Laboratorium
Metody Sztucznej Inteligencji

ćwiczenie 7-8

Planowanie SI w języku PDDL

Jakub Zaleśny
Karol Siomkajło
Grupa TI-1

Ćwiczenie 7

Zadanie 1)
Zamodelowanie i rozwiązanie przykładowych problemów znajdujących się w katalogu DOMAINS.

Problem: road-test
Domain: road-operatiors
Plik: travel.pddl

rozwiązanie:

```
Levels 1
  50 actions 52 propositions
 2
  66 actions 62 propositions
(((CROSS BULLDOZER A D) (CROSS CAR A D)) ((DRIVE CAR D G) (DRIVE BULLDOZER D G)))
```

statystyki:

```
Levels 1
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.062500 sec user, 0.000000 sec system
; cpu time (gc)     0.015625 sec user, 0.000000 sec system
; cpu time (total)  0.078125 sec user, 0.000000 sec system
; real time  0.090000 sec (86.81%)
; space allocation:
;  672,686 cons cells, 6,385,488 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 0.281250 sec user, 0.015625 sec system
; cpu time (gc)     0.187500 sec user, 0.000000 sec system
; cpu time (total)  0.468750 sec user, 0.015625 sec system
; real time  0.480000 sec (100.9%)
; space allocation:
;  3,725,823 cons cells, 71,484,192 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  50 actions 52 propositions
  8 action mutexes  16 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.001000 sec (  0.0%)
; space allocation:
;  11,601 cons cells, 248,672 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
 2
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.109375 sec user, 0.000000 sec system
; cpu time (gc)     0.015625 sec user, 0.000000 sec system
; cpu time (total)  0.125000 sec user, 0.000000 sec system
; real time  0.130000 sec (96.15%)
; space allocation:
;  970,929 cons cells, 9,280,912 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 0.625000 sec user, 0.000000 sec system
; cpu time (gc)     0.187500 sec user, 0.000000 sec system
; cpu time (total)  0.812500 sec user, 0.000000 sec system
; real time  0.828000 sec (98.13%)
; space allocation:
;  5,609,688 cons cells, 106,106,088 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  66 actions 62 propositions
  76 action mutexes  24 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.005000 sec (  0.0%)
; space allocation:
;  38,023 cons cells, 740,000 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
(((CROSS BULLDOZER A D) (CROSS CAR A D)) ((DRIVE CAR D G) (DRIVE BULLDOZER D G)))
```

Level	Time-expansion (s)	Time-bc (s)	Time-mutex (s)	Graph-size (akcje,propozycje)	Mutex-count (akcje, propozycje)
1	0.48	0.001	0.09	50-52	8-16
2	0.82	0.005	0.13	66-62	76-24
suma	1.3	0.006	0.22	--------	--------

Zadanie 2. Modyfikacja sytuacji początkowej i docelowej dla wybranej dziedziny i rozwiązanie zbioru problemów.

Pierwsza modyfikacja:

-Postanowiliśmy dodać dodatkową drogę od g do f, oraz zmieniliśmy sytuację początkową oraz docelową*:*

```
(define (problem road-test)
    (:domain road-operators)
  (:objects a d g f car bulldozer)
  (:init (vehicle car)(vehicle bulldozer)
         (place a)(place d)(place g)(place f)
         (at car a) (at bulldozer a)
         (road d g) (road g d)
         (road g f) (road f g)
         (bridge a d) (bridge d a))
  (:goal (and (at car f) (at bulldozer f))))
```

wyniki:

```
Levels 1
  78 actions 80 propositions
 2
  98 actions 92 propositions
 3
  114 actions 104 propositions
(((DRIVE CAR D G) (CROSS BULLDOZER A D)) ((DRIVE BULLDOZER D G) (DRIVE CAR G F)) ((DRIVE BULLDOZER G F)))
```

