

Ayudantía 05



Función Heuristica

Es una función que estima que tan cerca está un estado s de un estado final G.

Es un "atajo" para resolver problemas cuando no hay soluciones exactas o el tiempo de obtención de esta solución es muy largo.

Se utiliza para aproximar, ya que si indicara la distancia real al objetivo, el problema estaría resuelto.

Admisibilidad

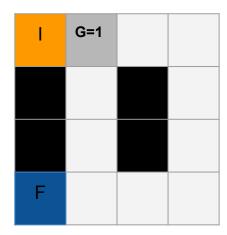
H(n) es admisible si no sobreestima el costo real para llegar al objetivo, es decir :

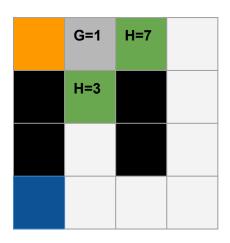
• $h(\mathbf{n}) \leq H(\mathbf{n}) \forall \mathbf{n}$, donde $H(\mathbf{n})$ es el costo real

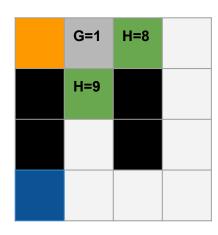
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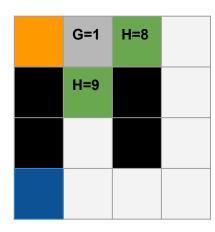
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I	G=1	
F		

G=1	H=7	
H=3		







Consistencia

H(n) es consistente si el valor de la heurística para los vecinos de cierto nodo no es mayor al valor de la heurística en el nodo más el costo por llegar al vecino, es decir:

- $h(\mathbf{n}) \le C(\mathbf{n}, a, \mathbf{n'}) + h(\mathbf{n'}) \ \forall \ \mathbf{n'}$ vecino de \mathbf{n} , donde $C(\mathbf{n}, a, \mathbf{n'})$ es el costo para llegar del nodo \mathbf{n} al nodo $\mathbf{n'}$
- $h(\mathbf{n}) = 0 \forall \mathbf{n} \in G$, es decir, \mathbf{n} es un objetivo

Consistencia

Reemplazando la condición de consistencia en F(**n**'):

- F(n') = G(n') + H(n')
- F(n') = G(n) + C(n, a, n') + H(n')
- $F(n') \ge G(n) + H(n) = F(n)$
- $F(n') \ge F(n)$

, de esta forma tenemos que $F(\mathbf{n})$ es una función no decreciente.

Distancia Manhattan y Euclidiana

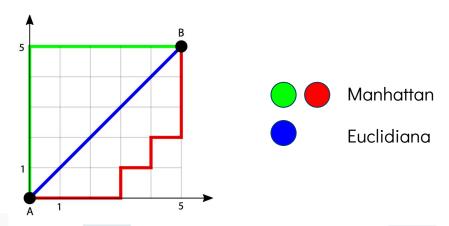
La distancia entre dos puntos es:

Manhattan: la suma de las diferencias absolutas de sus coordenadas

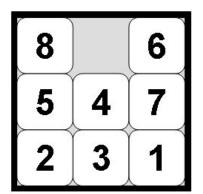
$$D_{Manhattan} = |x_1 - x_2| + |y_1 - y_2|$$

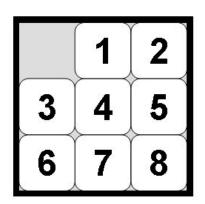
 $D_{Manhattan} = |x_1 - x_2| + |y_1 - y_2|$ Euclidiana: distancia en línea recta entre los puntos

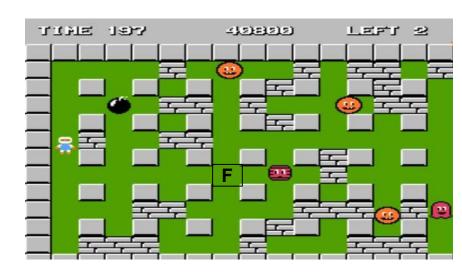
$$D_{\text{Euclidiana}} = \sqrt{[(x_1 - x_2)^2 + (y_1 - y_2)^2]}$$



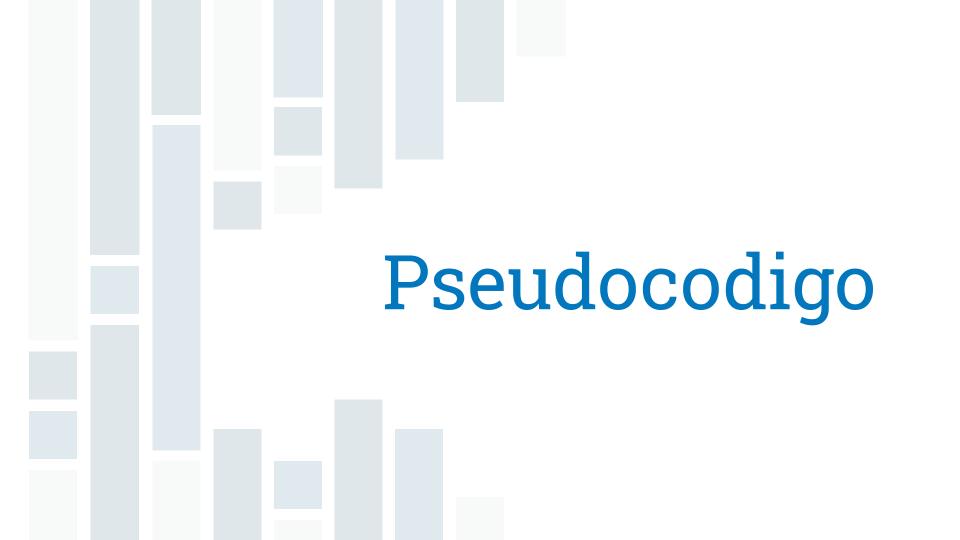
Relajación de problemas

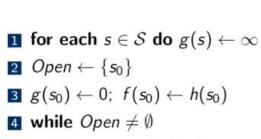














if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

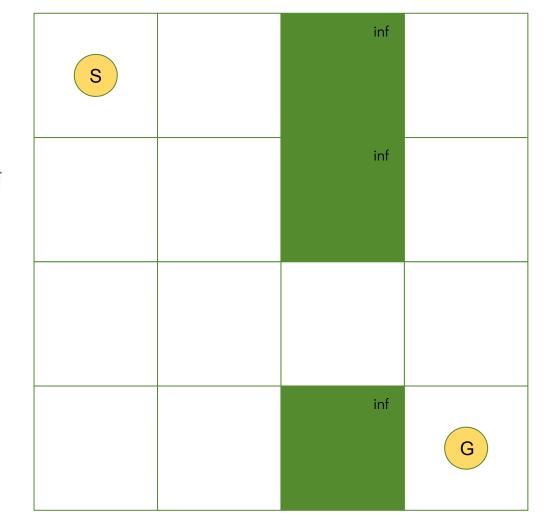
2 if
$$cost_v \ge g(v)$$
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$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- **2** *Open* ← $\{s_0\}$
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- **4** while $Open \neq \emptyset$
- Extrae un u desde Open con menor valor-f
- **if** u es objetivo **return** u
- for each $v \in Succ(u)$ do
 - $1 cost_v = g(u) + c(u, v)$
 - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$

