

Discussion and Result

Here, I used node structure to represent states in the search space. Each node contains state, plan, cost, and heuristic in the node. To compare node for heuristic later on, I used a priority queue to manage the nodes and prioritize those with lower total cost ($f = g+h$). An unordered set contains the explored states, so the planner does not revisit the same states.

(Data listed on table below)

Blocks environment takes the least time and states since it only has one type of components (block) and only 2 actions with not much precondition.

Blocks and triangles environment has 7 objects and increase the possible configurations exponentially. More nodes will be expanded due to the larger state space. The increased complexity leads to longer computation times.

Fire extinguisher environment requires specific sequences of action with strict precondition and there are limited applicable. This reduces the branching factor and narrows down the possible action paths.

Extra Credit:

New Environment

I created a robot that cooks and serves breakfast. Initially, all the components are on the table. Robot can move everything except the clean tableware. Its goal is to have hot egg in bowl and hot pancake with butter on plate. The robot needs to heat the food on pan at the stove in order to serve it. I have included the performance of this scenario below with heuristic and without heuristic.

Heuristic

In the code, I included `use_heuristic` variable to turn it on and off.

The speed and step significantly improved for some scenarios after I implement the heuristic. Here are the comparison.

	Speed (millisecond)		# of expanded state	
	Heuristic	No Heuristic	Heuristic	No Heuristic
Blocks	4	6	15	40
Blocks and Triangles	1486	1306	1617	1656
Fire Extinguisher	365	361	2526	2526
Pancakey	2250	6918	4146	15889

Block: the simplicity of the problem allows heuristic to be effective, leading to minimum node expansion and a quick solution.

Blocks and Triangles: the increased number of object result in a larger state space and cause the planner to explore more nodes. Heuristic, which only counts unsatisfied goals, did not provide sufficient guidance in complex environment, which lead to more node expansion and slower performance.

Fire Extinguisher: Since there are specific actions with limited preconditions, the path is already set efficiently without heuristic. Therefore, there are not much difference between using heuristic and without heuristic.