Statystyki:

```
Levels 1
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.093750 sec user, 0.000000 sec system
; cpu time (gc)     0.062500 sec user, 0.000000 sec system
; cpu time (total)  0.156250 sec user, 0.000000 sec system
; real time  0.161000 sec (97.05%)
; space allocation:
;  1,581,003 cons cells, 14,689,936 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 0.640625 sec user, 0.015625 sec system
; cpu time (gc)     0.437500 sec user, 0.000000 sec system
; cpu time (total)  1.078125 sec user, 0.015625 sec system
; real time  1.107000 sec ( 98.8%)
; space allocation:
;  8,543,759 cons cells, 164,299,664 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  78 actions 80 propositions
  14 action mutexes  20 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.001000 sec (  0.0%)
; space allocation:
;  17,005 cons cells, 367,168 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
 2
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.140625 sec user, 0.000000 sec system
; cpu time (gc)     0.078125 sec user, 0.000000 sec system
; cpu time (total)  0.218750 sec user, 0.000000 sec system
; real time  0.222000 sec (98.54%)
; space allocation:
;  2,113,341 cons cells, 19,737,440 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 1.140625 sec user, 0.015625 sec system
; cpu time (gc)     0.484375 sec user, 0.000000 sec system
; cpu time (total)  1.625000 sec user, 0.015625 sec system
; real time  1.658000 sec (98.95%)
; space allocation:
;  12,956,028 cons cells, 248,749,304 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  98 actions 92 propositions
  120 action mutexes  32 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.005000 sec (  0.0%)
; space allocation:
;  38,774 cons cells, 838,888 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
```

```
 3
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.250000 sec user, 0.000000 sec system
; cpu time (gc)     0.078125 sec user, 0.000000 sec system
; cpu time (total)  0.328125 sec user, 0.000000 sec system
; real time  0.324000 sec (101.3%)
; space allocation:
;  2,708,939 cons cells, 25,277,784 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 1.343750 sec user, 0.000000 sec system
; cpu time (gc)     0.843750 sec user, 0.000000 sec system
; cpu time (total)  2.187500 sec user, 0.000000 sec system
; real time  2.191000 sec (99.84%)
; space allocation:
;  16,376,474 cons cells, 307,819,592 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  114 actions 104 propositions
  204 action mutexes  40 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.015625 sec user, 0.000000 sec system
; cpu time (total)  0.015625 sec user, 0.000000 sec system
; real time  0.009000 sec (173.6%)
; space allocation:
;  63,618 cons cells, 1,231,040 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
(((DRIVE CAR D G) (CROSS BULLDOZER A D)) ((DRIVE BULLDOZER D G) (DRIVE CAR G F)) ((DRIVE BULLDOZER G F)))
```

Level	Time-expansion (s)	Time-bc (s)	Time-mutex (s)	Graph-size (akcje,propozycje)	Mutex-count (akcje, propozycje)
1	1.107	0.001	0.161	78-80	14-20
2	1.658	0.005	0.222	98-92	120-32
3	2.191	0.009	0.324	114-104	204-40
suma	4.956	0.015	0.707	----------	----------

Druga modyfikacja:

Postanowiliśmy dodać do domenu road-operators nową drogę do przebycia (tunel) którą można przebyć nową akcją (drive-through). Zmieniliśmy również sytuacje początkową i docelową w problemie. Miejscem docelowym jest miejsce ‘i’ do którego można się dostać poprzez tunel z miejsca ‘f’.

```
(define (domain road-operators)
 (:requirements :strips)
 (:predicates (at ?v ?l)
 (road ?l1 ?l2)
 (bridge ?l1 ?l2)
 (tunel ?l1 ?l2)
 (place ?l)
 (vehicle ?v))
 (:action drive
 :parameters (?vehicle ?location1 ?location2)
 :precondition (and (at ?vehicle ?location1)
 (road ?location1 ?location2))
 :effect
 (and (at ?vehicle ?location2)
 (not (at ?vehicle ?location1))))
 (:action cross
 :parameters (?vehicle ?location1 ?location2)
 :precondition (and (at ?vehicle ?location1)
 (bridge ?location1 ?location2))
 :effect
 (and (at ?vehicle ?location2)
 (not (at ?vehicle ?location1))))
 (:action drive-through
 :parameters (?vehicle ?location1 ?location2)
 :precondition (and (at ?vehicle ?location1)
 (tunel ?location1 ?location2))
 :effect
 (and (at ?vehicle ?location2)
 (not (at ?vehicle ?location1)))))
```

```
(define (problem road-test-1)
 (:domain road-operators)
 (:objects a d g f i car bulldozer)
 (:init (vehicle car)(vehicle bulldozer)
 (place a)(place d)(place g)(place f)
 (at car d) (at bulldozer a)
 (road d g) (road g d)
 (road g f) (road f g)
 (bridge a d) (bridge d a)
 (tunel f i) (tunel i f))
 (:goal (and (at car i) (at bulldozer i))))
```

wyniki:

```
Levels 1
  112 actions 114 propositions
 2
  141 actions 135 propositions
 3
  166 actions 156 propositions
 4
  191 actions 177 propositions
(((CROSS BULLDOZER A D) (DRIVE CAR D G)) ((DRIVE CAR G F) (DRIVE BULLDOZER D G)) ((DRIVE BULLDOZER G F) (DRIVE-THROUGH CAR F I))
 ((DRIVE-THROUGH BULLDOZER F I)))
```