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 - **6** if $v \in Open$ then Reordenar Open
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inf	inf	inf	inf
S			
6	5		3
inf	inf	inf	inf
5	4		2
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inf	inf	inf	inf
			G
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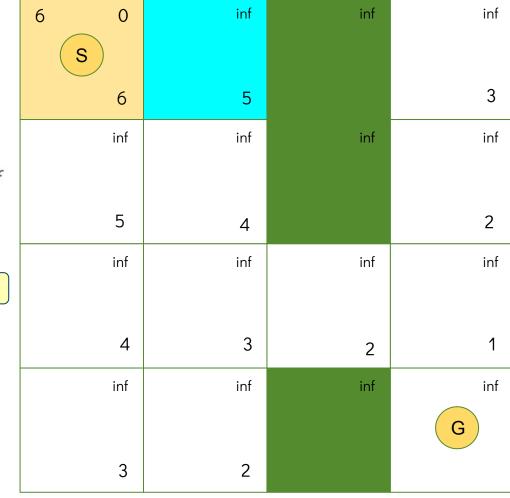
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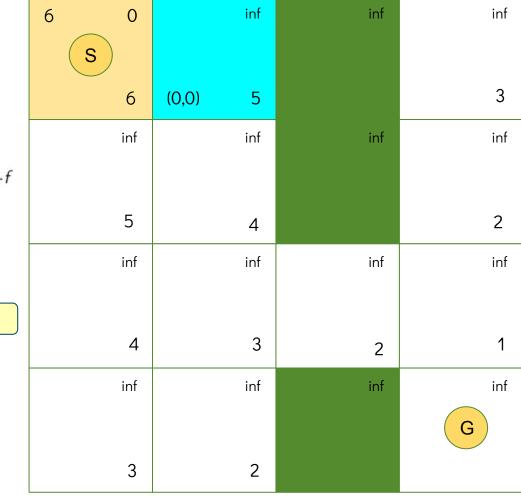
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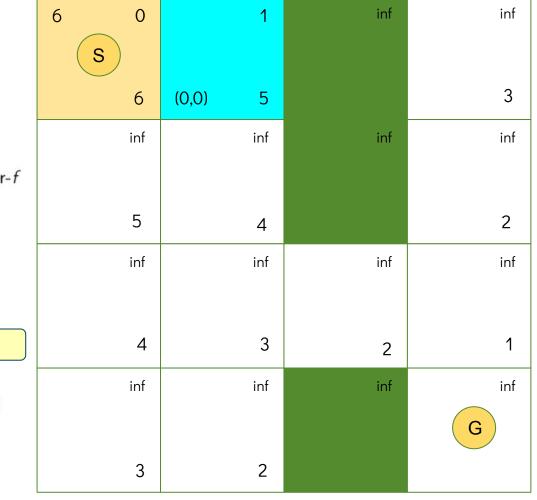
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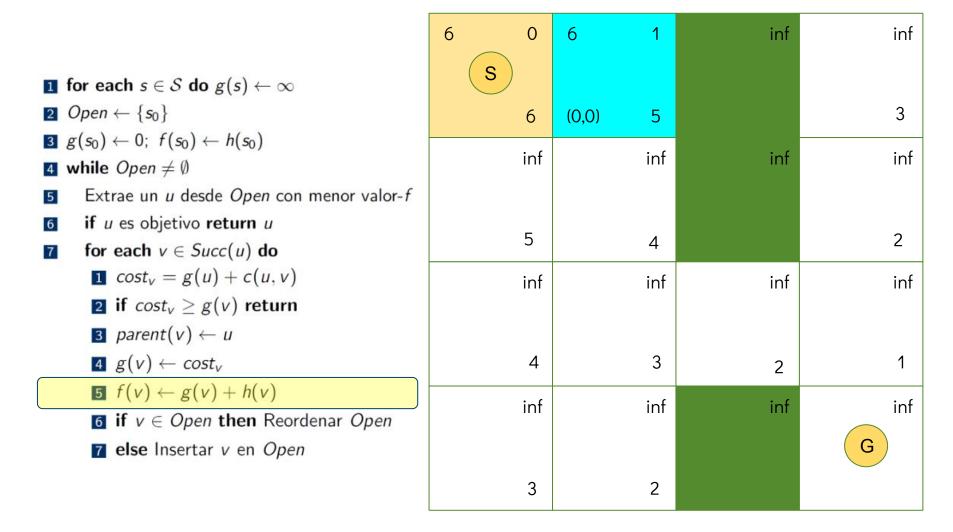
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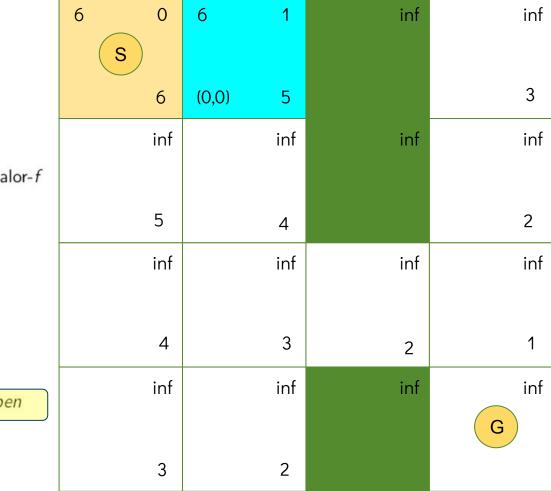
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	6 0	6 1	inf	inf
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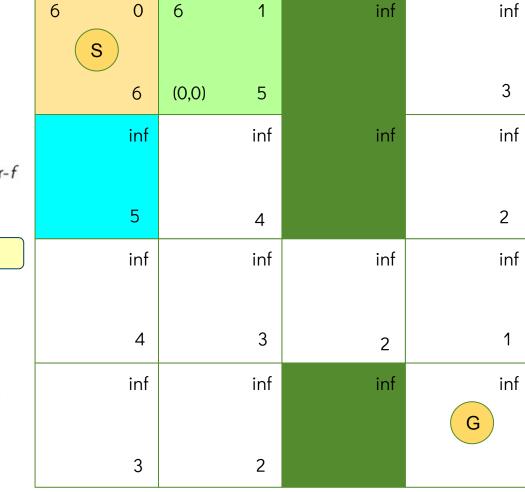
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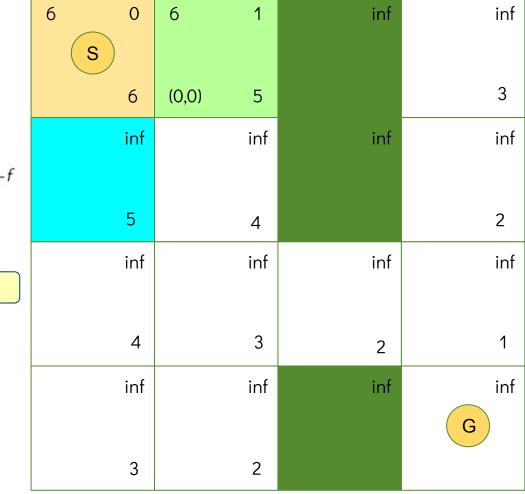
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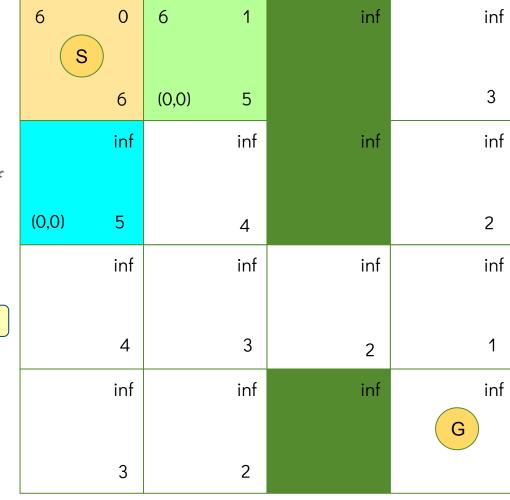
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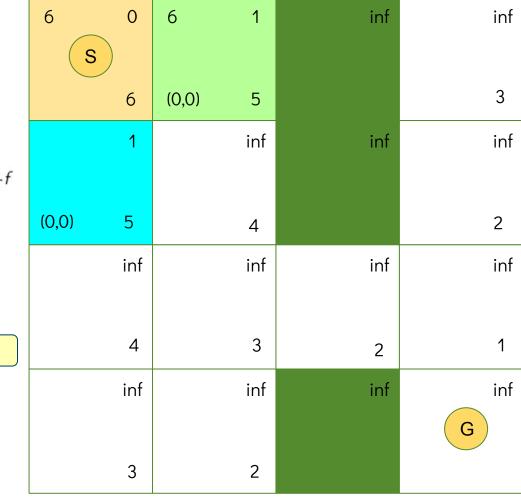
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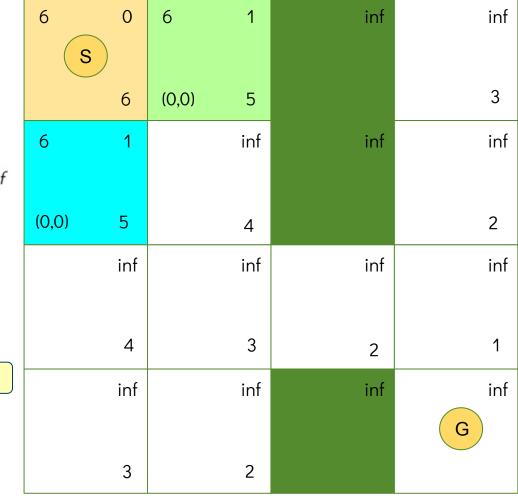
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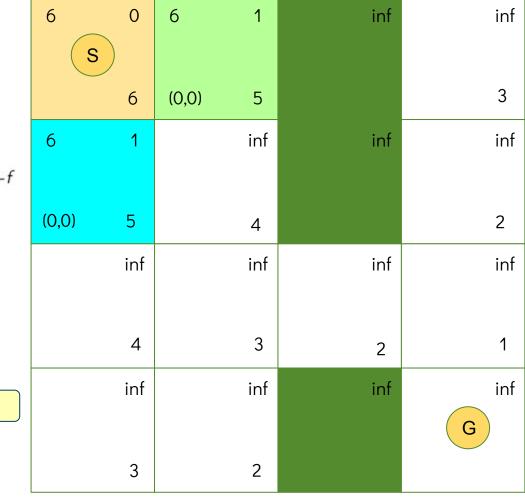
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	6	0	6	1	inf	inf
	S)				
		6	(0,0)	5		3
	6	1		inf	inf	inf
or-f						
	(0,0)	5		4		2
		inf		inf	inf	inf
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(0,0)	5		4		2
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	inf		inf	inf	inf
					G
	3		2		
	6	6 6 1 (0,0) 5 inf 4 inf	6 (0,0) 6 1 (0,0) 5 inf 4 inf	6 (0,0) 5 6 1 inf (0,0) 5 4 inf inf 4 3 inf inf	6 (0,0) 5 6 1 inf inf (0,0) 5 4 inf inf inf inf inf inf

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

for each
$$v \in Succ(u)$$
 do

$$1 cost_v = g(u) + c(u, v)$$

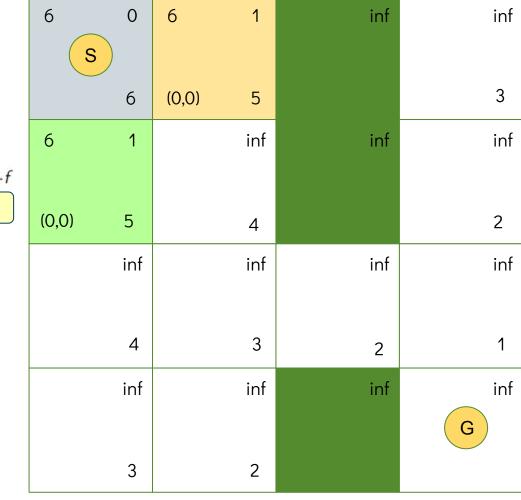
2 if
$$cost_v \ge g(v)$$
 return

$$=$$
 $($

$$\blacksquare$$
 parent $(v) \leftarrow u$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

