# A\* Algorithm — Detailed Step-by-Step Trace

Graph (adjacency list with edge weights):

* A: [('B', 5), ('F', 4)]
* B: [('C', 6), ('D', 8)]
* C: [('D', 3), ('E', 3)]
* D: [('C', 2), ('E', 1)]
* E: [('I', 1), ('J', 7)]
* F: [('G', 5), ('H', 2)]
* G: [('I', 4)]
* H: [('I', 3)]
* I: [('E', 2), ('J', 4)]

Heuristic function h(n): (estimated cost to goal J)

* h(A) = 6
* h(B) = 3
* h(C) = 6
* h(D) = 5
* h(E) = 3
* h(F) = 7
* h(G) = 6
* h(H) = 8
* h(I) = 10
* h(J) = 0

## Algorithm description

A\* chooses the node from the open set with the smallest f(n) = g(n) + h(n). g(n) is the known cost from the start to n. h(n) is a heuristic estimate from n to goal. We maintain an open set (frontier) and closed set (already-expanded nodes). For each selected node n we examine its neighbors m and update g and parent information.

## Initial conditions

Start node: A  
Goal node: J  
Initial open\_set = {A}  
Initial closed\_set = {}  
Initial g(A) = 0  
parents[A] = A

## Iteration-by-iteration trace

### Iteration 1: selected node = A

Open set before: ['A']

Closed set before: []

g (before): {'A': 0}

parents (before): {'A': 'A'}

Action summary: Expanded A

Neighbors examined:

1. Neighbor B: weight=5, g\_current=None, g\_via\_n=5. Added B to open\_set with g=5, parent=A
2. Neighbor F: weight=4, g\_current=None, g\_via\_n=4. Added F to open\_set with g=4, parent=A

Open set after: ['B', 'F']

Closed set after: ['A']

g (after): {'A': 0, 'B': 5, 'F': 4}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A'}

### Iteration 2: selected node = B

Open set before: ['B', 'F']

Closed set before: ['A']

g (before): {'A': 0, 'B': 5, 'F': 4}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A'}

Action summary: Expanded B

Neighbors examined:

1. Neighbor C: weight=6, g\_current=None, g\_via\_n=11. Added C to open\_set with g=11, parent=B
2. Neighbor D: weight=8, g\_current=None, g\_via\_n=13. Added D to open\_set with g=13, parent=B

Open set after: ['C', 'D', 'F']

Closed set after: ['A', 'B']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B'}

### Iteration 3: selected node = F

Open set before: ['C', 'D', 'F']

Closed set before: ['A', 'B']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B'}

Action summary: Expanded F

Neighbors examined:

1. Neighbor G: weight=5, g\_current=None, g\_via\_n=9. Added G to open\_set with g=9, parent=F
2. Neighbor H: weight=2, g\_current=None, g\_via\_n=6. Added H to open\_set with g=6, parent=F

Open set after: ['C', 'D', 'G', 'H']

Closed set after: ['A', 'B', 'F']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F'}

### Iteration 4: selected node = H

Open set before: ['C', 'D', 'G', 'H']

Closed set before: ['A', 'B', 'F']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F'}

Action summary: Expanded H

Neighbors examined:

1. Neighbor I: weight=3, g\_current=None, g\_via\_n=9. Added I to open\_set with g=9, parent=H

Open set after: ['C', 'D', 'G', 'I']

Closed set after: ['A', 'B', 'F', 'H']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H'}

### Iteration 5: selected node = G

Open set before: ['C', 'D', 'G', 'I']

Closed set before: ['A', 'B', 'F', 'H']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H'}

Action summary: Expanded G

Neighbors examined:

1. Neighbor I: weight=4, g\_current=9, g\_via\_n=13. No update (existing g is better)

Open set after: ['C', 'D', 'I']

Closed set after: ['A', 'B', 'F', 'G', 'H']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H'}

### Iteration 6: selected node = C

Open set before: ['C', 'D', 'I']

Closed set before: ['A', 'B', 'F', 'G', 'H']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H'}

Action summary: Expanded C

Neighbors examined:

1. Neighbor D: weight=3, g\_current=13, g\_via\_n=14. No update (existing g is better)
2. Neighbor E: weight=3, g\_current=None, g\_via\_n=14. Added E to open\_set with g=14, parent=C

Open set after: ['D', 'E', 'I']

Closed set after: ['A', 'B', 'C', 'F', 'G', 'H']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C'}

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### Iteration 7: selected node = E

Open set before: ['D', 'E', 'I']

Closed set before: ['A', 'B', 'C', 'F', 'G', 'H']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C'}

Action summary: Expanded E

Neighbors examined:

1. Neighbor I: weight=1, g\_current=9, g\_via\_n=15. No update (existing g is better)
2. Neighbor J: weight=7, g\_current=None, g\_via\_n=21. Added J to open\_set with g=21, parent=E

Open set after: ['D', 'I', 'J']

Closed set after: ['A', 'B', 'C', 'E', 'F', 'G', 'H']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14, 'J': 21}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C', 'J': 'E'}

### Iteration 8: selected node = D

Open set before: ['D', 'I', 'J']

Closed set before: ['A', 'B', 'C', 'E', 'F', 'G', 'H']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14, 'J': 21}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C', 'J': 'E'}

Action summary: Expanded D

Neighbors examined:

1. Neighbor C: weight=2, g\_current=11, g\_via\_n=15. No update (existing g is better)
2. Neighbor E: weight=1, g\_current=14, g\_via\_n=14. No update (existing g is better)

Open set after: ['I', 'J']

Closed set after: ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14, 'J': 21}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C', 'J': 'E'}

### Iteration 9: selected node = I

Open set before: ['I', 'J']

Closed set before: ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 14, 'J': 21}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'C', 'J': 'E'}

Action summary: Expanded I

Neighbors examined:

1. Neighbor E: weight=2, g\_current=14, g\_via\_n=11. Updated E: g=11, parent=I
2. Neighbor J: weight=4, g\_current=21, g\_via\_n=13. Updated J: g=13, parent=I

Open set after: ['E', 'J']

Closed set after: ['A', 'B', 'C', 'D', 'F', 'G', 'H', 'I']

g (after): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 11, 'J': 13}

parents (after): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'I', 'J': 'I'}

### Iteration 10: selected node = J

Open set before: ['E', 'J']

Closed set before: ['A', 'B', 'C', 'D', 'F', 'G', 'H', 'I']

g (before): {'A': 0, 'B': 5, 'F': 4, 'C': 11, 'D': 13, 'G': 9, 'H': 6, 'I': 9, 'E': 11, 'J': 13}

parents (before): {'A': 'A', 'B': 'A', 'F': 'A', 'C': 'B', 'D': 'B', 'G': 'F', 'H': 'F', 'I': 'H', 'E': 'I', 'J': 'I'}

Action summary: Goal reached. Path: ['A', 'F', 'H', 'I', 'J']

Open set after:

Closed set after:

g (after):

parents (after):

## Final result

Path found: ['A', 'F', 'H', 'I', 'J']