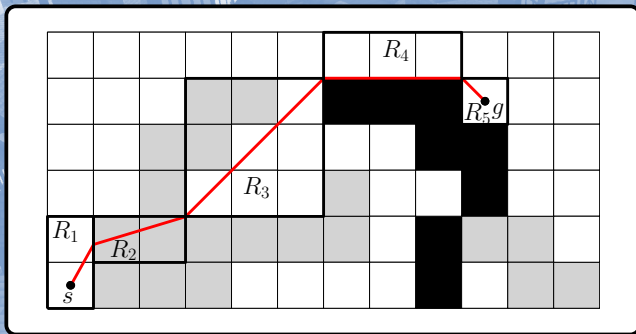
All regions aligned with the grid

We prove:
$$\text{Costs}(\text{grid path}) \leq \left(4 + \sqrt{4 - 2\sqrt{2}}\right) \cdot \text{Costs}(\text{optimal path})$$



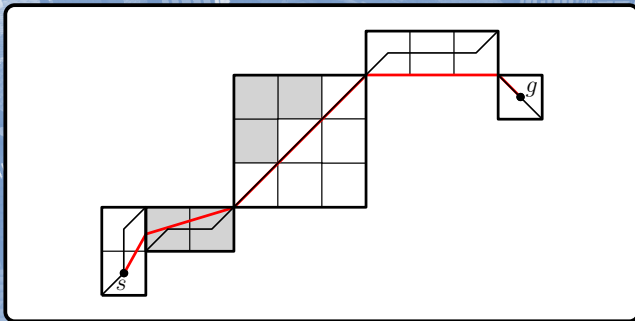
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A blue-tinted 3D rendering of a medieval city. In the background, a large castle with multiple towers and battlements sits on a hill overlooking the sea. In the foreground, a path of white lines winds through the city's streets and around a central courtyard. A small boat is visible in the courtyard. A white oval labeled "Goal" is positioned at the end of the path in the lower right area.

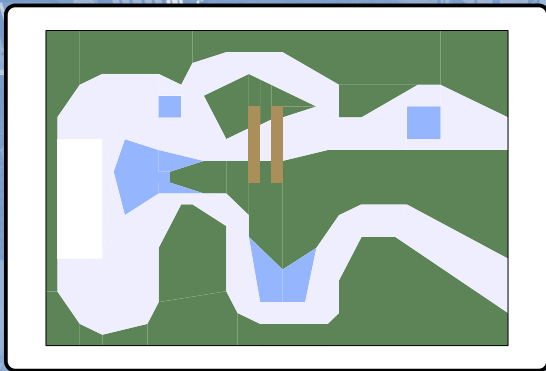
Contribution 2

Path planning method: Vertex-based pruning (VBP)

Goal

Idea of VBP:


- Compute a grid-optimal path π on a weighted square grid using A^* [3]
- Prune the search space: Only consider triangle vertices close to bending points of π
- Use an existing ϵ -approximation method on the pruned graph
- Here: *Steiner Point Method* by Aleksandrov et al. [1]



Experimental Results (Excerpt)

Scene	ϵ	Method	Constr.time (ms)	Query time (ms)	Nodes explored	Path costs
<i>Forest</i>	0.1	Steiner point	163325.0	1141.1	47969	2461.2
		VBP	16857.2	224.6	15413	2461.2
	0.2	Steiner point	9638.0	127.8	17710	2461.4
		VBP	1049.6	26.8	5700	2461.4
	0.3	Steiner point	1794.7	34.3	9370	2461.9
		VBP	351.9	7.8	3031	2461.9
	0.4	Steiner point	600.6	13.4	5744	2462.5
		VBP	245.0	3.1	1863	2462.5
	0.5	Steiner point	300.4	6.4	3826	2464.2
		VBP	225.4	1.4	1243	2464.2

Goal

A blue-tinted 3D rendering of a medieval city. In the background, a castle with a tall tower and crenellated walls sits on a hill overlooking the sea. The foreground shows a dense cluster of buildings with tiled roofs and half-timbered facades. A white path starts from the bottom left and winds through the streets, ending at a small blue oval labeled "Goal" on a roof in the lower right. A white-bordered box with a black border is centered in the upper half of the image, containing text. Below it, another smaller white-bordered box with a black border also contains text.

**Example:
Region-based path following
using our MIRAN method [4]**

See video!

Goal



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