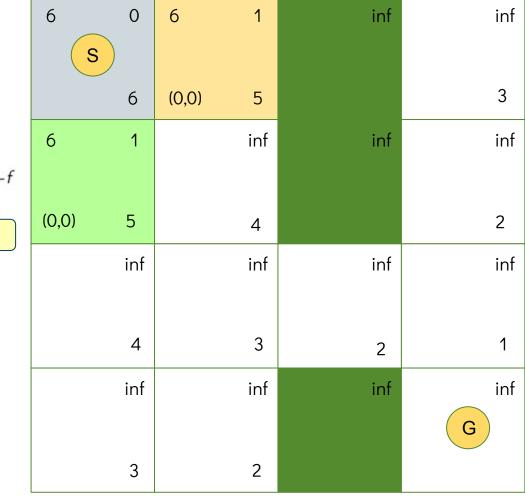
2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

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 then Reordenar $Open$



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$$s \in \mathcal{S}$$
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for each
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6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S)				
		6	(0,0)	5		3
	6	1		inf	inf	inf
r-f						
	(0,0)	5		4		2
		inf		inf	inf	inf
		4		3	2	1
		inf		inf	inf	inf
						G
		3		2		

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
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$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

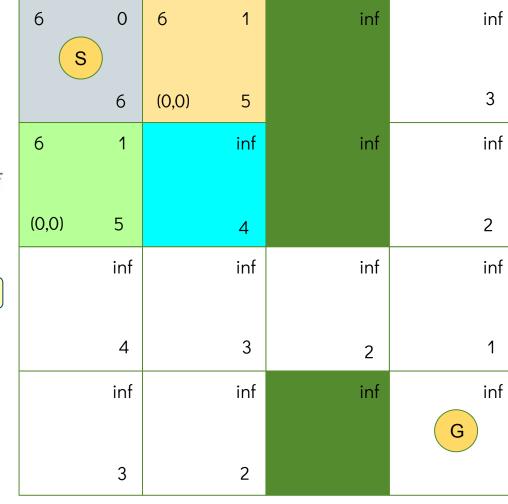
2 if
$$cost_v \ge g(v)$$
 return

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 do

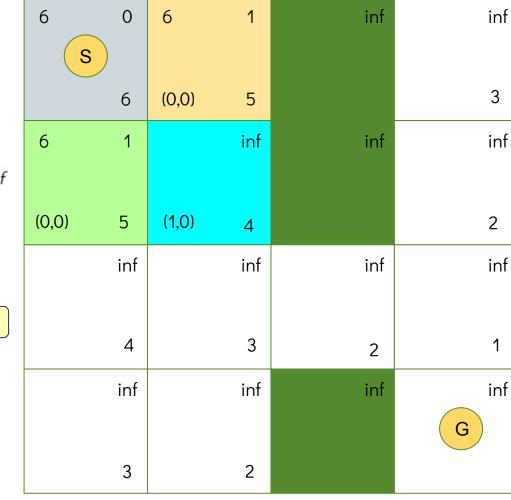
2 if
$$cost_v \geq g(v)$$
 return

3
$$parent(v) \leftarrow u$$

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$$f(v) \leftarrow g(v) + h(v)$$

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$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

1
$$cost_v = g(u) + c(u, v)$$

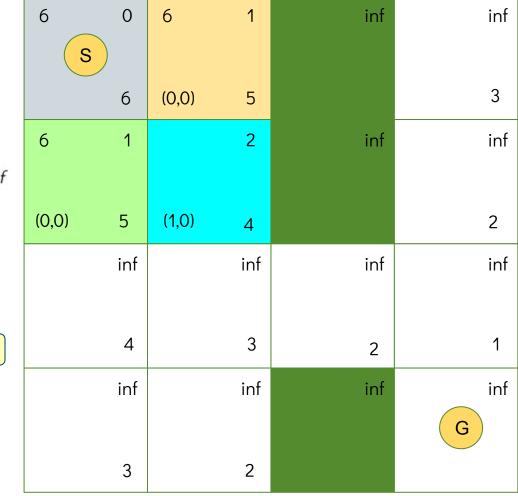
2 if
$$cost_v \ge g(v)$$
 return

$$\exists parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
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$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

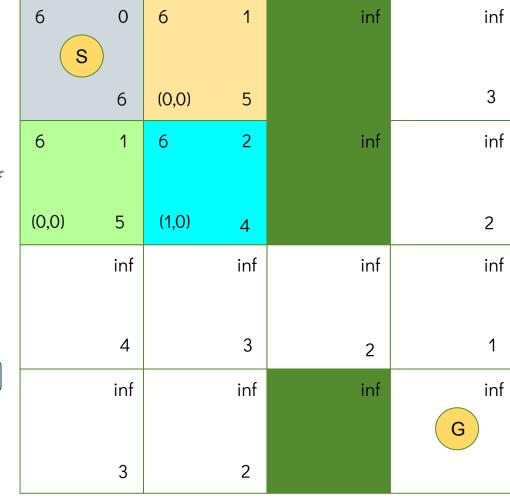
for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

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$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

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$$cost_v = g(u) + c(u, v)$$

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5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

6	0	6	1	inf	inf
S					
	6	(0,0)	5		3
6	1	6	2	inf	inf
(0,0)	5	(1,0)	4		2
	inf		inf	inf	inf
	4		3	2	1
	inf		inf	inf	inf
					G
	3		2		
	6	s 6 6 1 (0,0) 5 inf 4 inf	6 (0,0) 6 1 6 (0,0) 5 (1,0) inf 4 inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 inf inf 4 3 inf inf	6 (0,0) 5 6 1 6 2 inf (0,0) 5 (1,0) 4 inf inf inf inf inf inf

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

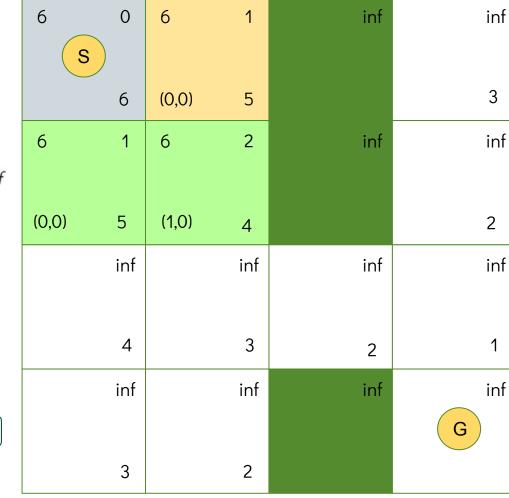
for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

5
$$f(v) \leftarrow g(v) + h(v)$$

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1 for each
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$$Open \leftarrow \{s_0\}$$

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$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
r-f						
	(0,0)	5	(1,0)	4		2
		inf		inf	inf	inf
		4		3	2	1
		inf		inf	inf	inf
						G
		3		2		_

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

7 for each
$$v \in Succ(u)$$
 do

$$1 cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

$$\exists parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5 $f(v) \leftarrow g(v) + h(v)$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S)				
		6	(0,0)	5		3
	6	1	6	2	inf	inf
r-f						
	(0,0)	5	(1,0)	4		2
		inf		inf	inf	inf
		4		3	2	1
		inf		inf	inf	inf
						G
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
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 do

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 return

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6 if
$$v \in Open$$
 then Reordenar $Open$

6	0	6	1	inf	inf
S					
	6	(0,0)	5		3
6	1	6	2	inf	inf
(0,0)	5	(1,0)	4		2
	inf		inf	inf	inf
	4		3	2	1
	inf		inf	inf	inf
					G
	3		2		
	6	(0,0) 5 inf inf	6 (0,0) 6 1 6 (0,0) 5 (1,0) inf 4 inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 inf inf 4 3 inf inf	6 (0,0) 5 6 1 6 2 inf (0,0) 5 (1,0) 4 inf inf inf inf inf inf inf

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

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$$parent(v) \leftarrow u$$

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$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

3
3
inf
2
inf
1
inf

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
-f						
	(0,0)	5	(1,0)	4		2
		inf		inf	inf	inf
		4		3	2	1
		inf		inf	inf	inf
						G
		3		2		

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

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$$\leftarrow \{s_0\}$$

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$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
f						
	(0,0)	5	(1,0)	4		2
		inf		inf	inf	inf
		4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		_

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

1
$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$parent(v) \leftarrow u$$

6 if
$$v \in Open$$
 then Reordenar $Open$

6	0	6	1	inf	inf
S					
	6	(0,0)	5		3
6	1	6	2	inf	inf
(0,0)	5	(1,0)	4		2
	inf		3	inf	inf
	4	(1,1)	3	2	1
	inf		inf	inf	inf
					G
	3		2		
	6	s 6 6 6 1 (0,0) 5 inf 4 inf	6 (0,0) 6 1 6 (0,0) inf 4 (1,1) inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 inf 3 inf inf inf	6 (0,0) 5 6 1 6 2 inf (0,0) 5 (1,0) 4 inf 3 inf 4 (1,1) 3 2 inf inf

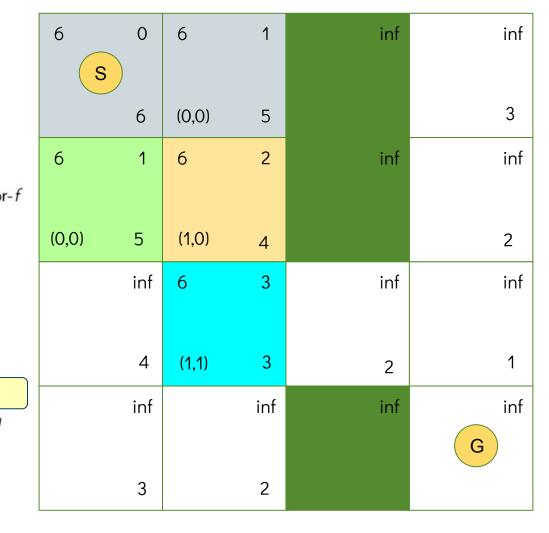
for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

