Computing High-Quality Paths in Weighted Regions

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Motion in Games 2014

Universiteit Utrecht

COMMIT/

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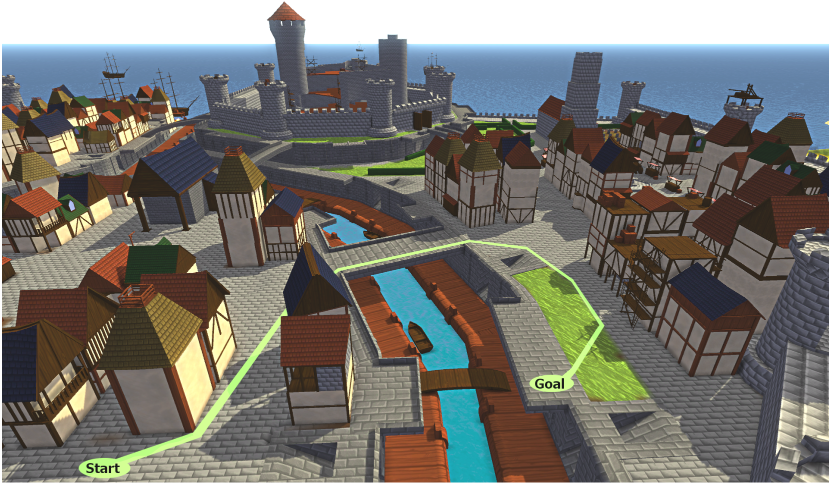
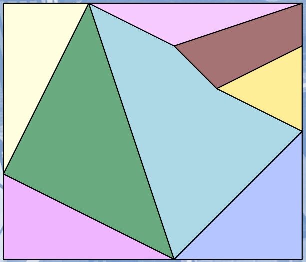

Goal
Start

Weighted Region Problem

Introduced by Mitchell and Papadimitriou [6] in 1991



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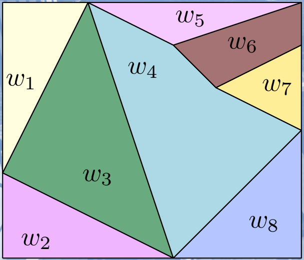

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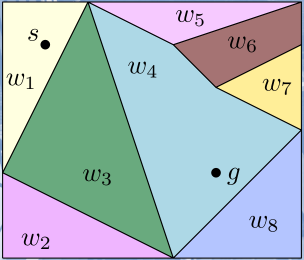

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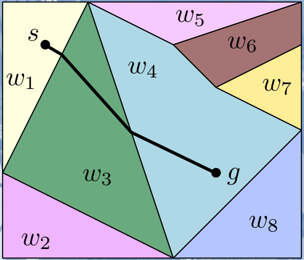
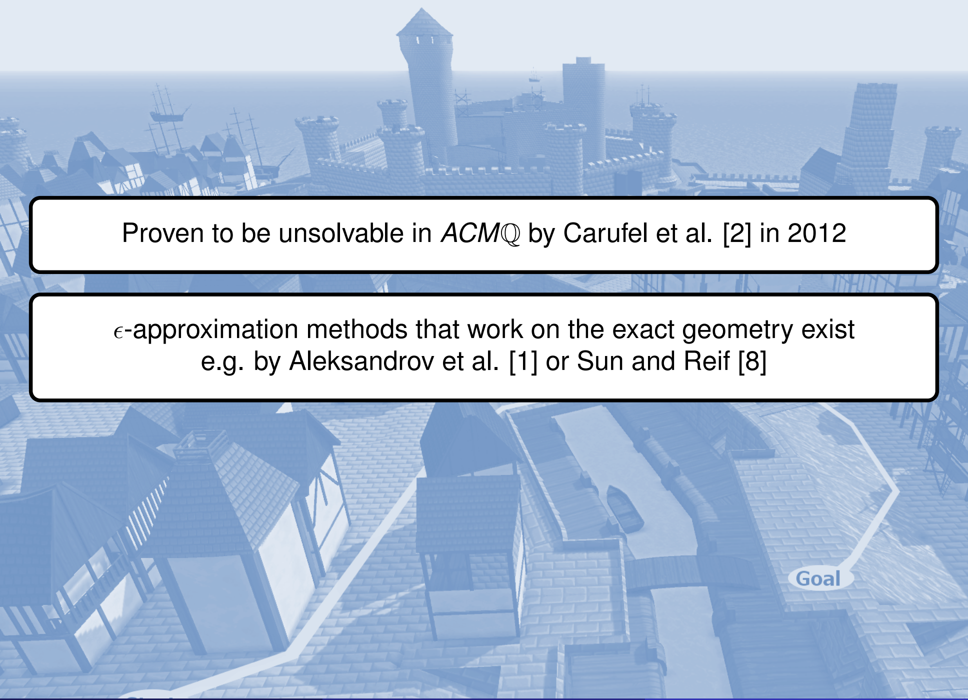




