

Summary of the research paper:

The research paper firstly described a general problem that occurs on the existing bidirectional heuristic algorithm, that is, any-front-to-end bidirectional heuristic algorithm can be denominated by unidirectional heuristic algorithm or their brute-force version. Researchers in this paper aimed to come with a solution; hence they introduced a novel general breadth-first heuristic search algorithm, GBFHS, that unifies both unidirectional and bidirectional search into a single algorithm. The paper argued that GBFHS is admissible, proved that it is well-behaved (guaranteed not to expand more nodes for the same split if the heuristic improves), and ensures optimality upon the first collision in unit-cost domains. Researchers also carried out experiments to analyse that GBFHS can expand substantially fewer nodes than the new algorithms: NBS, MM, and MME. Future steps of GBFHS have been discussed including finding a way to automatically determine the value for least cost edge in the search space from the problem and domain description. What I analysed from this paper and these findings is that GBFHS was shown to have some desirable pros: (1) It returns an optimal solution when the edges are non-negative integers with expanding fewer nodes than most of the existing algorithms; (2) In unit cost domains, the first solution GBFHS finds is guaranteed to be optimal; (3) Its frontiers can be made to meet anywhere using a proper split function, that is, it can run bidirectionally or unidirectionally, with unit-cost or arbitrary-cost, with or without a heuristic; and (4) it is well-behaved, admissible and reasonable. However, GBFHS is not perfect at the current stage, it has cons including it is only guaranteed to return an optimal solution when the edge costs are (non-negative) integers. This would limit the future application and use of this algorithm on designing artificial intelligence programs; hence I analysed that future work of modifying GBFHS to guarantee optimal solutions for any edge costs will be required.

Key points of the research paper:

- Related Works.
Brief view of the background of bidirectional search and the general problem.
Describe some existing bidirectional heuristic search algorithm such as MM and NBS. Describe their lacks.
- The approach of the GBFHS algorithm.
Describe the GBFHS algorithm: how it works (pseudocode) and the theorems behind the algorithm. Argue that GBFHS is admissible; it can always stop on first collision in unit cost domains; and it is well-behaved.
- Experiments and Analysis of GBFHS.
 - Carry out experiments to compare GBFHS and other algorithms including A*, MM/Mme and NBS. Deeply analysis the experiments' results and conclude that GBFHS is better than them.

Questions:

1. Considering the search algorithms in AI that we have previously studied in computer science courses, such as BFS, DFS and Dijkstra's algorithm, what is the main difference between them and the existing algorithms I presented today and why the latter are better?
2. As I have mentioned the general problem of new algorithms (bidirectional heuristic search algorithm), e.g., MM, MMe and NBS, (i.e., they are ill-behaved), what are the possible reasons for that?
3. (Challenge) Would you think GBFHS can be modified in a way so that it is guaranteed to return an optimal solution for any edge costs (non-negative and negative)? If so, could you come with any ideas and would that result in some significant changes? (Hint: think about what we have previously studied about Dijkstra's algorithm and The Bellman–Ford algorithm on solving the SSSP problem. Dijkstra works whenever all weights are nonnegative. It may fail in the presence of negative weight arcs. While the Bellman–Ford algorithm on the hand solves the SSSP problem even when there are negative weight arcs, but it runs more slowly than Dijkstra's algorithm.)