18.06.22
saturday

informed search

- adding some extra info w/ the search to help w/ the time issue.
- not a blind search.
- distance from goal is given → heuristic

↳ in 8 puzzle problem:

Starting node →

1	8	7
4		5
2	3	6

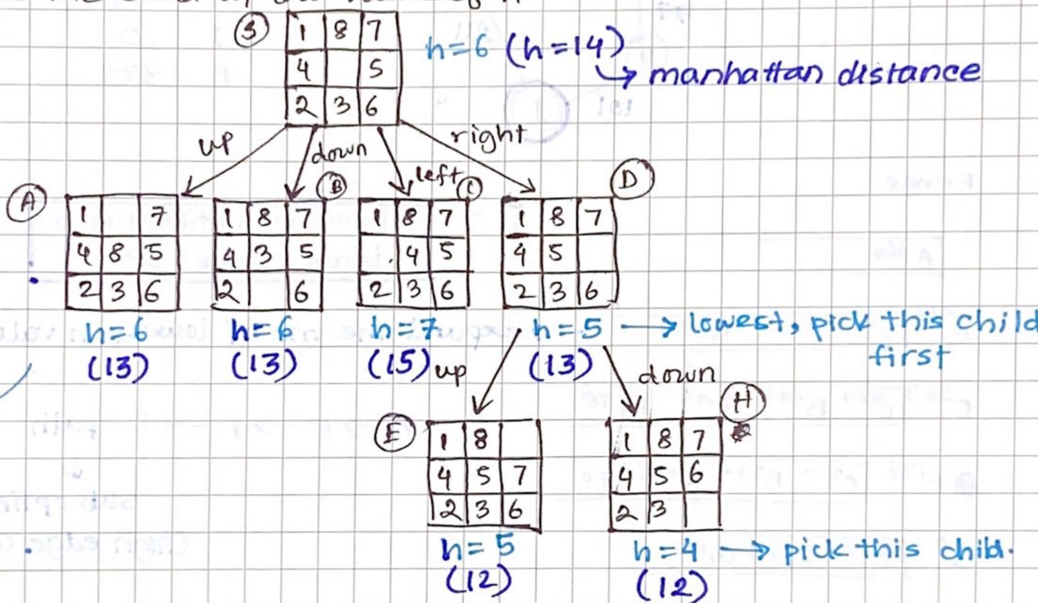
1	2	3
4	5	6
7	8	

→ goal

- first step is calculate the distance from goal.
  ↳ how many tiles misplaced. → heuristic function

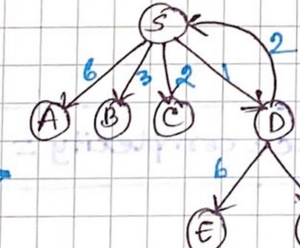
h = 1+1+1+1+1+1 = 6 → distance from goal.
~~m~~ need to make 0 to get goal.

- choose the child w/ low value of h.



for this case, h_1 = number of misplaced tiles.
also could be h_2 = amount of misplacement for all tiles → manhattan distance.

- the h depends on the problem, can be difficult to form a proper heuristic function for complex problems.
  → $h_2 >> h_1$ → h_2 dominates h_1 → has more info.
- choose ~~to~~ the dominant heuristic function. ∴ pick h_2



state	h(state)
S	6
A	6
B	6
C	7
D	5
E	5
H	4

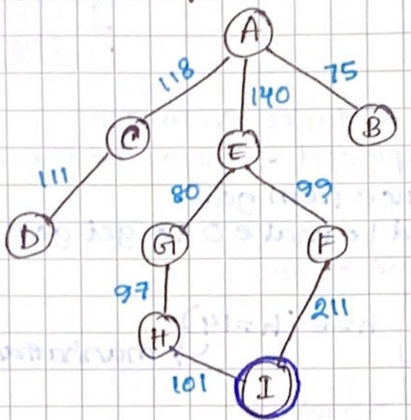
~~up=6~~
~~down=3~~
~~left=~~

up = 6
down = 3
left = 2
right = 1

- The heuristic table will help in the algorithm.
- Types of informed search:
  1. Greedy Best First Search.
  2. A* Search

Greedy Best First Search:

~~used in video game pathfinding~~



x	$h(x)$
A	366
C	329
D	244
E	253
F	178
G	193
H	98
I	0
B	374

→ straight line distance from goal.

Fringe

A^{366}

A^{366}: C^{329} E^{253} B^{374} → expand the one w/ lowest h value.

E^{253}: C^{329} B^{374} G^{193} F^{178}

F^{178}: C^{329} B^{374} G^{193} I^{0}

I^{0}: C^{329} B^{374} G^{193}

Terminate.

- Focuses entirely on h
  Ignores edge cost.

