

F29AI- Artificial Intelligence and Intelligent Agents

CW-1

A* Search and Automated Planning

Student Declaration of Authorship



Course code and name:	F29AI - Artificial Intelligence and Intelligent Agents - 2024-2025
Type of assessment:	Paired
Coursework Title:	F29AI_CW1_UG A*Search and Automated Planning
Student Name:	Abhijith Pattali Satish
Student ID Number:	H00407665

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Course code and name:	F29AI - Artificial Intelligence and Intelligent Agents - 2024-2025
Type of assessment:	Pair Coursework
Coursework Title:	F29AI_CW1_UG A*Search and Automated Planning
Student Name:	Shyam Sundar Velmurugan
Student ID Number:	H00418621

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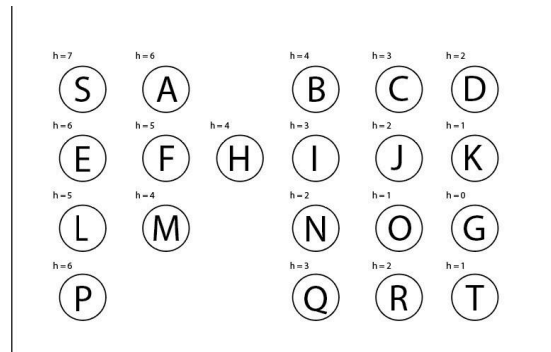
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Part 1 : A* Search For Graph 1

1.1)



1.2) Manhattan distance heuristic formula :
 $f(n) = (x_{\text{goal}} - x_{\text{current}}) + (y_{\text{goal}} - y_{\text{current}})$

For node S, $h(S) = (5 - 0) + (2 - 0) = 5 + 2 = 7$

For node A, $h(A) = (5 - 1) + (2 - 0) = 4 + 2 = 6$

For node B, $h(B) = (5 - 3) + (2 - 0) = 2 + 2 = 4$

For node C, $h(C) = (5 - 4) + (2 - 0) = 1 + 2 = 3$

For node D, $h(D) = (5 - 5) + (2 - 0) = 0 + 2 = 2$

For node E, $h(E) = (5 - 0) + (2 - 1) = 5 + 1 = 6$

For node F, $h(F) = (5 - 1) + (2 - 1) = 4 + 1 = 5$

For node H, $h(H) = (5 - 2) + (2 - 1) = 3 + 1 = 4$

For node I, $h(I) = (5 - 3) + (2 - 1) = 2 + 1 = 3$

For node J, $h(J) = (5 - 4) + (2 - 1) = 1 + 1 = 2$

For node K, $h(K) = (5 - 5) + (2 - 1) = 0 + 1 = 1$

For node L, $h(L) = (5 - 0) + (2 - 2) = 5 + 0 = 5$

For node M, $h(M) = (5 - 1) + (2 - 2) = 4 + 0 = 4$

For node N, $h(N) = (5 - 3) + (2 - 2) = 2 + 0 = 2$

For node O, $h(O) = (5 - 4) + (2 - 2) = 1 + 0 = 1$

For node G, $h(G) = (5 - 5) + (2 - 2) = 0 + 0 = 0$

For node P, $h(P) = (5 - 0) + (2 - 3) = 5 + 1 = 6$

For node Q, $h(Q) = (5 - 3) + (2 - 3) = 2 + 1 = 3$

For node R, $h(R) = (5 - 4) + (2 - 3) = 1 + 1 = 2$

For node T, $h(T) = (5 - 5) + (2 - 3) = 0 + 1 = 1$

1.3) A* Search Derivation

$F = \{S, f=0+7=7\}$, $C = \{\}$

Remove S, expand

$F = \{A, f=1+6=7\}, \{E, f=2+6=8\}$, $C = \{S\}$

$$h(B) = (3 - 3) + (4 - 0) = 0 + 4 = 4$$

$h(C) = (3 - 4) + (4 - 0) = 1 + 4 = 5$
 $h(D) = (3 - 0) + (4 - 1) = 3 + 3 = 6$
 $h(E) = (3 - 1) + (4 - 1) = 2 + 3 = 5$
 $h(F) = (3 - 2) + (4 - 1) = 1 + 3 = 4$
 $h(H) = (3 - 3) + (4 - 1) = 0 + 3 = 3$
 $h(I) = (3 - 4) + (4 - 1) = 1 + 3 = 4$
 $h(J) = (3 - 0) + (4 - 2) = 3 + 2 = 5$
 $h(K) = (3 - 1) + (4 - 2) = 2 + 2 = 4$
 $h(L) = (3 - 3) + (4 - 2) = 0 + 2 = 2$
 $h(M) = (3 - 4) + (4 - 2) = 1 + 2 = 3$
 $h(N) = (3 - 0) + (4 - 3) = 3 + 1 = 4$
 $h(O) = (3 - 1) + (4 - 3) = 2 + 1 = 3$
 $h(P) = (3 - 2) + (4 - 3) = 1 + 1 = 2$
 $h(Q) = (3 - 3) + (4 - 3) = 0 + 1 = 1$
 $h(R) = (3 - 4) + (4 - 3) = 1 + 1 = 2$
 $h(T) = (3 - 0) + (4 - 4) = 3 + 0 = 3$
 $h(G) = (3 - 3) + (4 - 4) = 0 + 0 = 0$
 $h(U) = (3 - 4) + (4 - 4) = 1 + 0 = 1$