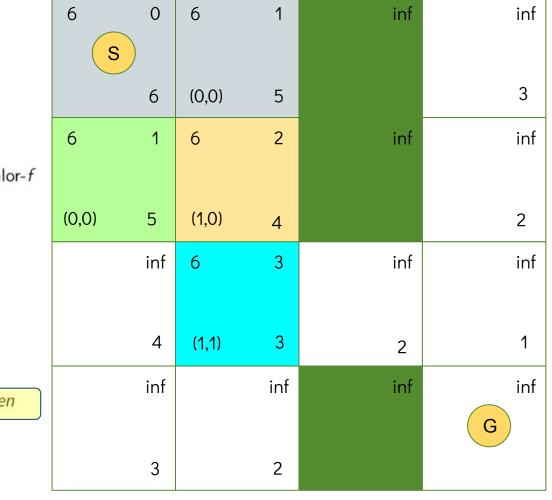
3
$$parent(v) \leftarrow u$$

$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if $v \in Open$ then Reordenar Open



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

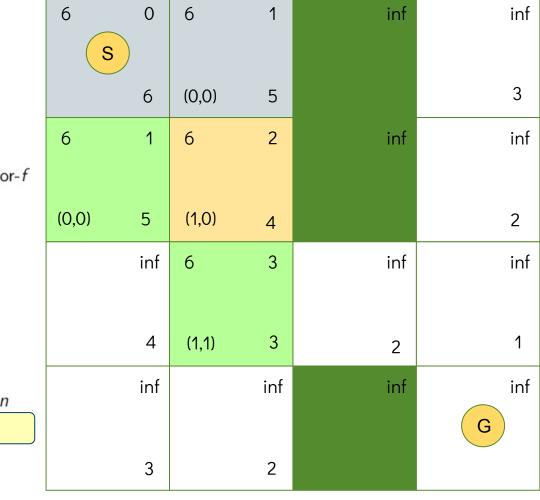
2 if
$$cost_v \ge g(v)$$
 return

$$=$$
 11 costy $\geq g(v)$ recta

$$\exists$$
 parent(v) \leftarrow u

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$\mathbf{I} cost_v = g(u) + c(u, v)$$

2 if
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 return

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$$parent(v) \leftarrow u$$

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$$v \in Open$$
 then Reordenar $Open$



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$$v \in Succ(u)$$
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$$parent(v) \leftarrow u$$

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$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6 S	0	6	1	inf	inf
		6	(0,0)	5		3
f	6	1	6	2	inf	inf
	(0,0)	5	(1,0)	4		2
		inf	6	3	inf	inf
		4	(1,1)	3	2	1
		inf		inf	inf	inf
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

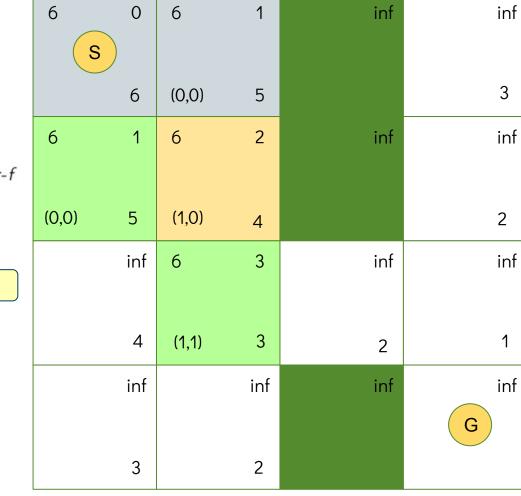
2 if
$$cost_v \ge g(v)$$
 return

$$\exists parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5 $f(v) \leftarrow g(v) + h(v)$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

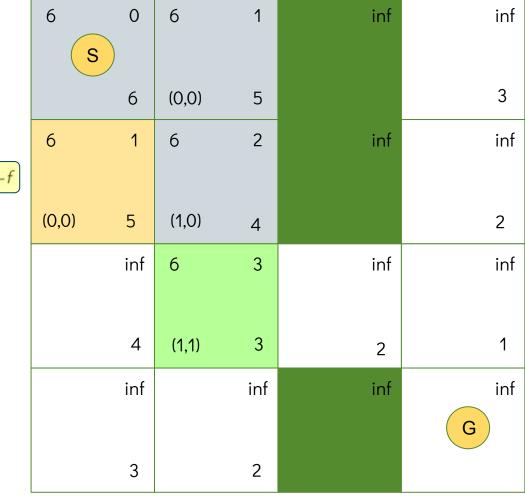
1
$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

$$\square$$
 parent $(v) \leftarrow u$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo return u

7 **for each**
$$v \in Succ(u)$$
 do

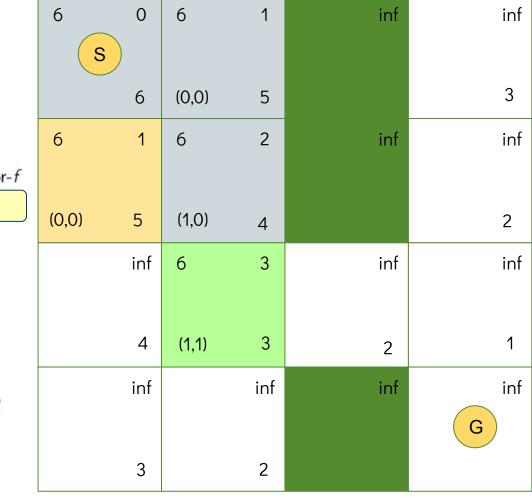
$$1 cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

$$\exists$$
 parent(v) \leftarrow u

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

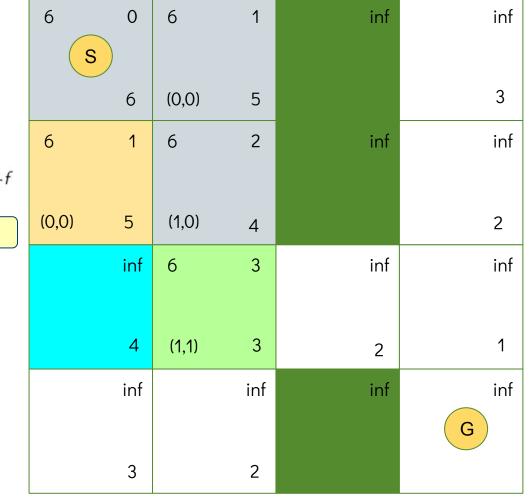
for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



inf

inf

inf

inf

G

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 *Open*
$$\leftarrow$$
 { s_0 }

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

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$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6 S	0	6	1	inf	inf
		6	(0,0)	5		3
f	6	1	6	2	inf	inf
	(0,0)	5	(1,0)	4		2
		inf	6	3	inf	inf
		4	(1,1)	3	2	1
		inf		inf	inf	inf
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S)				
		6	(0,0)	5		3
	6	1	6	2	inf	inf
f						
	(0,0)	5	(1,0)	4		2
		inf	6	3	inf	inf
	(O,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

$$\mathbf{3} \ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
f						
	(0,0)	5	(1,0)	4		2
		2	6	3	inf	inf
	(0,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

1
$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



- 2 *Open* \leftarrow { s_0 }
- $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- Extrae un u desde Open con menor valor-
- if u es objetivo return u
- for each $v \in Succ(u)$ do
 - 1 $cost_v = g(u) + c(u, v)$
 - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$

 - 4 $g(v) \leftarrow cost_v$
 - 5 $f(v) \leftarrow g(v) + h(v)$
 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
r-f						
	(0,0)	5	(1,0)	4		2
	6	2	6	3	inf	inf
	(O,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		
1						

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

$$\mathbf{3} \ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S					
		6	(0,0)	5		3
	6	1	6	2	inf	inf
f						
	(0,0)	5	(1,0)	4		2
	6	2	6	3	inf	inf
	(0,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1	inf	inf
	S	6	(0,0)	5		3
	6	1	6	2	inf	inf
f	(0.0)	_	(4.0)			2
	(0,0)	5	(1,0)	4		2
	6	2	6	3	inf	inf
	(O,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
						G
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 Open
$$\leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

7 for each
$$v \in Succ(u)$$
 do

$$1 cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \geq g(v)$$
 return

$$\exists$$
 parent(v) \leftarrow u

4
$$g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

3
inf
2
inf
1
inf
G

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$\mathbf{I} cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$\exists parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5 $f(v) \leftarrow g(v) + h(v)$

$$g(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

6	0	6	1	inf	inf
S					
	6	(0,0)	5		3
6	1	6	2	inf	inf
(0,0)	5	(1,0)	4		2
6	2	6	3	inf	inf
(0,1)	4	(1,1)	3	2	1
	inf		inf	inf	inf
					G
	3		2		
	6 (0,0)	(0,0) 5 6 2 (0,1) 4 inf	6 (0,0) 6 1 6 (0,0) 5 (1,0) 6 2 6 (0,1) 4 (1,1) inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 6 2 6 3 (0,1) 4 (1,1) 3 inf	6 (0,0) 5 6 1 6 2 inf (0,0) 5 (1,0) 4 6 2 6 3 inf (0,1) 4 (1,1) 3 2 inf inf

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6 S	0	6	1	inf	inf
		6	(0,0)	5		3
f	6	1	6	2	inf	inf
	(0,0)	5	(1,0)	4		2
	6	2	6	3	inf	inf
	(0,1)	4	(1,1)	3	2	1
		inf		inf	inf	inf
		3		2		