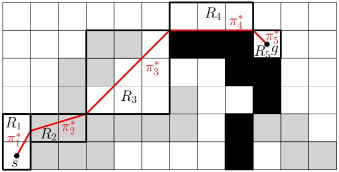
Proven to be unsolvable in $ACM\mathbb{Q}$ by Carufel et al. [2] in 2012

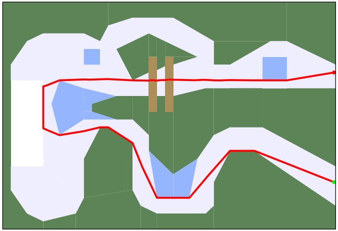
ϵ-approximation methods that work on the exact geometry exist
e.g. by Aleksandrov et al. [1] or Sun and Reif [8]

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

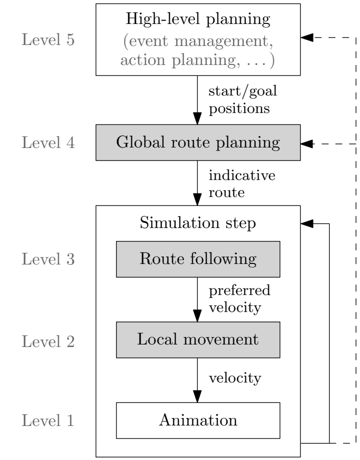
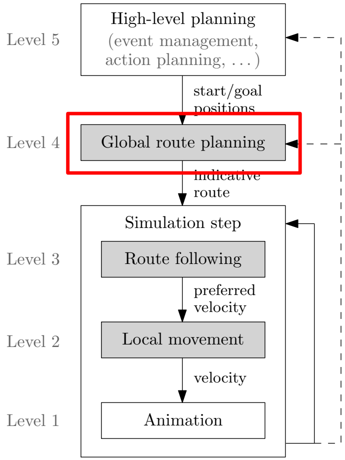


Figure: Taken from [5]