2.3) A* Derivation

$F = \{ \{S, f=0+7\} \}$, $C = \{ \}$
 Remove S, expand
 $F = \{ \{A, f=1+6=7\}, \{D, f=2+6=8\} \}$, $C = \{S\}$
 Remove A, expand
 $F = \{ \{E, f=2+5=7\}, \{D, f=2+6=8\} \}$, $C = \{S, A\}$
 Remove E, expand
 $F = \{ \{F, f=3+4=7\}, \{K, f=3+4=7\}, \{D, f=2+6=8\} \}$, $C = \{S, A, E\}$
 Remove F, expand
 $F = \{ \{K, f=3+4=7\}, \{D, f=2+6=8\}, \{H, f=5+3=8\} \}$, $C = \{S, A, E, F\}$
 Remove K, expand
 $F = \{ \{O, f=4+3=7\}, \{D, f=2+6=8\}, \{H, f=5+3=8\}, \{J, f=4+5=9\} \}$, $C = \{S, A, E, F, K\}$
 Remove O, expand
 $F = \{ \{D, f=2+6=8\}, \{H, f=5+3=8\}, \{P, f=6+2=8\}, \{J, f=4+5=9\}, \{N, f=6+4=10\} \}$, $C = \{S, A, E, F, K, O\}$
 Remove D, expand
 $F = \{ \{H, f=5+3=8\}, \{J, f=3+5=8\}, \{P, f=6+2=8\}, \{N, f=6+4=10\} \}$, $C = \{S, A, E, F, K, O, D\}$
 Remove H, expand
 $F = \{ \{J, f=3+5=8\}, \{L, f=6+2=8\}, \{P, f=6+2=8\}, \{I, f=6+4=10\}, \{N, f=6+4=10\}, \{B, f=7+4=11\} \}$,
 $C = \{S, A, E, F, K, O, D, H\}$
 Remove J, expand
 $F = \{ \{L, f=6+2=8\}, \{P, f=6+2=8\}, \{N, f=5+4=9\}, \{I, f=6+4=10\}, \{B, f=7+4=11\} \}$,
 $C = \{S, A, E, F, K, O, D, H, J\}$
 Remove L, expand
 $F = \{ \{P, f=6+2=8\}, \{Q, f=7+1=8\}, \{N, f=5+4=9\}, \{I, f=6+4=10\}, \{M, f=7+3=10\}, \{B, f=7+4=11\} \}$,
 $C = \{S, A, E, F, K, O, D, H, J, L\}$

Remove P,expand

$F = \{\{Q, f=7+1=8\}, \{N, f=5+4=9\}, \{I, f=6+4=10\}, \{M, f=7+3=10\}, \{B, f=7+4=11\}\}$,

$C = \{S, A, E, F, K, O, D, H, J, L, P\}$

Remove Q,expand

$F = \{\{G, f=8+0=8\}, \{N, f=5+4=9\}, \{I, f=6+4=10\}, \{M, f=7+3=10\}, \{B, f=7+4=11\}, \{R, f=9+2=11\}\}$,

$C = \{S, A, E, F, K, O, D, H, J, L, P, Q\}$

Remove G

States expanded: S, A, E, F, K, O, D, H, J, L, P, Q

Goal paths: {S, A, E, K, O, P, Q, G}, {S, A, E, F, H, L, Q, G}

Total cost: 8

Part 2: Automated Planning

PDDL

2A: Modeling the Domain

Task 1.1: Describing the World State:

There are 3 types of objects involved in the missions:

- 1) UUV {The Unmanned Underwater Vehicle}
- 2) ship {The ship where the Unmanned Underwater Vehicle starts}
- 3) waypoint {They are the locations that are present in the environment.}

Task 1.2: Defining the Actions

The UUV has been deployed, reached a specific waypoint, captured an image, performed a sonar scan, connected two waypoints by a path, collected a sample, transmitted the data back to the ship, made the sample available at the waypoint, and now holds both the image and sonar scan.

