



# Práctica 3

Inteligencia Artificial

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Grupo 5.

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## 1. Tabla comparativa de algoritmos para el tablero propuesto.

Tipo de Búsqueda	Solución	Coste	Nodos expandidos	Tamaño de la cola	Tamaño máximo de la cola
Primero en anchura	<u>4.1.</u>	23	1798	649	953
Primero en profundidad	<u>4.2.</u>	262	264	787	788
Coste uniforme	<u>4.3.</u>	23	2045	475	1274
Greedy Best First Graph Distancia hasta la meta	<u>4.4.</u>	58	204	388	389
Greedy Best First Search Graph Obstáculos	<u>4.5.</u>	24	127	204	205
A* Graph Distancia hasta la meta	<u>4.6.</u>	23	1222	1203	1441

## 2. Análisis de los resultados de los distintos algoritmos.

Tras solucionar el juego con los distintos algoritmos que nos ofrece el Aima, analizamos sus resultados para ver que datos relevantes nos puede ofrecer:

De estos datos podemos concluir que la búsqueda que encuentra la solución óptima más rápido es la A\* GraphSearch con la heurística Obstáculos. Sin embargo la mejor búsqueda con respecto a memoria que sigue encontrando la solución óptima es la búsqueda en anchura, aunque esta lleve más tiempo en calcularse.

A pesar de que las dos búsquedas anteriores son muy buenas, la mejor búsqueda para este problema es la Greedy Best First Search con GraphSearch y la heurística de Obstáculos, pues si bien no encuentra la solución óptima, se acerca en gran medida a esta (coste 24 respecto a los 23 de la óptima) y con una velocidad muy superior al resto (127 nodos expandidos respecto a los 679 de la A\* Graph con heurística obstáculos), usando una cantidad de memoria muy inferior al resto (205 como tamaño máximo de la cola frente a 953 del primero en anchura).

### 3. Discusión sobre la admisibilidad y consistencia de las heurísticas.

#### 3.1. Heurística distancia a meta.

Esta es una heurística muy sencilla en la que tomamos como valor la distancia del coche rojo hasta la meta en línea recta. Es muy simple ya que ignora los coches que bloquean el camino del coche rojo hasta su objetivo final y por ello no es la mejor heurística de las dos que aportamos (como se puede observar en la [tabla](#)).

Aún siendo una mala heurística que obvia muchos datos, es admisible puesto que siempre se van a necesitar  $h'$  movimientos como mínimo para poder llegar al estado objetivo, por tanto, siempre  $h'$  siempre será menor o igual al coste real de llegar a un estado objetivo. Un ejemplo claro de lo expuesto: si no hay ningún coche que impida el movimiento del coche rojo, el coste real y el de la heurística coinciden, sino el coste real siempre será mayor que el coste de la heurística.

Por otra parte, la heurística también es consistente ya que todas las acciones tienen coste 1 y por tanto el coste real de llegar de  $n_i$  a  $n_j$  (siendo  $n_j$  hijo de  $n_i$ ) siempre va a ser 1 y la varianza de la heurística siempre está entre  $-1$  (si te alejas de la meta) y  $1$  (si te acercas a la meta). Es por ello por lo que la varianza de la heurística siempre es menor o igual al coste real de pasar de un estado padre a cualquiera de sus hijos.

#### 3.2. Heurística obstáculos.

Esta heurística es un poco más compleja que la anterior. En esta heurística, tomamos como valor la cantidad de coches distintos que hay desde el coche rojo hasta la meta más la distancia del coche hasta la salida.

Esta heurística resulta ser bastante buena para este problema pues la dificultad de llevar un coche hasta la meta depende de cuál sea la distancia hasta la salida, y en mayor medida de la cantidad de coches que tenga obstaculizando el camino, puesto que a mayor cantidad de coches obstaculizando nuestro camino, más acciones serán necesarias para despejar la salida.

La heurística de obstáculos es admisible porque en todo momento el coste real de llevar el coche rojo hasta el objetivo es mayor igual al de la heurística. Esto se debe a varios factores:

- Si no hay coches obstaculizando la salida, el valor de la heurística es igual al coste real.
- Si hay varios coches que podemos despejar con un solo movimiento por cada uno de ellos, el valor de  $h'$  será también igual al coste real para llegar al objetivo.
- Si existen vehículos que necesitan más de un movimiento para despejar el camino del coche rojo, entonces, el valor de la heurística siempre será menor que el coste real.