Context: 5-Level Hierarchy for Path Planning



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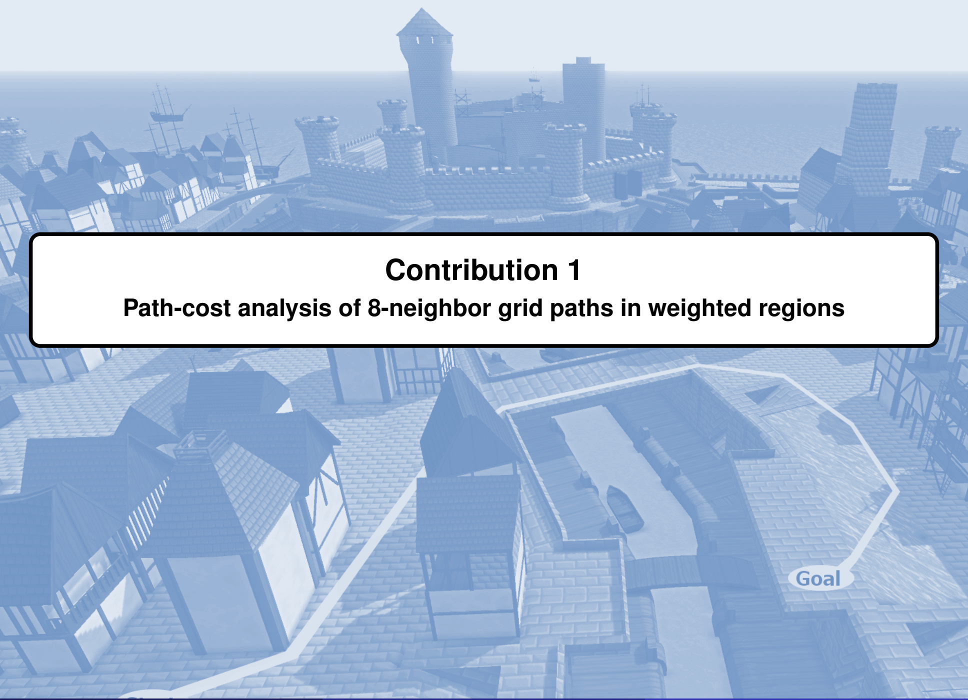
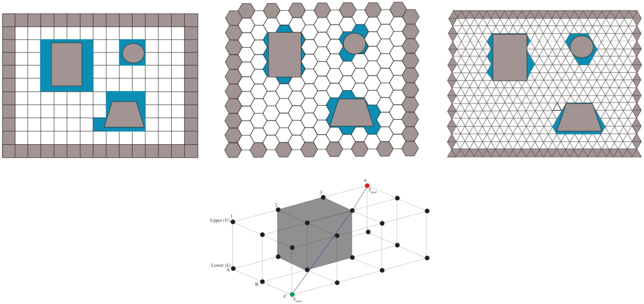
Contribution 1

