Combining Bounding Boxes and JPS to Prune Grid Pathfinding

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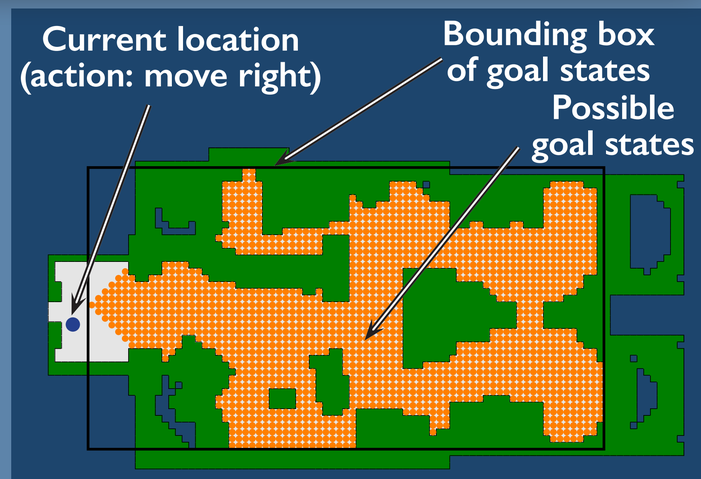
What are bounding boxes?

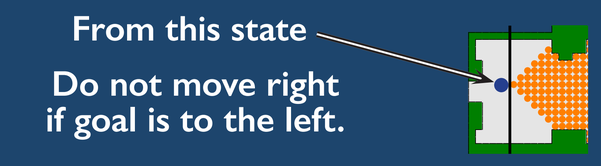
Bounding boxes are a form of geometric container (Wagner, Willhalm and Zaroliagis, 2005).

Each edge in the graph is annotated with the bounding box associated with all possible states that could be reached *optimally* by following that edge.

Bounding boxes have not been tested on grid maps or on A* (heuristic) search.



During search, if the goal isn't inside the bouding box for an edge, that edge can be pruned from the search.



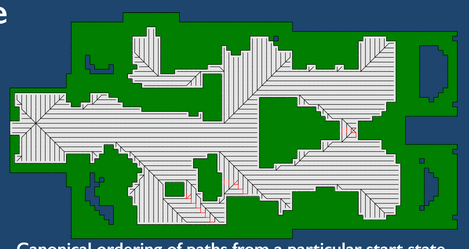
Bounding boxes are effective even with a basic A* search.

Algorithm	Time	Reduction
A*	14.492	-
A* + BB	1.888	8.2

What is JPS?

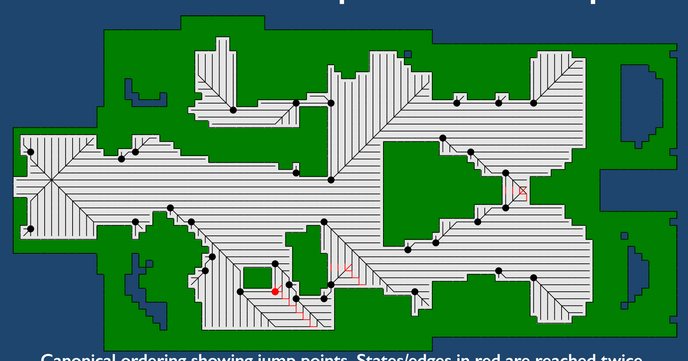
JPS (Harabor and Grastien, 2011) adds specialized pruning rules to improve search speed.

We summarize these as a *canonical ordering* over all possible paths. The canonical ordering reduces the number of duplicate paths to each state in the map.



Canonical ordering of paths from a particular start state.

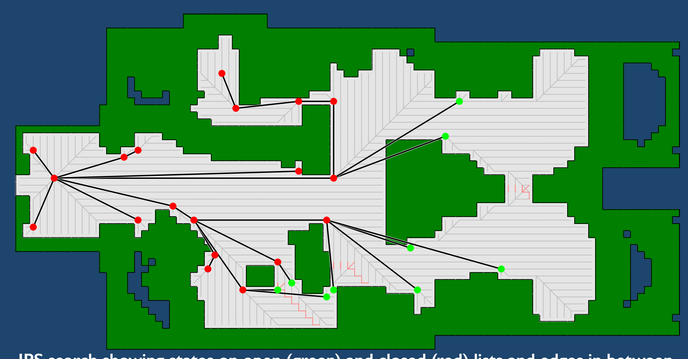
A simple canonical ordering orders diagonal moves before cardinal moves, but this isn't sufficient to reach all points in the map.



Canonical ordering showing jump points. States/edges in red are reached twice.

Jump points are added at the corners of obstacles, where the canonical ordering is reset. This makes all states reachable.

JPS only searches the graph of jump points. Thus, it expands far fewer states than A*, but it has to scan the map for jump points. JPS+ caches the location of jump points for even faster search.

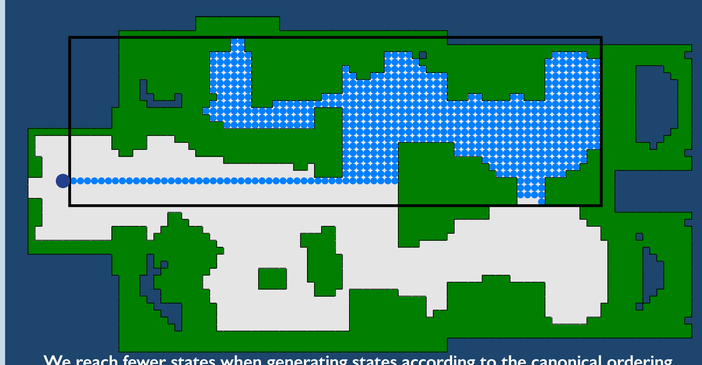


JPS search showing states on open (green) and closed (red) lists and edges in between.

How do we combine them?

A naive ordering of states results in many duplicate paths which unnecessary.

Using the canonical ordering of states reduces the size of our bounding boxes! These can be used in A* or JPS.



We reach fewer states when generating states according to the canonical ordering.

In JPS the bounding box check is done when generating the successors of the start state and any jump points.

Full results on GPPC competition maps.

Algorithm	Time	Reduction
A*	14.492	-
A*+BB	1.888	8.2
A*+BB+Can	0.524	29.6
JPS+	0.072	215.2
JPS+BB	0.014	1106.6
JPS+BB+Can	0.010	1549.2

Full results on Grid-Based Path Competition maps. Time in *ms*; pre-comp in minutes.

Algorithm	Year	Time (Tot)	Time (Avg)	RAM (MB)	Disk	Pre-comp.
Subgoal	2013	2485.0	1.429	40.00	93 MB	1.0
NLevelSubgoal	2014	1345.2	0.773	42.54	293 MB	2.6
Contractions	2014	630.4	0.362	72.04	2.4 GB	968.9
JPS+BB+Can	2015	259.9	0.149	82.43	2.0 GB	3049.0
SRC	2014	251.7	0.145	274.16	52.0 GB	12330.8