Action 1 {Deploying the UUV}

Preconditions:

The UUV starts from the initial waypoint (ship's location) and currently it is not deployed yet.

Postconditions:

The UUV is considered deployed and no longer present in its initial waypoint (ship's location), but at its new target waypoint.

Action 2 {Moving of UUV between the connected waypoints}

Preconditions:

The UUV is present at waypoint1 (ship's location), and the path between waypoint1 and waypoint2 are connected.

Postconditions:

The UUV is no longer present at waypoint1, and will be now present at waypoint2.

Action 3 {Capturing the image at the specific waypoint}

Preconditions:

The UUV is present at the waypoint and it doesn't have an image to be stored.

Postconditions:

The UUV has captured an image at the waypoint and its stored in the memory.

Action 4 {Performing a sonar scan at the specific waypoint}

Preconditions:

The UUV is present at the waypoint and it doesn't have a sonar scan to be stored.

Postconditions:

The UUV has captured a sonar scan at the waypoint and its stored in the memory.

Action 5 {Collecting the sample from waypoint}

Preconditions:

The UUV is present at the waypoint and the sample is not stored in UUV but present at the waypoint.

Postconditions:

The UUV has the sample but the waypoint doesn't have it anymore.

Task 2.1: Problem 1

Task:

UUV begins its journey from ship, which is waypoint1 and saves an image at waypoint3 and performs sonar scan at waypoint4.

Found Plan (output)
(uuv_moved uuv1 waypoint1 waypoint2)
(uuv_moved uuv1 waypoint2 waypoint3)
(image_captured uuv1 waypoint3)
(uuv_moved uuv1 waypoint3 waypoint4)
(sonar_scan_performed uuv1 waypoint4)

Task 2.2: Problem 2

Task:

UUV begins its journey from ship, which is waypoint1 and saves an image at waypoint5, performs a sonar scan at waypoint3 and collects a sample from the waypoint1.

Found Plan (output)
(sample_collection uuv1 waypoint1)
(uuv_moved uuv1 waypoint1 waypoint4)
(uuv_moved uuv1 waypoint4 waypoint3)
(sonar_scan_performed uuv1 waypoint3)
(uuv_moved uuv1 waypoint3 waypoint5)
(image_captured uuv1 waypoint5)

Task 2.3: Problem 3

Task:

Introducing a secondary UUV and a secondary ship for assisting the mission, where the first UUV starts from waypoint2 and the secondary UUV from the secondary ship. The UUV must save an image at waypoint3 and waypoint 2, while sonar scan at waypoint 4 and waypoint 6. The sample must be collected from waypoint 5 and waypoint 1.

Task 3.1: Problem 4

Task:

Now an engineer has been added for assisting and deploying the robot in the north sea. Two new locations are added for the ship in which the engineer can walk in between [The bay and control centre]. UUV can only be deployed or returned to the ship if the engineer is present at the bay, and can transmit images and scan data if the engineer is present at the control centre.

Found Plan (output)
(capture_image uuv1 waypoint2)
(move_engineer engineer1 bay control_centre)
(transmit_data uuv1 ship1 engineer1)
(move uuv1 waypoint2 waypoint4)
(perform_sonar uuv1 waypoint4)
(perform_sonar uuv2 waypoint4)
(transmit_data uuv2 ship2 engineer1)
(move uuv2 waypoint4 waypoint2)
(move uuv2 waypoint2 waypoint1)
(collect_sample uuv2 waypoint1)
(move uuv2 waypoint1 waypoint2)
(move uuv2 waypoint2 waypoint5)
(capture_image uuv2 waypoint5)
(move uuv2 waypoint5 waypoint5)
(move uuv2 waypoint5 waypoint6)
(perform_sonar uuv2 waypoint6)
(move_engineer engineer1 control_centre bay)
(deploy_uuv uuv1 waypoint4 waypoint5 engineer1)
(collect_sample uuv1 waypoint5)

Link to the video:

https://heriotwatt-my.sharepoint.com/:v/g/personal/ap2092_hw_ac_uk/Efr-iAVKFQdAi2WcvnuiJRIBvQaYsHAIsVNBEKVafR2Bag?nav=eyJyZWZlcnJhbEluZm8iOmsicmVmZXJyYWxBcHAIoiJPbmVEcmI2ZUZvckJ1c2luZXNzIiwicmVmZXJyYWxBcHBQbGF0Zm9ybSI6IldlYiIsInJlZmVycmFsTW9kZSI6InZpZXciLCJyZWZlcnJhbFZpZXciOiJNeUZpbGVzTGlua0NvcHkifX0&e=W83ymz

