A Brief History of Three Planning and Search Topics
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A* Search

A* search is an informed, heuristics-based search strategy which takes a best-first search approach – meaning it heads straight for the goal via the lowest heuristic – but includes in its heuristic both the cost of getting to that node and the estimated remaining distance to the goal. It is both complete and optimal, given a heuristic that is admissible (never overestimates) and consistent (a reduction of a path cost is at least fully reflected in the reduction of the heuristic). It has been used extensively for path finding searches where a naive distance calculation is used a heuristic and solution planning where select conditions are relaxed. Examples of appropriate application are in path finding and circuit board line routing. The "character" of the solution A* produces can be "tweaked" by weighting the costs of certain routes or of heuristics – such as in a route-finding algorithm that avoids highways or uses them exclusively. This is done by adding costs to types of actions or states, which allows the heuristics to continue to be admissible. The A* star search was developed out of the Stanford Research Institute in 1968 by Peter Hart, Nils Nilsson and Bertram Raphael as an improvement on a shortest path between two points algorithm by Edsger Djikstra from 1959, which required exploration of every possible path. The paper which introduced A* focused on the practical implementation benefits of the method vs the mathematically-based algorithms which were guaranteed to find a solution, but were unconcerned with computational cost, mostly due to approaches which may cover the entire search space in order to find the optimal solution. Also introduced in the paper was a graph model for formal mathematical modeling of problems. A* is special because given a true heuristic, it is guaranteed to find the minimum cost path between two points – generally an initial state and a goal. A* searching has been implemented as a parallel search technique, for instance in Evett et al.'s paper "PRA*: Massively Parallel Heuristic Search," which is effectively an improvement on Iterative-Deepening A* (IDA*).

Evett, M., Hendler, J., Mahanti, A., and Nau, D., PRA*: Massively Parallel Heuristic Search, Journal of Parallel and Distributed Computing, Volume 25, Issue 2, 1995, pp. 133-143.
Dijkstra, E. W. (1959). "A note on two problems in connexion with graphs". Numerische Mathematik. 1: 269–271.
Hart, P.E., Nilsson, N.J., and Raphael, B. (1968). A formal basis for the heuristic determination of minimum cost paths. *IEEE Transactions on System Science and Cybernetics, SSC-4(2)*, 100-107.

General Problem Solver (GPS)

A running theme in AI appears to be decisions around how a program should approach a problem, not only in the sense of designing algorithms within a search space, but in terms of deciding on a level of intelligence to solve the problem. The General Problem Solver, published by Allen Newell and Herbert Simon in 1961 was a step towards a more abstract means of solving problems which were previously solved in sequential or arithmetic fashion. It was a program designed to "simulate human thought." The paper introducing it, "GPS, A Program that Simulates Human Thought," published in a journal called "Lernende Automaten" (Learning Machines/Computers) spends a large amount of time describing concepts from psychology, which were to offer insights to ways in which machines should think. Based on a set of logic symbols ('and', 'or', 'implies', and 'not') and 12 logic rules, a human subject was instructed to equate to expressions while speaking aloud their line or reasoning. The GPS system was designed after studying the human techniques and broke an overall goal down into many subgoals. This is strikingly similar to algorithms that have been used in our coursework so far and is a strong step in artificial intelligence where it's possible to consider subgoals independently and given perfect knowledge of a state space.

Newell, A. and Simon, H. A. (1961). GPS, a program that simulates human thought. In Billing, H. (Ed.), *Lernende Automaten*, pp. 109-124. R. Oldenbourg.

Branch-and-Bound

First published in 1960 under the title "An Automatic Method of Solving Discrete Programming Problems," and then coined as "branch-and-bound" in the 1963 paper "An Algorithm for the Traveling Salesman Problem," both by Little et al., the branch-and-bound algorithm was presented as a way for significantly reducing the search space when solving NP-hard problems by considering only the branch with the lowest possible solution cost. It has been shown that the A* algorithm can be formulated from a generalized version of branch-and-bound in a 1984 paper by Nau et al, titled "General Branch and Bound, and Its Relation to A* and AO*."

Little, John D. C.; Murty, Katta G.; Sweeney, Dura W.; Karel, Caroline (1963). "An algorithm for the traveling salesman problem". Operations Research. 11 (6): 972–989.
Nau, Dana S.; Kumar, Vipin; Kanal, Laveen (1984). "General branch and bound, and its relation to A∗ and AO∗". Artificial Intelligence. 23 (1): 29–58.