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$1 cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
2 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
5 Extrae un u desde $Open$ con menor valor- f
6 if u es objetivo return u
7 for each $v \in Succ(u)$ do
9 $cost_v = g(u) + c(u, v)$
1 $f(s_0) \leftarrow g(v) + f(s_0)$
2 if $cost_v \geq g(v)$ return
1 $f(s_0) \leftarrow g(v) \leftarrow f(s_0)$
3 $f(s_0) \leftarrow f(s_0) \leftarrow f(s_0)$
6 $f(s_0) \leftarrow f(s_0)$
6 $f(s_0) \leftarrow f(s_0)$
6 $f(s_0) \leftarrow f(s_0)$
6 $f(s_0) \leftarrow f(s_0)$
7 else Insertar $f(s_0) \leftarrow f(s_0)$
8 $f(s_0) \leftarrow f(s_0)$
9 $f(s_0) \leftarrow f(s_0)$
9

inf

inf

inf

inf

1 for each
$$s \in S$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
5 Extrae un u desde $Open$ con menor valor- f
6 if u es objetivo return u
7 for each $v \in Succ(u)$ do
9 $cost_v = g(u) + c(u, v)$
1 if $cost_v \geq g(v)$ return
1 parent(v) $\leftarrow u$
1 $g(v) \leftarrow cost_v$
2 if $v \in Open$ then Reordenar $Open$
1 else Insertar v en $Open$

6 0 0 6 1 inf

(0,0) 5

(1,0) 4

(1,1) 3 (1,2) 2

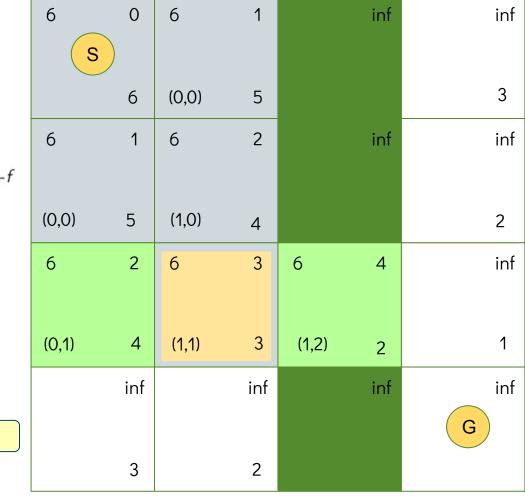
inf

inf

inf

inf

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
4 while $Open \neq \emptyset$
5 Extrae un u desde $Open$ con menor valor- f
6 if u es objetivo return u
7 for each $v \in Succ(u)$ do
1 $cost_v = g(u) + c(u, v)$
2 if $cost_v \geq g(v)$ return
3 $parent(v) \leftarrow u$
4 $g(v) \leftarrow cost_v$
5 $f(v) \leftarrow g(v) + h(v)$
6 if $v \in Open$ then Reordenar $Open$
7 else Insertar v en $Open$



I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- $2 Open \leftarrow \{s_0\}$
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- **5** Extrae un *u* desde *Open* con menor valor-
- **if** u es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

- 1 $cost_v = g(u) + c(u, v)$
- **2** if $cost_v \ge g(v)$ return
- 3 $parent(v) \leftarrow u$
- $4 g(v) \leftarrow cost_v$
- 5 $f(v) \leftarrow g(v) + h(v)$
- **6** if $v \in Open$ then Reordenar Open
- **7 else** Insertar v en Open

	6	0	6	1		inf	inf
	S						
		6	(0,0)	5			3
	6	1	6	2		inf	inf
-f							
	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
	(0,1)	4	(1,1)	3	(1,2)	2	1
		inf		inf		inf	inf
							G
		3		2			
	(0,1)	inf	(1,1)	inf	(1,2)		in

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- 2 $Open \leftarrow \{s_0\}$
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- **5** Extrae un *u* desde *Open* con menor valor-*f*
- **if** u es objetivo **return** u
- for each $v \in Succ(u)$ do
 - - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$
 - $\mathbf{4} \ g(v) \leftarrow cost_v$
 - $f(v) \leftarrow g(v) + h(v)$
 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open

6	0	6	1		inf	inf
S						
	6	(0,0)	5			3
6	1	6	2		inf	inf
(0,0)	5	(1,0)	4			2
6	2	6	3	6	4	inf
(O,1)	4	(1,1)	3	(1,2)	2	1
	inf		inf		inf	inf
						G
	3		2			
	6 (0,0)	6 6 1 (0,0) 5 6 2 (0,1) 4 inf	6 (0,0) 6 1 6 (0,0) 5 (1,0) 6 2 6 (0,1) 4 (1,1) inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 6 2 6 3 (0,1) 4 (1,1) 3 inf	6 (0,0) 5 6 1 6 2 (0,0) 5 (1,0) 4 6 2 6 3 6 (0,1) 4 (1,1) 3 (1,2) inf inf	6 (0,0) 5 6 1 6 2 inf (0,0) 5 (1,0) 4 6 2 6 3 6 4 (0,1) 4 (1,1) 3 (1,2) 2 inf inf

I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- **2** *Open* \leftarrow { s_0 }
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- **5** Extrae un *u* desde *Open* con menor valor-*f*
- **if** u es objetivo **return** u
- for each $v \in Succ(u)$ do

 - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$
 - $4 g(v) \leftarrow cost_v$
 - 5 $f(v) \leftarrow g(v) + h(v)$
 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open

	6	0	6	1		inf	inf
	S						
		6	(0,0)	5			3
	6	1	6	2		inf	inf
r-f							
	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
	(0,1)	4	(1,1)	3	(1,2)	2	1
		inf		inf		inf	inf
							G
		3		2			

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
4 while $Open \neq \emptyset$
5 Extrae un u desde $Open$ con u

Extrae un
$$u$$
 desde $Open$ con menor valor- f

2 if
$$cost_v \geq g(v)$$
 return

3
$$parent(v) \leftarrow u$$

6 if
$$v \in Open$$
 then Reordenar $Open$



	6	0	6	1		inf	inf
	S						
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5			3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	inf
Extrae un u desde $Open$ con menor valor- f							
if u es objetivo return u	(0,0)	5	(1,0)	4			2
for each $v \in Succ(u)$ do	(0,0)	J	(1,0)	4			
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	inf
2 if $cost_v \geq g(v)$ return							
3 $parent(v) \leftarrow u$							
	(O,1)	4	(1,1)	3	(1,2)	2	1
$f(v) \leftarrow g(v) + h(v)$		inf		4		inf	inf
6 if $v \in Open$ then Reordenar $Open$		11 11				1111	
7 else Insertar v en Open							G
		3	(1,2)	2			

	6	0	6	1		inf	inf
	S						
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5			3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	inf
Extrae un u desde $Open$ con menor valor- f							
if u es objetivo return u	(0,0)	5	(1,0)	4			2
for each $v \in Succ(u)$ do	(0,0)	J	(1,0)	4			۷
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	inf
2 if $cost_v \geq g(v)$ return							
3 $parent(v) \leftarrow u$							
	(O,1)	4	(1,1)	3	(1,2)	2	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf	inf
6 if v ∈ Open then Reordenar Open7 else Insertar v en Open							G
a cise insertal v en Open							
		3	(1,2)	2			

	6	0	6	1		inf	inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S						
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5			3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	inf
Extrae un u desde $Open$ con menor valor- f							
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			2
$ 1 cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	inf
2 if $cost_v \ge g(v)$ return							
3 $parent(v) \leftarrow u$							
	(0,1)	4	(1,1)	3	(1,2)	2	1
5 $f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open$ then Reordenar $Open$		inf	6	4		inf	inf
7 else Insertar v en Open							G
		3	(1,2)	2			_

	6	0	6	1		inf	inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S						
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5			3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	inf
Extrae un u desde $Open$ con menor valor- f							
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			2
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	inf
2 if $cost_v \geq g(v)$ return							
$\exists parent(v) \leftarrow u$							
	(0,1)	4	(1,1)	3	(1,2)	2	1
5 $f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open$ then Reordenar $Open$		inf	6	4		inf	inf
7 else Insertar v en Open							G
		3	(1,2)	2			

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 *Open*
$$\leftarrow$$
 { s_0 }

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$a$$
 parent(v) $\leftarrow u$

4
$$g(v) \leftarrow cost_v$$

5 $f(v) \leftarrow g(v) + h(v)$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \geq g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1		inf	inf
	S						
		6	(0,0)	5			3
	6	1	6	2		inf	inf
-f							
	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
	(0,1)	4	(1,1)	3	(1,2)	2	1
		inf	6	4		inf	inf
							G
		3	(1,2)	2			_
		3	(1,2)	2			

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2
$$Open \leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

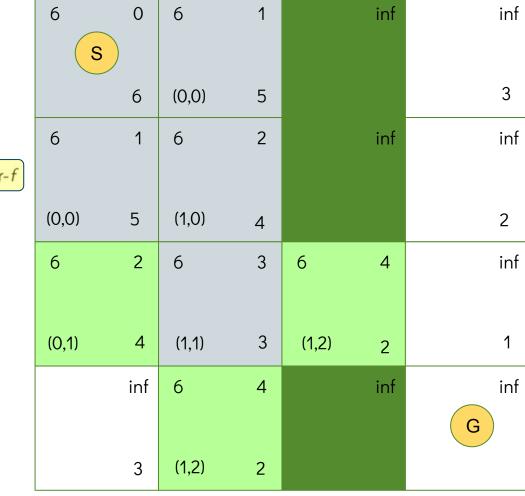
$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$

	6	0	6	1		inf	inf
	S						
		6	(0,0)	5			3
	6	1	6	2		inf	inf
r-f							
	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
	(0,1)	4	(1,1)	3	(1,2)	2	1
		inf	6	4		inf	inf
							G
		3	(1,2)	2			

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
4 while $Open \neq \emptyset$
5 Extrae un u desde $Open$ con menor valor- f
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6 if $v \in Open$ then Reordenar $Open$

else Insertar v en Open



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
4 while $Open \neq \emptyset$
5 Extrae un u desde $Open$ con menor valor- f
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5 $f(v) \leftarrow g(v) + h(v)$