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



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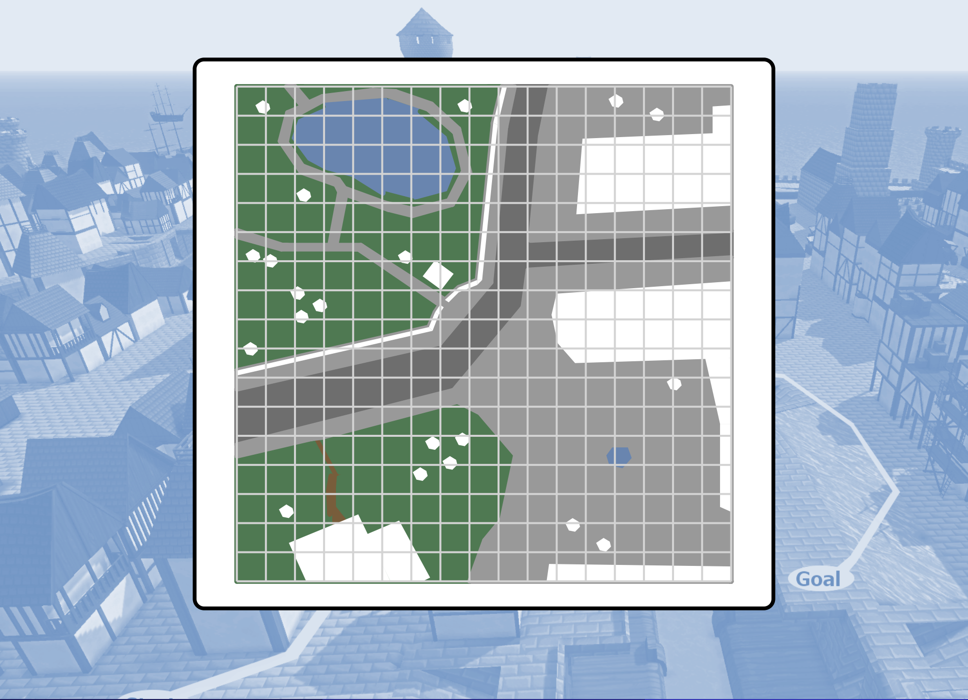
Goal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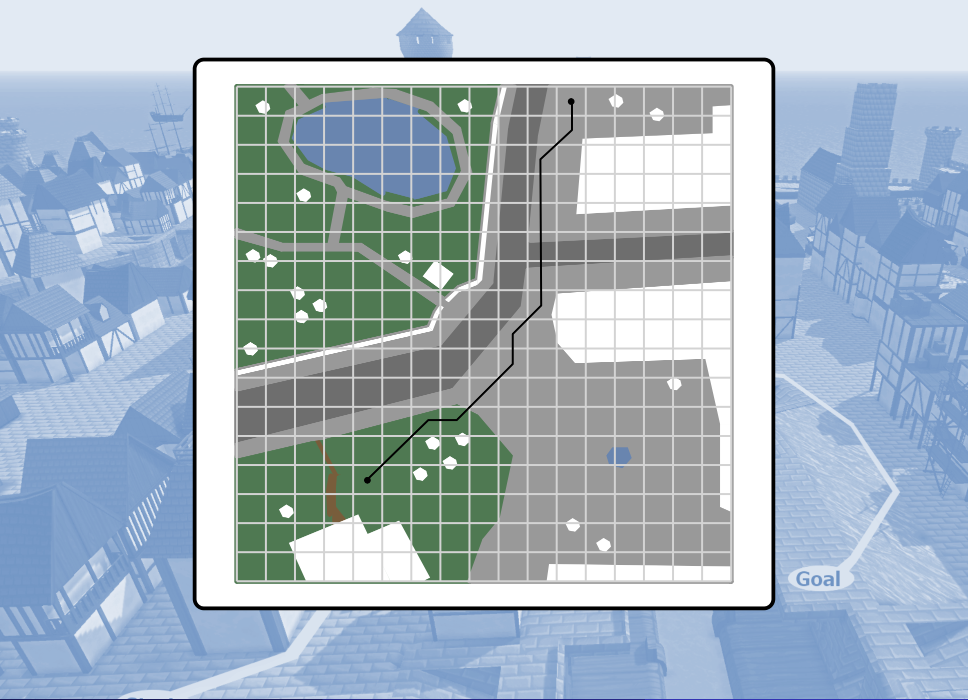
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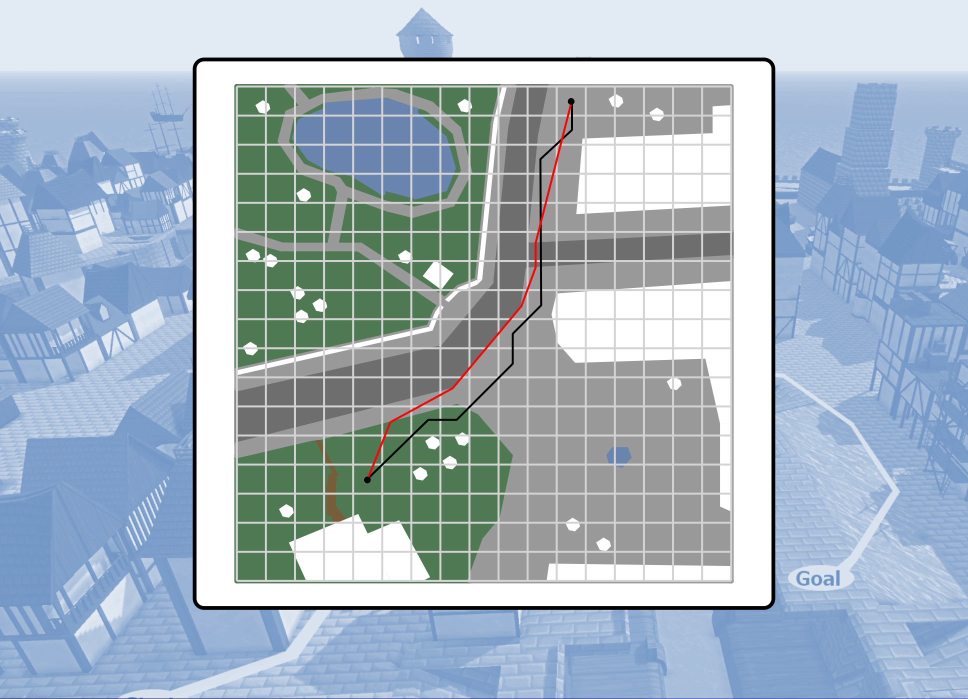
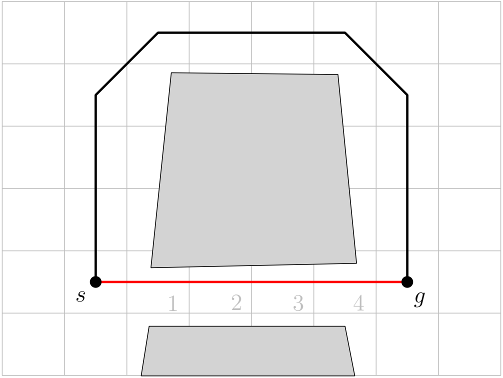

