

A Short History of the Development of A* and STRIPS

Hello, my name is Nils Nilsson, and I helped in the development of A* and STRIPS. I'd like to tell you a little about the history of these systems.

In the mid-1960s at SRI (then called the Stanford Research Institute) I was working on a robot called "Shakey." Shakey's software included programs for perception, such as machine vision, in addition to programs for controlling the robot itself. These control programs had to deal with two major problems:

First, how should Shakey navigate efficiently without bumping into things?

And second, how should Shakey string together its high-level actions to achieve high level goals, such as re-arranging objects and going from room to room?

Navigation depended on setting up the coordinates of a set of waypoints that stood off a bit from the objects in the room. These waypoints can be arranged as nodes in a graph whose edges are straight-line, object-free paths between pairs of waypoints. Navigation amounts to finding a shortest, or least costly, path in the graph from a starting node to a goal node.

Edsger Dijkstra had previously proposed a means for finding such paths, but his method was inefficient, considering as it did all possible paths outward from the start. Instead, we wanted to focus search in the direction of the goal. I was familiar with the "graph-traverser" method of Jim Doran and Donald Michie of the University of Edinburgh that did that.

They ranked the nodes to be explored next by a number that purported to measure the remaining difficulty of getting to the goal. I suggested to some colleagues at SRI that the number used to rank nodes should be the "straight-line distance" (ignoring obstacles) from points in the graph to the goal.

My colleague at SRI, Bert Raphael, thought that the number also ought to take into account the distance traveled so far so that exploration wouldn't be led down promising but ultimately futile paths. Our final "evaluation" number would then be the distance traveled so far plus an estimate of the distance to go.

Another colleague, Peter Hart, conjectured that if the estimate of the distance to go was a lower bound on the true distance, then the algorithm, which we named A*, would be guaranteed to find the shortest path. The three of us then found a proof for Peter's conjecture.

We also wanted Shakey to be able to string together high-level actions, such as pushing boxes, to accomplish various goals. Another SRI colleague Richard Fikes and I built a planning system called STRIPS (for Stanford Research Institute Problem Solver) that could figure out how to construct such strings.

For the purpose of achieving high-level goals, Shakey modeled its world by a database consisting of statements in a logical language.

Goals for Shakey were also expressed as logical statements. In planning sequences of high level actions to accomplish goals, STRIPS used structures called “STRIPS Rules” to compute how actions changed the logical model. Each rule had a Precondition, which stated what had to be true in a state in order to apply the corresponding action; a Delete list, which gave a list of statements that might no longer be true after the corresponding action was applied; and an Add list, which gave a list of statements that now would be true after the corresponding action was applied.

Planning sequences of actions could then be viewed as the same kind of search problem we had for navigation.

The starting node was a list of statements true at the start, successor nodes could be created by applying all the STRIPS rules that could be applied to that starting state, and search could continue outward from the starting state until a model was created that satisfied the goal condition. If we had good heuristics for estimating how far any state was from the goal state, we could easily apply a search procedure such as A*. We were also able to search backward from the goal through various sub-goals until one of these was already true in the initial state.

Those of us involved in these early AI developments are gratified to see that both A* and STRIPS have several descendants that are used in many of today’s applications.

Nils Nilsson, January 2013

Nilsson, N.J. (2010) “The Quest for Artificial Intelligence - A History of Ideas and Achievements”, Stanford University, Web Version, <http://ai.stanford.edu/~nilsson/> and <http://ai.stanford.edu/~nilsson/QAI/qai.pdf>

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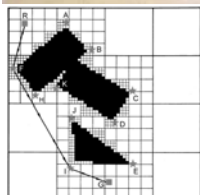
Sven Wahlstrom (engineer in charge of building the Shakey vehicle), Shakey, and Nils Nilsson in 1967



Shakey Team in 1983

Kneeling in Front: Richard Fikes, Helen Wolf

Rear: Charlie Rosen, Bert Raphael, Dick Duda, Milt Adams, Shakey, Jerry Gleason, Ted Brain, Peter Hart, Jim Baer



Shakey/STRIPS Waypoints

Figure 12.5 from Quest for Artificial Intelligence