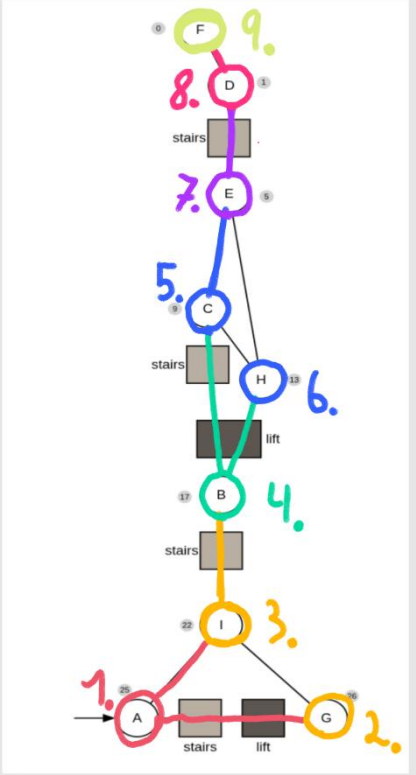
Assignment 1 – Tasks

Anders Emil Bergan & Jens Martin Jahle

2.1. Uninformed Search

1. Path costs
    a. (A,G) = 4
    b. (A,I) = 1
    c. (G, I) = 1
    d. (I, B) = 2 (1+1)
    e. (B,H) = 3
    f. (H, C) = 1 (1)
    g. (B, C) = 4 (1+2+1)
    h. (H, E) = 1 (1)
    i. (C, E) = 1 (1)
    j. (E, D) = 2 (1+1)
    k. (D, F) = 1 (1)

2. Search Methods
    a. BFS
        i. Order of expansion:
            1. A: G
            2. A: I
            3. I: B
            4. B: C
            5. B: H
            6. C: E
            7. E: D
            8. D: F
        ii. Found path: AIBCEDF
        iii. Cost of path:
        1+2+4+1+2+1=11



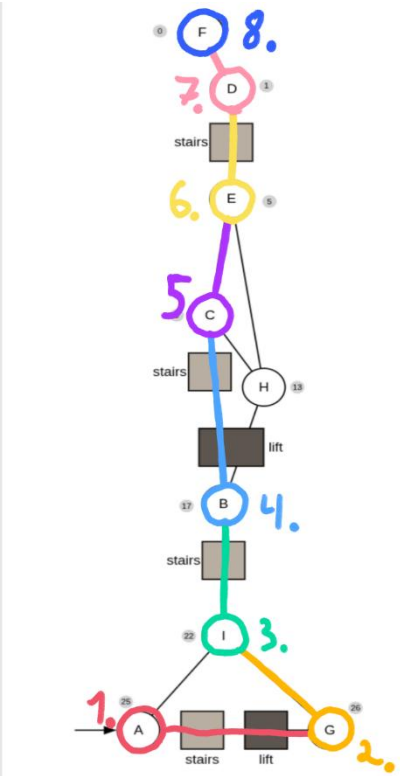
b. DFS

i. Order of expansion:

1. A: G
2. G: I
3. I: B
4. B: C
5. C: E
6. E: D
7. D: F

ii. Found path: AGIBCEDF

iii. Cost of path: 4+1+2+4+1+2+1=15



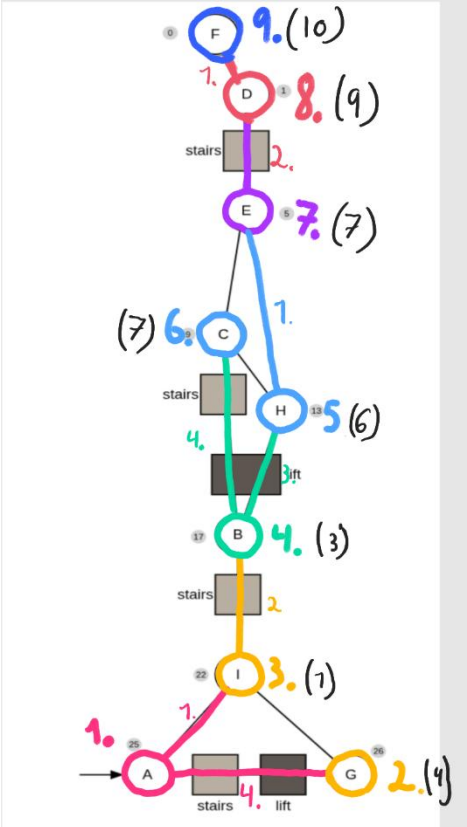
c. UCS

i. Order of expansion:

1. A(0)
2. G(4), I(1)
3. B(3)
4. C(7), H(6)
5. E(7)
6. D(9)
7. F(10)

ii. Found path: AIBHEDF

iii. Cost of path: 0 + 1 + 2 + 3 + 1 + 2 + 1 = 10



2.2 Informed Search

3. Search methods

a. GBFS

i. Order of expansion:

1. A: I
2. I: B
3. B: C
4. C: E
5. E: D
6. D: F

Ii. Found path: AIBCEDF

Iii. Const of path: 1 + 2 + 4 + 1 + 2 + 1 = 11

b. A*

Path	Actual + Heuristic	Sum
AI	1 + 22	23
AG	4 + 26	30

Next point: I

Path	Actual + Heuristic	Sum
AIB	1 + 2 + 17	20
AG	4 + 26	30
AIG	1 +1 + 26	28

Next point: B

Path	Actual + Heuristic	Sum
AIBH	1 + 2 + 3 + 13	19
AG	4 + 26	30
AIG	1 + 1 + 26	28
AIBC	1 + 2 + 4 + 9	16