Esta heurística también es consistente ya que, por un lado, todo movimiento tiene coste 1 y (el coste de pasar de un estado padre a un estado hijo siempre es 1) y la heurística del estado padre menos la del hijo siempre va a valer 1 o  $-1$ , por tanto, el coste real de pasar del estado padre al estado hijo siempre va a ser menor o igual que la varianza de la heurística entre estado padre y estado hijo.

## 4. Soluciones de los algoritmos.

### 4.1. Solución búsqueda en anchura:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

```
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle c -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
```

Tablero final:

				b	
a	a			b	
				r	r
		e	f	c	d
g	g	e	f	c	d
		e			d

#### 4.2. Solución primero en profundidad:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g -1]

Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle d -1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle a -1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle d 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle a -1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle d -1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle e -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle d 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g -1]



Action[name==MoveVehicle r -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle d -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle e -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle c -1]  
 Action[name==MoveVehicle f -1]  
 Action[name==MoveVehicle e -1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r 1]

Action[name==MoveVehicle e 1]  
 Action[name==MoveVehicle f 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g -1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle g 1]  
 Action[name==MoveVehicle e -1]  
 Action[name==MoveVehicle r 1]  
 Action[name==MoveVehicle r 1]

Tablero final:

-----					
				f	b
-----					
	a		a		f
-----					
					r
-----					
			e		c
-----					
	g		g		e
-----					
			e		d
-----					



#### 4.3. Solución coste uniforme:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

```
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle c -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
```

Tablero final:

				b	
a	a			b	
				r	r
		e	f	c	d
g	g	e	f	c	d
		e			d

#### 4.4. Solución GreedyBestFirstSearch con GraphSearch y DistanciaMetaHeuristic:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

Action[name==MoveVehicle a -1]	Action[name==MoveVehicle a -1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle r -1]
Action[name==MoveVehicle r -1]	Action[name==MoveVehicle f -1]
Action[name==MoveVehicle e 1]	Action[name==MoveVehicle f 1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle g 1]
Action[name==MoveVehicle e -1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f -1]	Action[name==MoveVehicle g 1]
Action[name==MoveVehicle f -1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]	Action[name==MoveVehicle g 1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle g 1]
Action[name==MoveVehicle e 1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f -1]	Action[name==MoveVehicle g 1]
Action[name==MoveVehicle f -1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle f -1]	Action[name==MoveVehicle f -1]
Action[name==MoveVehicle e 1]	Action[name==MoveVehicle f 1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]	Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]	Action[name==MoveVehicle f -1]
Action[name==MoveVehicle g 1]	Action[name==MoveVehicle f -1]
Action[name==MoveVehicle g -1]	Action[name==MoveVehicle e -1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle f 1]
Action[name==MoveVehicle f 1]	Action[name==MoveVehicle f 1]
Action[name==MoveVehicle e -1]	Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]	Action[name==MoveVehicle c -1]
Action[name==MoveVehicle r 1]	Action[name==MoveVehicle d -1]
Action[name==MoveVehicle d -1]	Action[name==MoveVehicle r 1]

Tablero final:

			f	b	
a	a		f	b	
				r	r
		e		c	d
g	g	e		c	d
		e			d

#### 4.5. Solución GreedyBestFirstSearch con GraphSearch y ObstaculosHeuristic:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

```

Action[name==MoveVehicle d -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle c -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]

```

Tablero final:

			f	b	
a	a		f	b	
				r	r
		e		c	d
g	g	e		c	d
		e			d

#### 4.6. Solución A\* con GraphSearch y DistanciaMetaHeuristic:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

```
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle f -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle c -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
```

Tablero final:

				b	
a	a			b	
				r	r
		e	f	c	d
g	g	e	f	c	d
		e			d

#### 4.7. Solución A\* con GraphSearch y ObstaculosHeuristic:

Tablero inicial:

				b	d
		a	a	b	d
		r	r	c	d
		e		c	
		e	f	g	g
		e	f		

```

Action[name==MoveVehicle a -1]
Action[name==MoveVehicle a -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle r -1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle f 1]
Action[name==MoveVehicle e 1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle d -1]
Action[name==MoveVehicle g -1]
Action[name==MoveVehicle c -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle e -1]
Action[name==MoveVehicle f -1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]
Action[name==MoveVehicle r 1]

```

Tablero final:

				b	
a	a			b	
				r	r
		e	f	c	d
g	g	e	f	c	d
		e			d