Goal

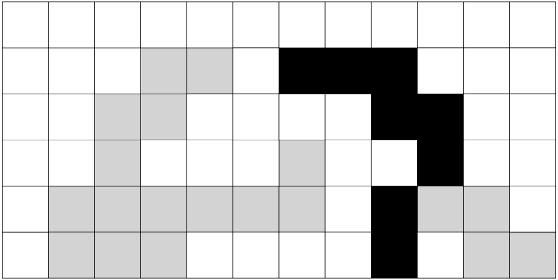
Arbitrary scene with arbitrary grid resolution



⇒ Grid path can be arbitrarily expensive

All regions aligned with the grid

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



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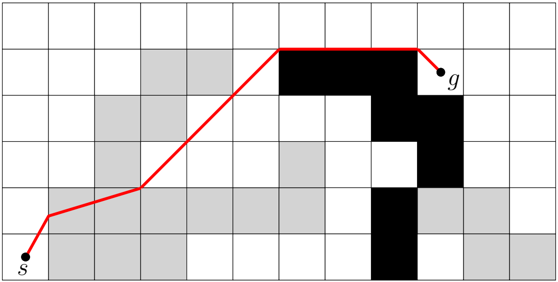

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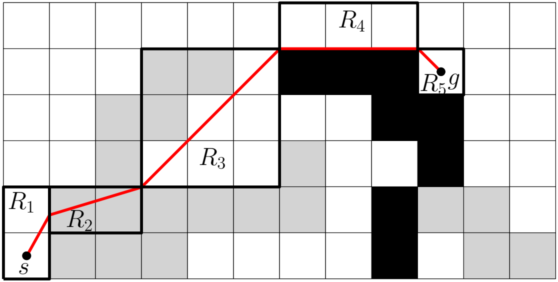

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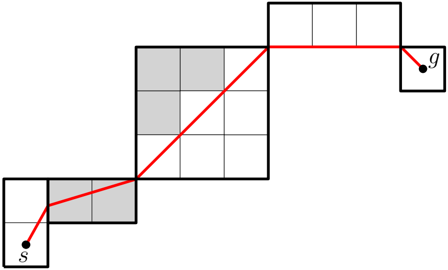

