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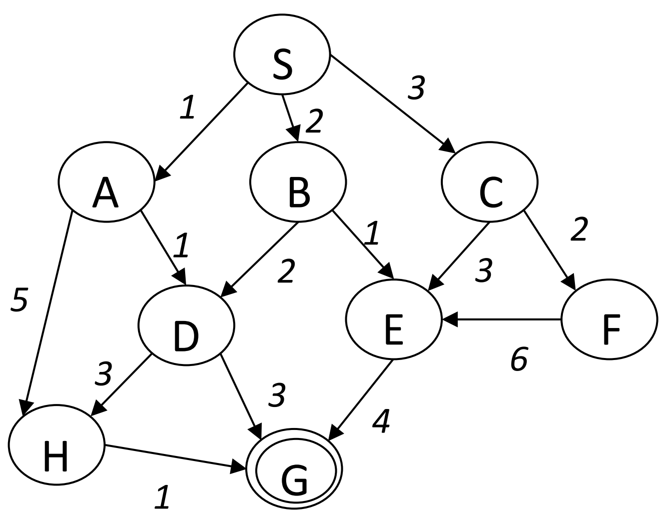
CS 6364

Take Home Quiz 2

Instructions: Do not communicate with anyone in any shape or form. This is an independent test. Do not delete any problem formulation, just attach your answer in the space provided. If the problem is deleted and you send only the answer, you shall receive ZERO points.

Copy and paste the Quiz into a Word document, enter your answers (either by typing in Word, or by inserting a VERY CLEAR picture of your hand-written solution) and transform the quiz into a PDF format. If we cannot clearly read the picture, you will get ZERO for that answer! Make sure that you insert EACH answer immediately after EACH question. Failure to do so will result in ZERO points for the entire quiz! Submit the PDF file with the **name QUIZ_2_netID.pdf**, where netID is your unique netid provided by UTD. If you submit your quiz in any other format your will receive ZERO points. The Quiz shall be submitted in eLearning before the deadline. No late submissions shall be graded!

Problem 1: Consider the following search graph:



(a) Perform **Uniform-Cost Search** to find a solution for the search problem if the initial node is *S* and the goal node is *G*.

Provide the current node and the contents of the explored list (*3 points*) and the content of the frontier (*6 points*) **at each step of the search**.

The format of the frontier should be:
{$Node_1$ (path-cost to $Node_1$), $Node_2$ (path-cost to $Node_2$,… . E.g. A ,B ,…..
Indicate the solution path from *S* to *G* (*3 points*) as well as its cost (*3 points*). (**TOTAL: 15 points**)

Answer:

Step	Current Node	Is It a Goal?	Frontier	Explored
1	S	No	{A(1),B(2),C(3)}	{S}
2	A	No	{B(2),D(2),C(3),H(6)}	{S,A}
3	B	No	{D(2),E(3),C(3),H(6)}	{S,A,B}
4	D	No	{E(3),C(3),G(5),H(5)}	{S,A,B,D}
5	E	No	{C(3),G(5),H(5)}	{S,A,B,D,E}
6	C	No	{G(5),H(5),F(5)}	{S,A,B,D,E,C}
7	G	Yes	-	-

Return **G <- D <- A <- S**

Path Cost: 3 + 1 + 1 = **5**

(b) If an informed search strategy, such as A*, needs to be performed on the same graph, given knowledge about the true-cost to the goal from each node, what are all the possible values of variables *a, b*, *c, d* and *e* such that the heuristic is admissible? (**TOTAL: 15 points**)

Node	S	A	B	C	D	E	F	G	H
Heuristic Value	5	*a*	3	3	3	4	2	0	*e*
True-Cost	6	5	*b*	3	5	*c*	*d*	0	10

Answer:

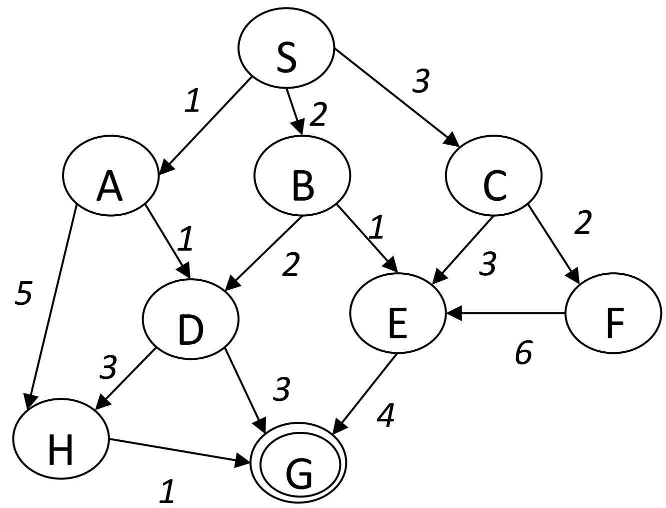
To solve for the values of *a-e* we need to recall the property of the ***admissible heuristics*** that they ***never over-estimate*** the value to the Node. As Heuristic is an estimate distance to the goal state it cannot be negative.

Value of *a: **0 < a <= 5***
Value of *b: **3 <= b***
Value of *c: **4 <= c***
Value of *d: **2 <= d***
Value of *e: **0 < e <= 10***

(c) If an informed search needs to be performed on the same graph and the heuristics function has the following values in the graph nodes:

Node	S	A	B	C	D	E	F	G	H
Heuristic Value	5	4	5	3	3	4	2	0	1

Find if this heuristic function is consistent. (**TOTAL: 15 points**)



Answer:

Node (n)	**Successor (n')**	**h(n)**	**c(n')**	**c(n') + h(n')**	**h(n) ≤ c(n,a,n') + h(n')**
S	A	5	1	1+4=5	Satisfied
S	B	5	2	2+5=7	Satisfied
S	C	5	3	3+3=6	Satisfied
A	D	4	1	1+3=4	Satisfied
A	H	4	5	5+1=6	Satisfied
B	D	5	2	2+3=5	Satisfied
B	E	5	1	1+4=5	Satisfied
C	E	3	3	3+4=7	Satisfied
C	F	3	2	2+2=4	Satisfied
F	E	2	6	6+4=10	Satisfied
E	G	4	4	4+0=4	Satisfied

D	H	3	3	3+1=4	Satisfied
D	G	3	3	3+0=3	Satisfied
H	G	1	1	1+0=1	Satisfied

As the triangle inequality holds true for every node, the above heuristic values are *consistent*.

Problem 2: Heuristic Search:

Consider the 8-puzzle problem, with the initial state represented as *I* and the Goal State as *G*:

7	4	2
1	3	5
	8	6

I

1	2	3
8		4
7	6	5

G

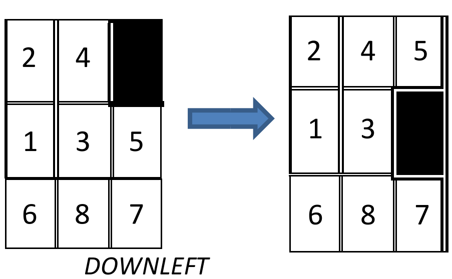
If the cost of sliding the empty square is equal to the sum of its neighboring squares in the successor state and you use a $heurstic = 2\times\ Manhattan\_Distance$, provide the details of the first 3 steps of the search using the Recursive Best-First Search (RBFS) strategy. (**TOTAL: 55 points**)

Hint 1: You will have to fill the values of the following table: (**30 points**)

	STEP 1	STEP 2	STEP 3
F_limit	?	?	?
best	?	?	?
alternative	?	?	?
Current State	?	?	?
New State	?	?	?

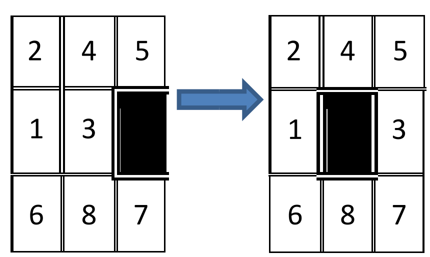
Hint 2: The following two examples show how you compute the cost of getting from a state S_i to a state S_j, when using some specific action:

EXAMPLE 1



S_i S_j

EXAMPLE 2



S_i S_j

For EXAMPLE 1: g(S_i, *DOWN*, S_j)=5+3+7=15. For EXAMPLE 2: g(S_i, *LEFT*, S_j)=1+4+3+8=16.