6 if $v \in Open$ then Reordenar Open

7 else Insertar v en Open



- 2 $Open \leftarrow \{s_0\}$
- **3** $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- 5 Extrae un *u* desde *Open* con menor valor-*t*

if u es objetivo return u

- 7 for each $v \in Succ(u)$ do
 - $1 cost_v = g(u) + c(u, v)$
 - **2** if $cost_v \ge g(v)$ return

 - $\exists parent(v) \leftarrow u$

 - $f(v) \leftarrow g(v) + h(v)$
 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open

	6	0	6	1		inf	inf
	S						
		6	(0,0)	5			3
	6	1	6	2		inf	inf
or-f							
	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
	(0,1)	4	(1,1)	3	(1,2)	2	1
ì		inf	6	4		inf	inf
26							G
		3	(1,2)	2			_

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
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for each
$$v \in Succ(u)$$
 do

$$1 cost_v = g(u) + c(u, v)$$

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$$cost_v \geq g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$a$$
 parent(v) $\leftarrow u$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



	6	0	6	1		inf	inf
	S)					
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5			3
$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$		4				٠. ر	• . (
4 while $Open \neq \emptyset$	6	1	6	2		inf	inf
Extrae un u desde $Open$ con menor valor- f							
if u es objetivo return u	(0.0)	_	(4.0)				2
for each $v \in Succ(u)$ do	(0,0)	5	(1,0)	4			2
	6	2	6	3	6	4	inf
2 if $cost_v \geq g(v)$ return							
3 $parent(v) \leftarrow u$							
4 $g(v) \leftarrow cost_v$	(O,1)	4	(1,1)	3	(1,2)	2	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf	inf
6 if $v \in Open$ then Reordenar $Open$		1111	O	4		1111	
7 else Insertar v en Open							G
		3	(1,2)	2			

1 for each
$$s \in S$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

$$\mathbf{3} \ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

$$cost_v = g(u) + c(u, v)$$

2 if
$$cost_v \ge g(v)$$
 return

2 II
$$cost_v \geq g(v)$$
 return

3
$$parent(v) \leftarrow u$$

4
$$g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

6 if
$$v \in Open$$
 then Reordenar $Open$



If for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

2 $Open \leftarrow \{s_0\}$

3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$

4 while $Open \neq \emptyset$

5 Extrae un u desde $Open$ con menor valor- f

5 if u es objetivo return u

7 for each $v \in Succ(u)$ do

8 $g(v) \leftarrow cost_v = g(u) + c(u, v)$

9 $g(v) \leftarrow cost_v$

1 $g(v) \leftarrow cost_v$

1 $g(v) \leftarrow cost_v$

1 $g(v) \leftarrow f(v) \leftarrow f(v) \rightarrow f(v)$

1 inf

2 if $v \in Open$ then Reordenar $Open$

1 else Insertar $v \in Open$

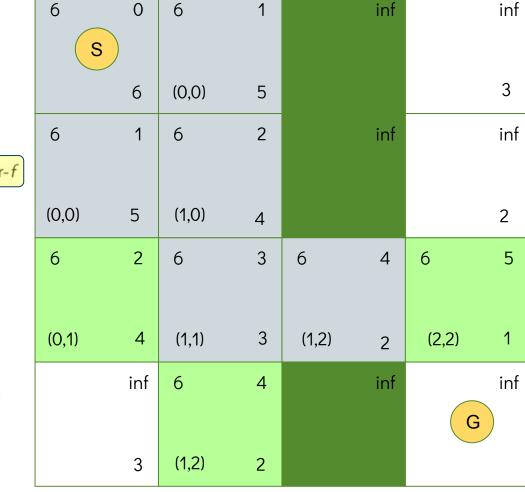
	6	0	6	1		inf		inf
$\textbf{1} \ \textbf{for each} \ s \in \mathcal{S} \ \textbf{do} \ g(s) \leftarrow \infty$	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
$ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0) $	6	1	6	2		inf		inf
4 while $Open \neq \emptyset$	0	'	O	۷		1111		""
Extrae un u desde $Open$ con menor valor- f								
if u es objetivo return u	(0.0)	5	(4.0)	_				2
for each $v \in Succ(u)$ do	(0,0)	<u> </u>	(1,0)	4				2
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4		5
2 if $cost_v \geq g(v)$ return								
3 $parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		inf
6 if $v \in Open$ then Reordenar $Open$			O					. '''
7 else Insertar v en Open							G	
		3	(1,2)	2				

	6	0	6	1		inf		inf
	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
$ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0) $	6	1	6	2		inf		inf
4 while $Open \neq \emptyset$		·		_				""
E xtrae un <i>u</i> desde <i>Open</i> con menor valor- <i>f</i>								
if u es objetivo return u	(0,0)	5	(1,0)	4				2
for each $v \in Succ(u)$ do					_			
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
3 parent $(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		inf
6 if $v \in Open$ then Reordenar $Open$		1111		7		1111		""
7 else Insertar v en Open							G	
		3	(1,2)	2				

	6	0	6	1		inf		inf
$\textbf{1} \ \textbf{for each} \ s \in \mathcal{S} \ \textbf{do} \ g(s) \leftarrow \infty$	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf		inf
Extrae un u desde $Open$ con menor valor- f								
if u es objetivo return u	(0,0)	5	(1,0)	4				2
for each $v \in Succ(u)$ do	(0,0)	J	(1,0)	4				
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
$parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		inf
6 if $v \in Open$ then Reordenar $Open$				·				
7 else Insertar v en Open							G	
		3	(1,2)	2				

	6	0	6	1		inf		inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf		inf
Extrae un u desde $Open$ con menor valor- f								
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4				2
$ 1 cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
$\exists parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
5 $f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open then Reardener Open$		inf	6	4		inf		inf
6 if v ∈ Open then Reordenar Open7 else Insertar v en Open							G	
		3	(1,2)	2				

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
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I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- 2 $Open \leftarrow \{s_0\}$
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- **4** while $Open \neq \emptyset$

- **if** *u* es objetivo **return** *u*
- for each $v \in Succ(u)$ do

 - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$
 - \mathbf{s} parent(\mathbf{v}) $\leftarrow \mathbf{u}$

 - $f(v) \leftarrow g(v) + h(v)$
 - **6 if** $v \in Open$ **then** Reordenar Open
 - **7 else** Insertar v en Open

	6	0	6	1		inf		inf
	S							
		6	(0,0)	5				3
	6	1	6	2		inf		inf
r-f								
	(0,0)	5	(1,0)	4				2
	6	2	6	3	6	4	6	5
	(O,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
		inf	6	4		inf		inf
							G	
		3	(1,2)	2				
		<u> </u>	(1,2)					

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
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else Insertar v en Open



		6	0	6	1		inf		inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$		S							
2	$Open \leftarrow \{s_0\}$		6	(0,0)	5				3
3	$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$	6	4	6			: £		٠(
4	while $Open \neq \emptyset$	6	1	6	2		inf		inf
5	Extrae un u desde $Open$ con menor valor- f								
6	if u es objetivo return u	(0.0)	_	(4.0)					
7	for each $v \in Succ(u)$ do	(0,0)	5	(1,0)	4				2
		6	2	6	3	6	4	6	5
	2 if $cost_v \geq g(v)$ return								
	$\exists parent(v) \leftarrow u$								
		(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
	$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		inf
	6 if $v \in Open$ then Reordenar $Open$		1111	O	4		inf		inf
	7 else Insertar v en Open							G	
			3	(1,2)	2				

1 for each
$$s \in S$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
2 $Open \leftarrow \{s_0\}$
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
5 Extrae un u desde $Open$ con menor valor- f
6 if u es objetivo return u
7 for each $v \in Succ(u)$ do
8 $g(v) \leftarrow cost_v = g(u) + c(u, v)$
9 if $cost_v \geq g(v)$ return
1 garent(v) ← u
1 g(v) ← $cost_v$
1 f(v) ← $g(v)$ + $h(v)$
1 inf $f(v) \leftarrow g(v)$ + $h(v)$
2 if $f(v) \leftarrow g(v)$ + $h(v)$
3 if $f(v) \leftarrow Open$ then Reordenar $Open$
1 else Insertar v en $Open$
3 (1,2) 2

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$

- 3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- Extrae un u desde Open con menor valor-f
- **if** u es objetivo **return** u
- for each $v \in Succ(u)$ do
 - $cost_v = g(u) + c(u, v)$
 - 2 if $cost_v \ge g(v)$ return
 - $\exists parent(v) \leftarrow u$
 - $parent(v) \leftarrow u$
 - 4 $g(v) \leftarrow cost_v$ 5 $f(v) \leftarrow g(v) + h(v)$

 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open



inf

inf

inf

	6	0	6	1		inf		inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S							
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf		6
Extrae un u desde $Open$ con menor valor- f								
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			(3,2)	2
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
	(O,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
5 $f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open$ then Reordenar $Open$		inf	6	4		inf		inf
7 else Insertar v en Open							G	
		3	(1,2)	2				

	6	0	6	1		inf		inf
	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	8	6
Extrae un u desde $Open$ con menor valor- f								
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			(3,2)	2
$ 1 cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
$\exists parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open$ then Reordenar $Open$		inf	6	4		inf		inf
7 else Insertar v en Open							G	
		3	(1,2)	2				

	6	0	6	1		inf		inf
	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	8	6
Extrae un u desde $Open$ con menor valor- f								
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			(3,2)	2
$ 1 cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \ge g(v)$ return								
$\exists parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
5 $f(v) \leftarrow g(v) + h(v)$ 6 if $v \in Open$ then Reordenar $Open$		inf	6	4		inf		inf
7 else Insertar v en Open							G	
		3	(1,2)	2				