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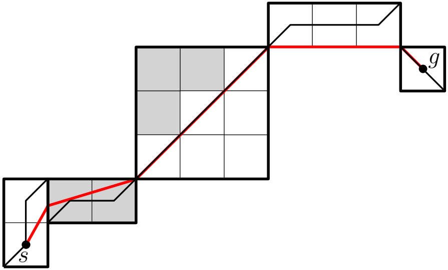
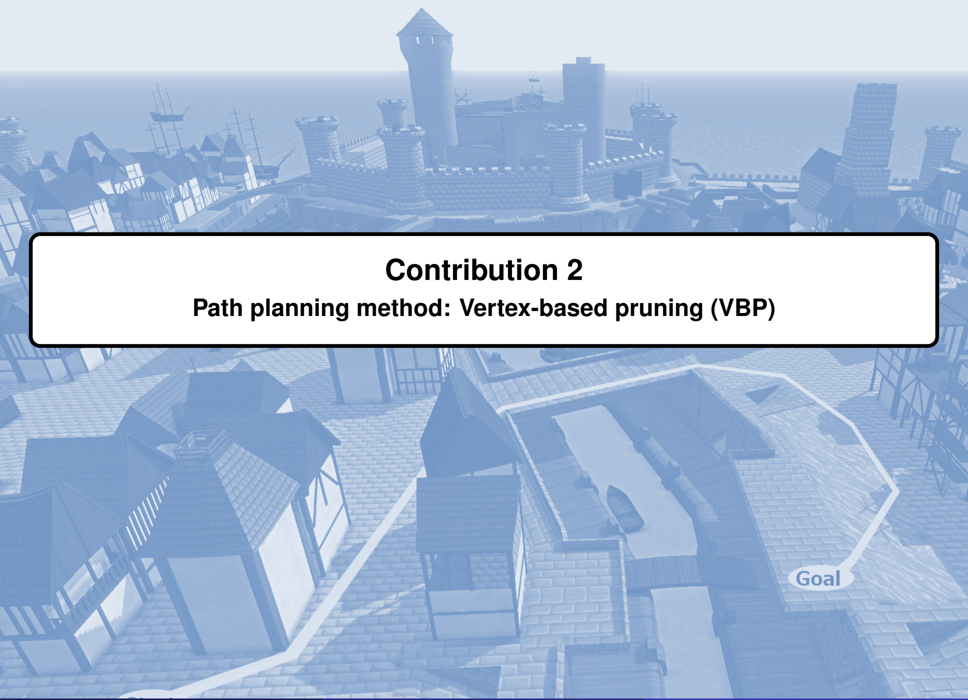


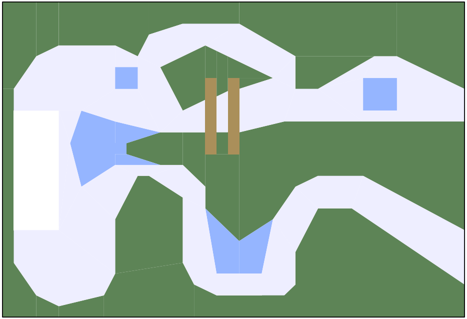


Contribution 2

Path planning method: Vertex-based pruning (VBP)

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]



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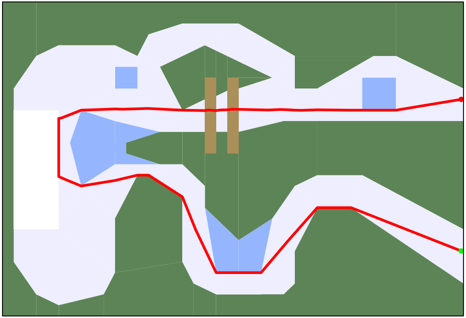

Experimental Results (Excerpt)

Scene	ϵ	Method	Constr.time (ms)	Query time (ms)	Nodes explored	Path costs
Forest	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

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

See video!

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