Hint 3: If you show correctly (a) all the successors of state as I as well as all successors produced in all first 3 steps and you compute correctly the cost from the initial state *I* to each search node as well as the heuristic value in each of the search nodes involved in the first 3 steps, you will be assigned. (**25 points)**

Solution starts on next page.

Answer:

Step 1:

Initial State

7	4	2
1	3	5
	8	6

7 + 1 + 3 = 11

7	4	2
	3	5
1	8	6

Slide-Up
Manhattan-Distance: 2+1+2+2+1+1+2+2 = 13
Heuristic = 2 * 13 = 26
Evaluation Function = 26 + 11 = 37
This becomes **Best**

8 + 3 + 6 = 17

7	4	2
1	3	5
8		6

Slide-Right
Manhattan-Distance: 1+1+2+2+1+1+2+1=11
Heuristic = 2*11 = 22
Evaluation Function = 17 + 22 = 39
This Becomes **Alternate**

	STEP 1	STEP 2	STEP 3
F_limit	Infinity	?	?
best	37	?	?

alternative	39	?	?
Current State	Initial State	?	?
New State	InitialState.Slide-Up	?	?

Step 2:

7	4	2
1	3	5
	8	6

7 + 1 + 3 = 11

7	4	2
	3	5
1	8	6

Cost = 11 + 7 + 4 = 22

	4	2
7	3	5
1	8	6

Slide-Up.
Manhattan-Distance: 2+1+2+2+1 +1+1+2=12
Heuristic = 2*12 = 24
Evaluation Function =22+24=46
This Becomes **Alternate**

Cost = 11+3+4+5+8 =31

7	4	2
3		5
1	8	6

Slide-Right.
Manhattan-Distance: 2+1+3+3+1 +1+2+2=15
Heuristic = 2*15 = 30
Evaluation Function =31+30=61

Cost = 11+1+8 = 20

7	4	2
1	3	5
	8	6

Slide-Down.
Manhattan-Distance: 1+1+2+2+1 +1+2+2=12
Heuristic = 2*12 = 24
Evaluation Function =20+24=44
This Becomes **Best**

	STEP 1	STEP 2	STEP 3
F_limit	Infinity	39	?
best	37	**44 (greater than f_limit)**	?
alternative	39	46	?
Current State	Initial State	InitialState.Slide-Up	?
New State	InitialState.Slide-Up	FAIL	?

As Best > F_limit in this step, we need to update the path cost in the previous step to

Update InitialState.Slide-Up = MAX(F[Initial,State.Slide-Up, F[best])

= MAX(37,44)

= 44

Step 3:

Initial State

7	4	2
1	3	5
	8	6

7 + 1 + 3 = 11

7	4	2
	3	5
1	8	6

Slide-Up

Manhattan-Distance: 2+1+2+2+1+1+2+2 = 13

Heuristic = 2 * 13 = 26

Evaluation Function = ~~26 + 11 = 37~~

Evaluation Function

= MAX(F[Initial,State.Slide-Up, F[best])

= MAX(37,44)

= **44**

This Becomes **Alternate**

8 + 3 + 6 = 17

7	4	2
1	3	5
8		6

Slide-Right

Manhattan-Distance: 1+1+2+2+1+1+2+1=11

Heuristic = 2*11 = 22

Evaluation Function = 17 + 22 = 39

This Becomes **Best**

	STEP 1	STEP 2	STEP 3
F_limit	Infinity	39	Infinity
best	37	**44 (greater than f_limit)**	39
alternative	39	46	44
Current State	Initial State	InitialState.Slide-Up	Initial State
New State	InitialState.Slide-Up	FAIL	InitialState.Slide-Right