Next point: C

Path	Actual + Heuristic	Sum
AIBH	1 +2 +3 + 13	19
AG	4 + 26	30
AIG	1 + 1 + 26	28
AIBCH	1 + 2 + 4 + 1 + 13	21
AIBCE	1 + 2 + 4 + 1 + 5	13

Next point: E

Path	Actual + Heuristic	Sum
AIBH	1 +2 +3 + 13	19
AG	4 + 26	30
AIG	1 + 1 + 26	28
AIBCH	1 + 2 + 4 + 1 + 13	21
AIBCEH	1 +2 +4 +1 +1 +13	22
AIBCED	1+ 2 + 4 + 1 + 2 + 1	11

Next point: D

Path	Actual + Heuristic	Sum
AIBH	1 +2 +3 + 13	19
AG	4 + 26	30
AIG	1 + 1 + 26	28
AIBCH	1 + 2 + 4 + 1 + 13	21
AIBCEDF	1 + 2 + 4 + 1 + 2 + 1 + 0	11

Destination reached: F

Total cost: 1 + 2 + 4 + 1 + 2 + 1 = 11

2.3. A* Search, Admissability and Consistency

4. The missing property is that the heuristic should be consistent. The above A* search resulted in a total cost of 11 (AIBCEDF), but the actual lowest cost is 10 (AIBHEDF), this happened since the heuristic is not consistent. Meaning it does not satisfy the following inequality:

$$h(n) \leq C(n, n') + h(n')$$

That means that the heuristics of a node must be lower or equal to the cost to travel to a neighboring node + the heuristics of that neighboring node.

5. For a graph to have consistent heuristics for all nodes the following inequality must be fulfilled:

$$h(n) \leq C(n, n') + h(n')$$

This is not fulfilled for example the node A and its neighbor I.

$$h(A) \leq C(A, I) + h(I)$$

$$25 \leq 1 + 22$$

$$25 \nleq 23$$

6. A* seach

Path	Actual + Heuristic	Sum
AI	1 + 9	10
AG	4 + 10	14

Next node: I

Path	Actual + Heuristic	Sum
AIG	1 + 1 + 9	11
AG	4 + 10	14
AIB	1 + 2 + 7	10

Next node: B

Path	Actual + Heuristic	Sum
AIG	1 + 1 + 9	11
AG	4 + 10	14
AIBC	1 + 2 + 4 + 4	11
AIBH	1 + 2 + 3 + 4	10

Next node: H

Path	Actual + Heuristic	Sum
AIG	1 + 1 + 9	11
AG	4 + 10	14
AIBC	1 + 2 + 4 + 4	11
AIBHC	1 + 2 + 3 + 1 + 4	11
AIBHE	1 + 2 + 3 + 1 + 3	10

Next node: E

Path	Actual + Heuristic	Sum
AIG	1 + 1 + 9	11
AG	4 + 10	14
AIBC	1 + 2 + 4 + 4	11
AIBHC	1 + 2 + 3 + 1 + 4	11
AIBHED	1 + 2 + 3 + 1 + 2 + 1	10
AIBHEC	1 + 2 + 3 + 1 + 1 + 4	11

Next node: D

Path	Actual + Heuristic	Sum
AIG	1 + 1 + 9	11
AG	4 + 10	14
AIBC	1 + 2 + 4 + 4	11
AIBHC	1 + 2 + 3 + 1 + 4	11
AIBHEDF	1 + 2 + 3 + 1 + 2 + 1 + 0	10
AIBHEC	1 + 2 + 3 + 1 + 1 + 4	12

Final path: AIBHEDF

Final cost: 1 + 2 + 3 + 1 + 2 + 1 = 10

7. If a heuristic is admissible it must never over estimate the cost to the destination. Meaning that the h(n) must always be lower than the actual shortest cost to the destination. For example, if a heuristic had said 600km to the destination, but the actual distance in 490km, then it would not be admissible. It must follow this rule:

$$h(n) \leq h^*(n)$$

In the updated figure 2 the h'(n) is admissible since for each node the heuristic h(n) is equal or lower than the cheapest cost h*(n).

8. The heuristic function h'(n) since the following equation is true for each node.

$$h(n) \leq C(n, n') + h(n')$$

That means that the heuristics of a node must be lower or equal to the cost to travel to a neighboring node + the heuristics of that neighboring node.

A G	$10 \leq 4 + 10$ $10 \leq 14$
A I	$10 \leq 1 + 9$ $10 \leq 10$
I G	$9 \leq 1 + 10$ $9 \leq 11$
I B	$9 \leq 7 + 2$ $9 \leq 9$
B C	$7 \leq 4 + 4$ $7 \leq 8$
B H	$7 \leq 3 + 4$ $7 \leq 7$
C H	$4 \leq 1 + 4$ $4 \leq 5$
C E	$4 \leq 1 + 3$ $4 \leq 4$
H E	$4 \leq 1 + 4$

	$4 \leq 4$
E D	$3 \leq 2 + 1$ $3 \leq 3$
D F	$1 \leq 1 + 0$ $1 \leq 1$