

Motion/Path Planning

Examples (of what is usually referred to as path planning):

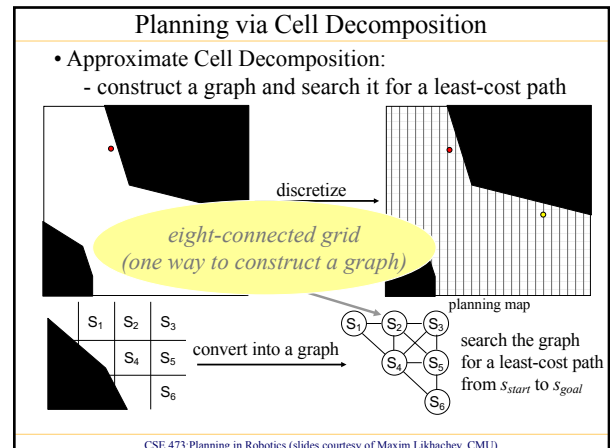
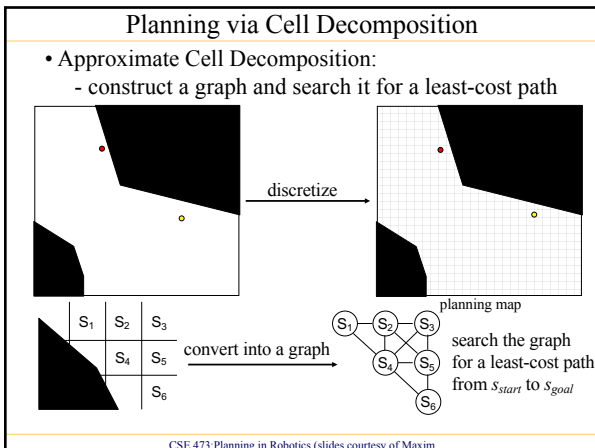
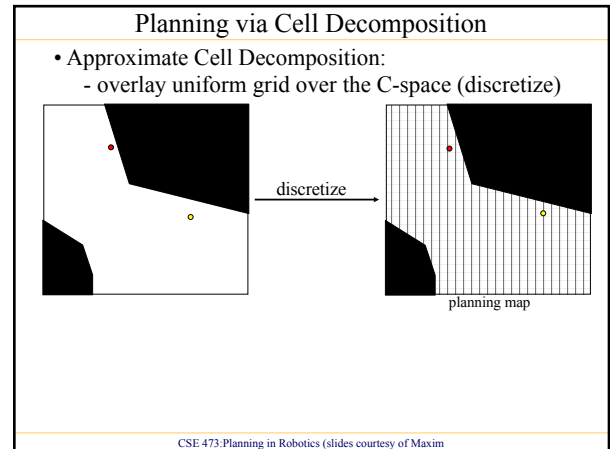
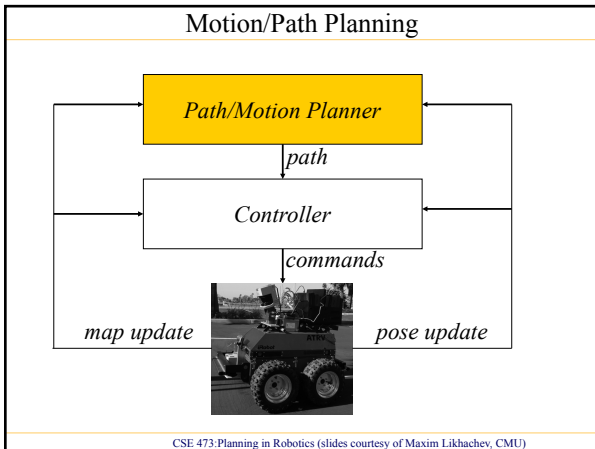
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Motion/Path Planning

Examples (of what is usually referred to as motion planning):

Planned motion for a 6DOF robot arm

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Planning via Cell Decomposition

- Graph construction:
 - lattice graph

outcome state is the center of the corresponding cell

each transition is feasible (constructed beforehand)

action template

replicate it online

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Planning via Cell Decomposition