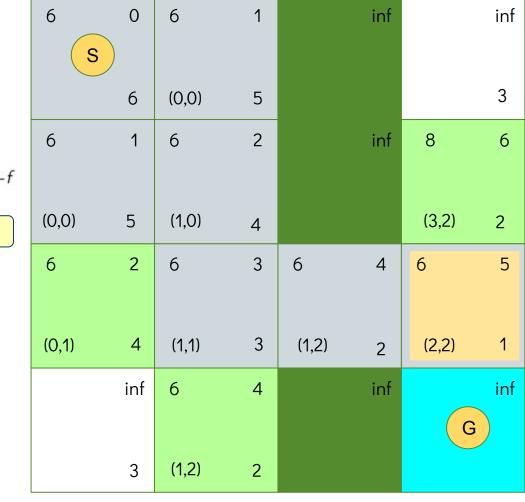
	6	0	6	1		inf		inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
$ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0) $	6	1	6	2		inf	8	6
4 while $Open \neq \emptyset$		•	ŭ	_			, and the second	Ü
Extrae un <i>u</i> desde <i>Open</i> con menor valor- <i>f</i>								
if u es objetivo return u	(0,0)	5	(1,0)	4			(3,2)	2
for each $v \in Succ(u)$ do			. , .				. , ,	
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
$\exists parent(v) \leftarrow u$								
4 $g(v) \leftarrow cost_v$	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		inf
6 if $v \in Open$ then Reordenar $Open$		1111	O	4		11 11		""
7 else Insertar <i>v</i> en <i>Open</i>							G	
		3	(1,2)	2				

1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

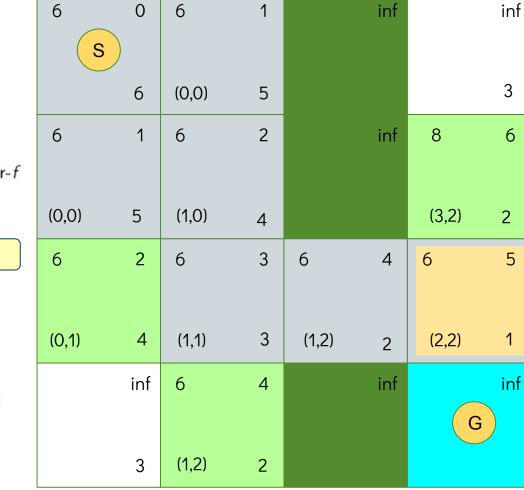
- 2 $Open \leftarrow \{s_0\}$
- $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- Extrae un u desde Open con menor valor-f
- **if** u es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

- **2** if $cost_v \ge g(v)$ return
- 3 $parent(v) \leftarrow u$
- 4 $g(v) \leftarrow cost_v$
- 5 $f(v) \leftarrow g(v) + h(v)$
- **6** if $v \in Open$ then Reordenar Open
- **7 else** Insertar *v* en *Open*



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$
2 $Open \leftarrow \{s_0\}$
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7 else Insertar v en $Open$



1 for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

- 2 $Open \leftarrow \{s_0\}$
- $g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$
- 4 while $Open \neq \emptyset$
- **E**xtrae un *u* desde *Open* con menor valor-
- **if** u es objetivo **return** u
- for each $v \in Succ(u)$ do

 - **2** if $cost_v \ge g(v)$ return
 - 3 $parent(v) \leftarrow u$

 - $f(v) \leftarrow g(v) + h(v)$
 - if w C Open then Boardanar Open
 - **6** if $v \in Open$ then Reordenar Open
 - 7 else Insertar v en Open

	6	0	6	1		inf		inf
	S							
		6	(0,0)	5				3
	6	1	6	2		inf	8	6
r-f								
	(0,0)	5	(1,0)	4			(3,2)	2
	6	2	6	3	6	4	6	5
	(O,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
		inf	6	4		inf		inf
							G	
		3	(1,2)	2				

1 for each
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4 while $Open \neq \emptyset$
5 Extrae un u desde $Open$ con menor valor- f
6 if u es objetivo return u
7 for each $v \in Succ(u)$ do
1 $cost_v = g(u) + c(u, v)$
2 if $cost_v \geq g(v)$ return
3 $parent(v) \leftarrow u$
4 $g(v) \leftarrow cost_v$
5 $f(v) \leftarrow g(v) + h(v)$
6 if $v \in Open$ then Reordenar $Open$
7 else Insertar v en $Open$



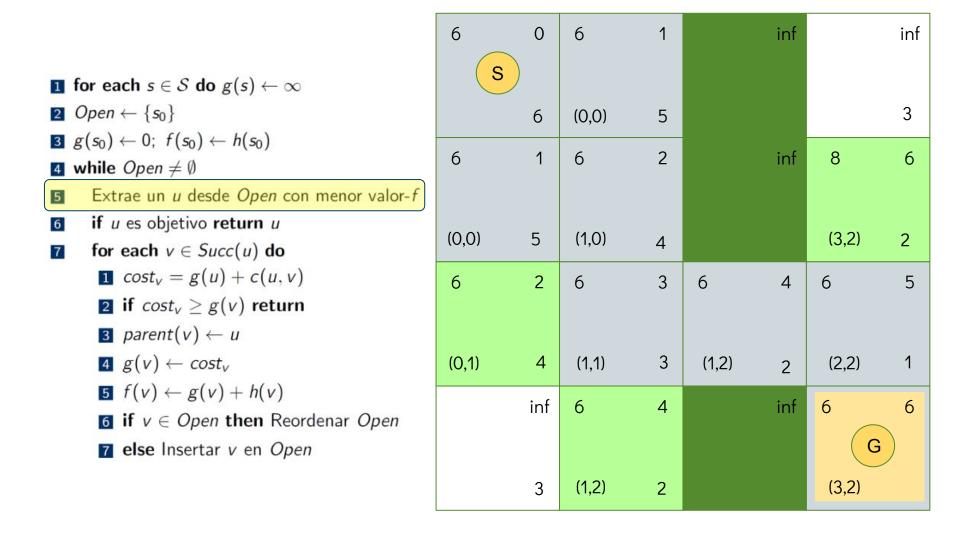
	6	0	6	1		inf		inf
1 for each $s \in \mathcal{S}$ do $g(s) \leftarrow \infty$	S)						
2 <i>Open</i> ← $\{s_0\}$		6	(O,O)	5				3
$3 \ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$	6	1	6	2		inf	8	6
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Extrae un u desde $Open$ con menor valor- f								
if u es objetivo return u	(0.0)	5	(1,0)	_			(3,2)	2
for each $v \in Succ(u)$ do	(0,0)	5	(1,0)	4			(3,2)	2
$ cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
$parent(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf		6
6 if $v \in Open$ then Reordenar $Open$								
7 else Insertar v en Open							G	
		3	(1,2)	2			(3,2)	

1 for each
$$s \in S$$
 do $g(s) \leftarrow \infty$
2 Open $\leftarrow \{s_0\}$
2 If $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$
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6 If $g(s_0) \leftarrow g(s_0) \leftarrow g(s_0)$
7 If $g(s_0) \leftarrow g(s_0) \leftarrow g(s_0)$
8 If $g(s_0) \leftarrow g(s_0) \leftarrow g(s_0)$
9 If $g(s_0) \leftarrow g($

	6	0	6	1		inf		inf
	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
$ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0) $	6	1	6	2		inf	8	6
4 while $Open \neq \emptyset$	O	'	O	_			O	U
Extrae un u desde $Open$ con menor valor- f								
if u es objetivo return u	(0.0)	E	(4.0)				(2.2)	2
for each $v \in Succ(u)$ do	(0,0)	5	(1,0)	4			(3,2)	2
$ 1 cost_v = g(u) + c(u, v) $	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
3 $parent(v) \leftarrow u$								
	(O,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf	6	6
6 if $v \in Open$ then Reordenar $Open$		11 11	O	4		1111		V
7 else Insertar v en Open							G	
		3	(1,2)	2			(3,2)	

	6	0	6	1		inf		inf
	S							
$ 2 Open \leftarrow \{s_0\} $		6	(O,O)	5				3
$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$	6	1	6	2		inf	8	6
4 while $Open \neq \emptyset$	0	'	O	۷		1111	O	O
Extrae un u desde $Open$ con menor valor- f								
if u es objetivo return u	(0,0)	5	(1,0)				(3,2)	2
for each $v \in Succ(u)$ do	(0,0)	5	(1,0)	4			(3,2)	
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2 if $cost_v \geq g(v)$ return								
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	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf	6	6
6 if $v \in Open$ then Reordenar $Open$		1111	O	4		1111	0	O
7 else Insertar v en Open							G	
		3	(1,2)	2			(3,2)	

	6	0	6	1		inf		inf
	S)						
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5				3
3 $g(s_0) \leftarrow 0$; $f(s_0) \leftarrow h(s_0)$ 4 while $Open \neq \emptyset$	6	1	6	2		inf	8	6
Extrae un <i>u</i> desde <i>Open</i> con menor valor- <i>f</i>								
 if u es objetivo return u for each v ∈ Succ(u) do 	(0,0)	5	(1,0)	4			(3,2)	2
	6	2	6	3	6	4	6	5
2 if $cost_v \ge g(v)$ return 3 $parent(v) \leftarrow u$								
	(O,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
 f(v) ← g(v) + h(v) if v ∈ Open then Reordenar Open else Insertar v en Open 		inf	6	4		inf	6 G	6
		3	(1,2)	2			(3,2)	