A → E → F → I path

↓

sub optimal.
(high edge cost)

- this search ~~is not complete and~~ not optimal.
- GBFS is complete for graph, not complete for tree.
- effective branching factor (b^*) →

$$\boxed{\text{Time complexity} = \text{space complexity} = O(b^{*d})}$$

* $b^* < b$

↳ better heuristic function, $b^* \downarrow$

23.06.22
Thursday

A* Search:

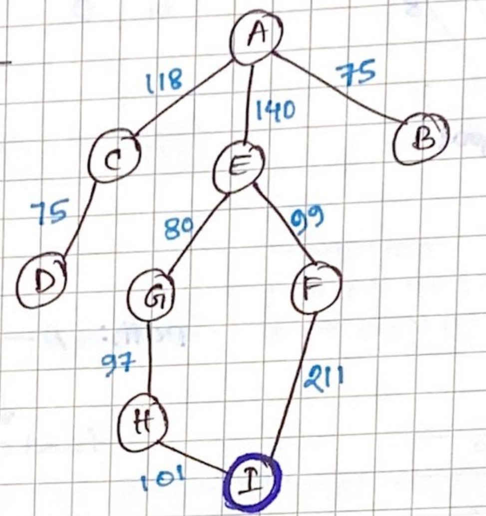
- a modified version of GBFS.
- GBFS ⟶ $h(x)$
  A* ⟶ $h(x)$ + path cost from root node. ⟶ $\boxed{f(x) = h(x) + g(x)}$

A* = GBFS + UCS

h-table.

A	366
B	374
C	329
D	244
E	253
F	178
G	93
H	98
I	0

if $h(H) = 138$,
we get sub-optimal path.



Fringe:

$A^{h(A)+g(A)} = 366 + 0 = 366$

A^{366} [$C^{329+118=447}$, $E^{253+140=393}$, $B^{374+75=449}$]

E^{393} [C^{447}, B^{449}, $G^{93+140+80=413}$, $F^{178+140+99=417}$]

G^{413} [C^{447}, B^{449}, F^{417}, H^{415}]

H^{415} [C^{447}, B^{449} F^{417} I^{418}]

F^{417} [C^{447} B^{449} I^{418} $\cancel{I^{140+99+211=450}}$]

I^{418} [C^{447} B^{449}]

terminate.

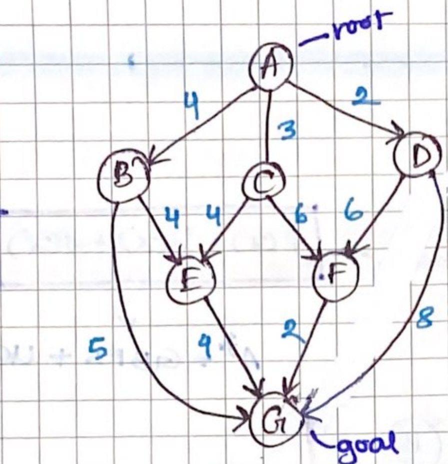
A ⟶ E ⟶ G ⟶ H ⟶ I

path

- in order for A* to be optimal, h needs to be admissible.

$\boxed{\text{h cost} \leq \text{actual distance to the goal.}}$

- this condition is applicable for all nodes in the graph, can't guarantee optimal path.



A	9
B	5
C	4
D	6
E	3
F	2
G	0

A^9

A^9 | B^9 C^7 D^8

C^7 | B^9 D^8 E^{10} F^{11}

D^8 | B^9 E^{10} $\cancel{F^{11}}$ F^{10} G^{10}

B^9 | E^{10} F^{10} $\cancel{G^{10}}$ $\cancel{E^{11}}$ G^9

G^9 | E^{10} F^{10}

terminate

path: $A \rightarrow B \rightarrow G$

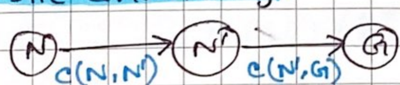
↓

found optimal path.

- if h is bigger than actual distance to goal, h is overestimated. might get suboptimal path.
  - $h \rightarrow$ not admissible $\rightarrow$ A* not optimal.

$$\boxed{\text{Time complexity} = \text{space complexity} = O(b^{*d})}$$

- in order to make b^* as small as possible, we ~~hee~~ need to make heuristic consistent.
- heuristic consistency:

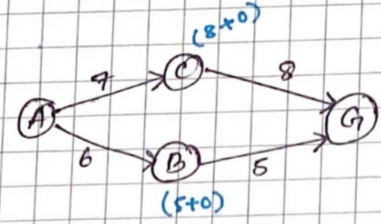


N	h(N)
N'	h(N')
G	h(G)

the heuristic of the graph will be consistent if:

$$\boxed{h(N) \leq c(N, N') + h(N')}$$

needs to be true for all nodes. except goal node.

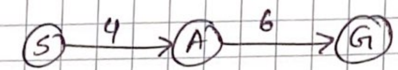


$6+4=10$

$\cancel{7+8} = 7+6 = 13$

A	11
B	4
C	6
G	0

} consistent heuristic



S	7
A	2
G	0

admissible:

$S \rightarrow 7 \le 10$

$A \rightarrow 2 \le 6$

$G \rightarrow 0 \le 0$

} admissible.

consistent:

$S \rightarrow 7 > 4+2=6 \longrightarrow$ not consistent

$\downarrow$

heuristic not the best.

$A \rightarrow 2 < 6+0 = 6$

- a heuristic can be admissible w/o being consistent.