Toward State Space Island Identification in Multi-process Bidirectional Heuristic Search

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Merit of bidirectional search with islands

- Multi-process bidirectional heuristic search algorithms that utilize island nodes (such as PBA*) have been shown to have the potential for exponential speedup over their plain counterparts that do not utilize island nodes.
Problem

- The performance of bidirectional search with islands can dramatically degrade if the island nodes are not appropriately placed in the state space prior to the beginning of such algorithms.
- The problem of how to generate appropriately located island nodes has resisted any general purpose solution to date.
Proposed solution

• This work is an initial proposal toward this end.

• Our method of how to select X-nodes which are located appropriately in the state space is described in \textbf{Algorithm PBA-VD}, next.
Algorithm PBA-VD.

- **Step A.1**: generate a set of candidate X-nodes.
- **Step A.2**: convert set X into set such that is the projection of onto a 2-dim space.
- **Step A.3**: Form D-graph, the Delaunay graph for set P.
- **Step A.4**: Calculate the shortest path \( SP = [S-X_1-X_2-\ldots-X_k-G] \) connecting S and G in the D-graph of step A.3.
- **Step A.5**: Select as X-nodes the nodes corresponding to points \( X_1, X_2, \ldots, X_k \) and execute algorithm PBA* between S and G.

(PBA* is a parallel bidirectional search algorithm, designed by the authors long ago. References are in the proceedings.)
Some results

• Result 1
• Result 2
• Result 3
Result 1

• For the vast majority of tests (more than 80% of test cases), the X-nodes used in algorithm PBA*-VD are more likely to aid in establishing a path connecting S and G than the X-nodes used by algorithm PBA*-R.
Result 2

• The overhead for incorporating the Voronoi-Dijkstra method in finding useful X-nodes is *negligible*. (in our tests, the overhead is about $4.03 \times 10^{-3}$ of the time to execute PBA-VD.)
Result 3

• *The Voronoi-Dijkstra “anomaly”*. The shortest path may not be the most desirable path to strive for!
The Voronoi-Dijkstra “anomaly”.

The shortest path suggests X1, X2, X3 as X-nodes.

However, most likely, a better choice of X-nodes would be C1, C2, ..., C5. (i.e., nodes that do not form a shortest path between S and G).
Future research

• Implement and test remedies of the Voronoi-Dijkstra “anomaly”.
• Implement and test PBA-VD with Voronoi Diagrams in N-dimensional space, where $N > 2$. 
The end

THANK YOU !!!