	6	0	6	1		inf		inf
	S)						
$ 2 Open \leftarrow \{s_0\} $		6	(0,0)	5				3
$ g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0) $	6	1	6	2		inf	8	6
4 while $Open \neq \emptyset$	0	'	O	۷		1111	U	U
E xtrae un u desde $Open$ con menor valor- f								
if <i>u</i> es objetivo return <i>u</i>	(O,O)	5	(1,0)	1			(3,2)	2
for each $v \in Succ(u)$ do	(0,0)	J	(1,0)	4			(5,2)	
	6	2	6	3	6	4	6	5
2 if $cost_v \geq g(v)$ return								
3 parent $(v) \leftarrow u$								
	(0,1)	4	(1,1)	3	(1,2)	2	(2,2)	1
$f(v) \leftarrow g(v) + h(v)$		inf	6	4		inf	6	6
6 if $v \in Open$ then Reordenar $Open$		1111	O	4		1111	0	
7 else Insertar v en Open							G	
		3	(1,2)	2			(3,2)	

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4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

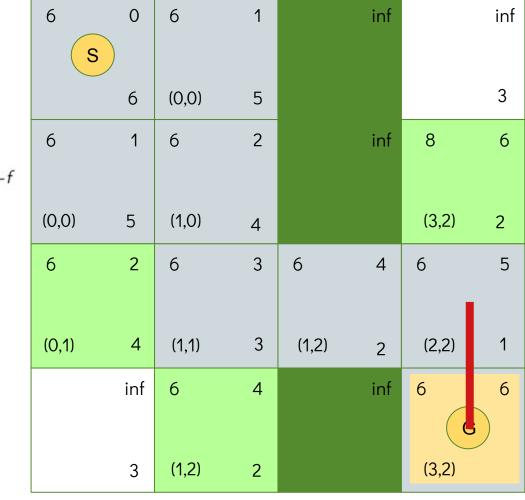
$$\blacksquare$$
 parent $(v) \leftarrow u$

$$g(v) \leftarrow cost_v$$

5
$$f(v) \leftarrow g(v) + h(v)$$

if
$$v \in Open$$
 then Reordenar $Open$

6 If
$$v \in Open$$
 then Reordenar $Open$



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 - $f(v) \leftarrow g(v) + h(v)$
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I for each
$$s \in \mathcal{S}$$
 do $g(s) \leftarrow \infty$

$$2 Open \leftarrow \{s_0\}$$

3
$$g(s_0) \leftarrow 0$$
; $f(s_0) \leftarrow h(s_0)$

4 while
$$Open \neq \emptyset$$

Extrae un
$$u$$
 desde $Open$ con menor valor- f

if
$$u$$
 es objetivo **return** u

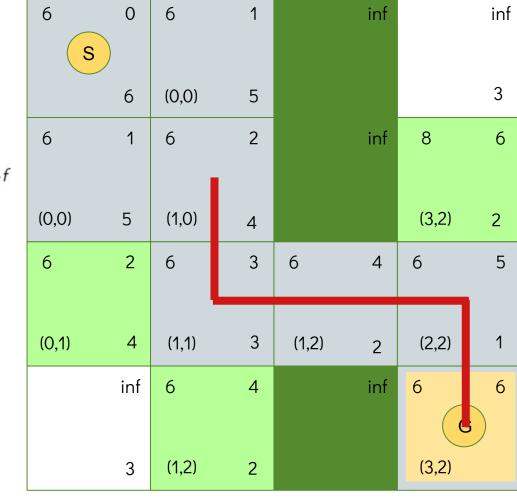
for each
$$v \in Succ(u)$$
 do

2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$f(v) \leftarrow g(v) + h(v)$$

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$$v \in Open$$
 then Reordenar $Open$



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$$Open \leftarrow \{s_0\}$$

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

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$$parent(v) \leftarrow u$$

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I for each
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2 *Open*
$$\leftarrow$$
 { s_0 }

$$g(s_0) \leftarrow 0; \ f(s_0) \leftarrow h(s_0)$$

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Extrae un
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if
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 es objetivo **return** u

for each
$$v \in Succ(u)$$
 do

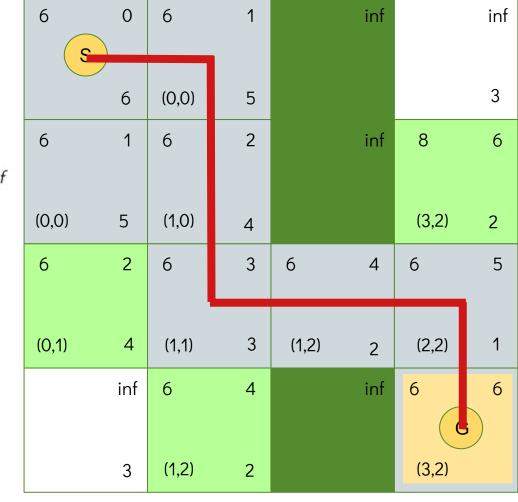
2 if
$$cost_v \ge g(v)$$
 return

3
$$parent(v) \leftarrow u$$

$$4 g(v) \leftarrow cost_v$$

$$f(v) \leftarrow g(v) + h(v)$$

if
$$v \in Open$$
 then Reordenar $Open$





$$f(n) = g(n) + h(n)$$

g(n): costo de un camino desde s_{start} hasta el nodo n

h(n): estima el costo de un camino desde n hasta s_{goal}

 $\delta(s,t)$: costo de un camino óptimo entre s y t

Admisibilidad : h es admisible si y solo si

$$h(s) \leq \delta(s, s_{goal}),$$

para todo estado s.

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$$h(s) \leq \delta(s, s_{goal}),$$

para todo estado s.

Algoritmo A*

$$h(s) \le \delta(s, s_{goal})$$

$$f(s^*) = g(s^*) + h(s^*)$$

Algoritmo Weighted A*

$$h(s) \le \delta(s, s_{goal})$$

$$f(s^*) = g(s^*) + wh(s^*)$$

$$h(s) \le \delta(s, s_{goal})$$

Al ser ejecutado con una heurística h admisible, Weighted A* retorna una solución cuyo costo está acotado superiormente por $w \cdot \underline{\delta(s_{start}, s_{goal})}$ costo óptimo

$$f(s^*) = g(s^*) + wh(s^*)$$

- 1. s^* está en un camino óptimo hacia s_{goal}
- 2. se cumple que $g(s^*) = \delta(s_{start}, s^*)$

$$h(s) \le \delta(s, s_{goal})$$

$$g(s_{start}) = \delta(s_{start}, s_{start}) = 0$$

$$O \longrightarrow O \longrightarrow S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow S_n$$

$$(s_1 = s_{start}) \longrightarrow S_n$$

$$(s_n = s_{goal})$$

 $g(s_{start}) = \delta(s_{start}, s_{start}) = 0$ $O \longrightarrow O \longrightarrow S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow S_n$ $(s_1 = s_{start}) \longrightarrow S_n$ $(s_n = s_{goal})$

$$\delta(s_{start}, s^*) + \delta(s^*, s_{goal}) = \delta(s_{start}, s_{goal})$$

$$g(s_{start}) = \delta(s_{start}, s_{start}) = 0$$

$$O \longrightarrow O \longrightarrow S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow S_n$$

$$(s_1 = s_{start}) \longrightarrow S_n$$

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$$\delta(s_{start}, s^*) + \delta(s^*, s_{goal}) = \delta(s_{start}, s_{goal})$$
$$g(s^*)$$

$$g(s_{start}) = \delta(s_{start}, s_{start}) = 0$$

$$O \longrightarrow O \longrightarrow S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow S_n$$

$$(s_1 = s_{start}) \longrightarrow S_n$$

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$$\delta(s_{start}, s^*) + \delta(s^*, s_{goal}) = \delta(s_{start}, s_{goal})$$
$$g(s^*)$$

$$g(s_{start}) = \delta(s_{start}, s_{start}) = 0$$

$$O \longrightarrow O \longrightarrow S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow S_n$$

$$(s_1 = s_{start}) \longrightarrow S_n$$

$$(s_n = s_{goal})$$

$$\delta(s_{start}, s^*) + \delta(s^*, s_{goal}) = \delta(s_{start}, s_{goal})$$
$$g(s^*) + h(s^*) \leq \delta(s_{start}, s_{goal})$$

$$g(s_{start}) = \delta(s_{start}, s_{start}) = 0$$

$$O \longrightarrow S \longrightarrow S \longrightarrow S^* \longrightarrow O \longrightarrow \cdots \longrightarrow O$$

$$S_1 \longrightarrow S_2 \longrightarrow S_j \longrightarrow S_{j+1} \longrightarrow \cdots \longrightarrow S_n$$

$$(s_1 = s_{start}) \longrightarrow S_n$$

$$(s_n = s_{goal})$$

$$f(s) = \min_{t \in Open} \{f(t)\}$$

$$f(s) \leq f(s^*)$$

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$$f(s) \le f(s^*)$$

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$$f(s) \le f(s^*)$$
$$f(s) \le g(s^*) + wh(s^*)$$

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$$f(s) \le w(g(s^*) + h(s^*)) \quad (con w > 1)$$

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$$f(s) \leq w(g(s^*) + h(s^*)) \quad (con w > 1)$$

$$f(s) \leq w\delta(s_{start}, s_{goal})$$

Todo estado s que es extraído de Open satisface:

$$f(s) \leq w\delta(s_{start}, s_{goal})$$

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$$f(s) \leq w\delta(s_{start}, s_{goal})$$

En particular, cuando s_{goal} es extraído:

$$g(s_{goal}) + wh(s_{goal}) \le w\delta(s_{start}, s_{goal})$$

Todo estado s que es extraído de Open satisface:

$$f(s) \leq w\delta(s_{start}, s_{goal})$$

En particular, cuando s_{qoal} es extraído:

$$g(s_{goal}) + wh(s_{goal}) \le w\delta(s_{start}, s_{goal})$$

 $g(s_{goal}) \le w\delta(s_{start}, s_{goal})$

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$$g(s_{goal}) \le \delta(s_{start}, s_{goal})$$

https://www.youtube.com/watch?v=_41v4I5GTNc