- Graph construction:
 - lattice graph
 - pros: sparse graph, feasible paths
 - cons: possible incompleteness

action template

replicate it online

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Example

Urban Challenge Race, CMU team, planning with Anytime D*

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Effect of the Heuristic Function

- A* Search: expands states in the order of $f = g + h$ values

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Effect of the Heuristic Function

- A* Search: expands states in the order of $f = g + h$ values

for large problems this results in A* quickly running out of memory (memory: $O(n)$)

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Effect of the Heuristic Function

- Weighted A* Search: expands states in the order of $f = g + \epsilon h$ values, $\epsilon > 1$ = bias towards states that are closer to goal

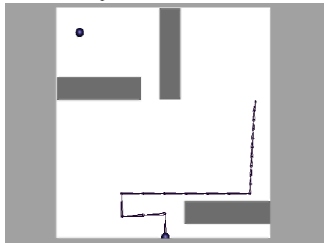
solution is always ϵ -suboptimal:
 $cost(solution) \leq \epsilon \cdot cost(optimal solution)$

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Effect of the Heuristic Function

- Weighted A* Search: expands states in the order of $f = g + \epsilon h$ values, $\epsilon > 1$ = bias towards states that are closer to goal

20DOF simulated robotic arm
state-space size: over 10^{26} states

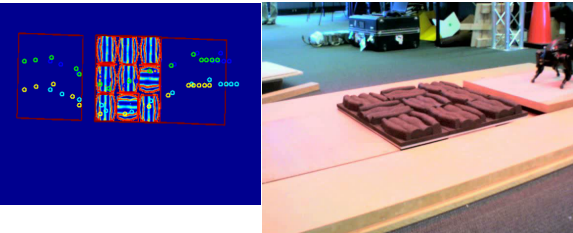


planning with ARA* (anytime version of weighted A*)

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Effect of the Heuristic Function

- planning in 8D ($\langle x, y \rangle$ for each foothold)
- heuristic is Euclidean distance from the center of the body to the goal location
- cost of edges based on kinematic stability of the robot and quality of footholds




planning with R* (randomized version of weighted A*)

joint work with Subhrajit Bhattacharya, Jon Bohren, Sachin Chitta, Daniel D. Lee, Aleksandr Kushleyev, Paul Vernaza

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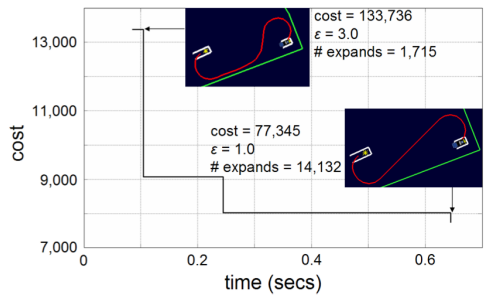
Heuristics



heuristic	states expanded	time (secs)
h	2,019	0.06
h_{2D}	26,108	1.30
h_{fsh}	124,794	3.49

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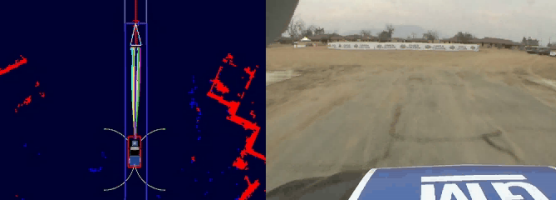
Anytime Aspects



Cost	ϵ	# expands
133,736	3.0	1,715
77,345	1.0	14,132

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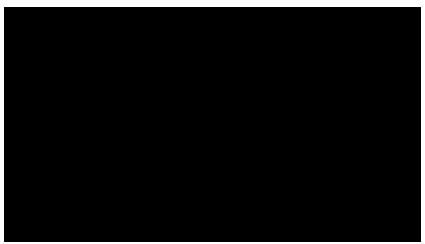
Example, again



*Urban Challenge Race, CMU team, planning with Anytime D**

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Planning Examples



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