Statystyki:

```
Levels 1
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.218750 sec user, 0.000000 sec system
; cpu time (gc)     0.125000 sec user, 0.000000 sec system
; cpu time (total)  0.343750 sec user, 0.000000 sec system
; real time  0.340000 sec (101.1%)
; space allocation:
;  3,195,150 cons cells, 29,280,064 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 2.015625 sec user, 0.000000 sec system
; cpu time (gc)     1.250000 sec user, 0.000000 sec system
; cpu time (total)  3.265625 sec user, 0.000000 sec system
; real time  3.283000 sec (99.47%)
; space allocation:
;  25,385,164 cons cells, 509,240,944 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  112 actions 114 propositions
  14 action mutexes  20 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.004000 sec (  0.0%)
; space allocation:
;  23,329 cons cells, 505,712 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
 2
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.328125 sec user, 0.000000 sec system
; cpu time (gc)     0.171875 sec user, 0.000000 sec system
; cpu time (total)  0.500000 sec user, 0.000000 sec system
; real time  0.493000 sec (101.4%)
; space allocation:
;  4,500,303 cons cells, 41,256,176 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 2.921875 sec user, 0.000000 sec system
; cpu time (gc)     1.921875 sec user, 0.000000 sec system
; cpu time (total)  4.843750 sec user, 0.000000 sec system
; real time  4.895000 sec (98.95%)
; space allocation:
;  38,364,549 cons cells, 761,744,968 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  141 actions 135 propositions
  120 action mutexes  32 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.004000 sec (  0.0%)
; space allocation:
;  27,529 cons cells, 597,944 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
```

```
 3
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.562500 sec user, 0.000000 sec system
; cpu time (gc)     0.078125 sec user, 0.000000 sec system
; cpu time (total)  0.640625 sec user, 0.000000 sec system
; real time  0.648000 sec (98.86%)
; space allocation:
;  6,018,520 cons cells, 55,097,872 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 3.937500 sec user, 0.031250 sec system
; cpu time (gc)     2.140625 sec user, 0.000000 sec system
; cpu time (total)  6.078125 sec user, 0.031250 sec system
; real time  6.121000 sec (99.81%)
; space allocation:
;  48,643,295 cons cells, 947,339,744 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  166 actions 156 propositions
  228 action mutexes  50 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.015625 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.015625 sec user, 0.000000 sec system
; real time  0.007000 sec (223.2%)
; space allocation:
;  63,193 cons cells, 1,373,752 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
 4
Expanding graph...
Finding mutexes...
; cpu time (non-gc) 0.578125 sec user, 0.000000 sec system
; cpu time (gc)     0.250000 sec user, 0.000000 sec system
; cpu time (total)  0.828125 sec user, 0.000000 sec system
; real time  0.819000 sec (101.1%)
; space allocation:
;  7,753,438 cons cells, 71,114,088 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
; cpu time (non-gc) 4.718750 sec user, 0.015625 sec system
; cpu time (gc)     2.546875 sec user, 0.000000 sec system
; cpu time (total)  7.265625 sec user, 0.015625 sec system
; real time  7.309000 sec (99.62%)
; space allocation:
;  58,661,159 cons cells, 1,116,671,120 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
  191 actions 177 propositions
  344 action mutexes  60 proposition mutexes
Backward searching...
; cpu time (non-gc) 0.000000 sec user, 0.000000 sec system
; cpu time (gc)     0.000000 sec user, 0.000000 sec system
; cpu time (total)  0.000000 sec user, 0.000000 sec system
; real time  0.013000 sec (  0.0%)
; space allocation:
;  105,659 cons cells, 2,060,736 other bytes, 0 static bytes
; Page Faults: major: 0 (gc: 0), minor: 0 (gc: 0)
```

Level	Time-expansion (s)	Time-bc (s)	Time-mutex (s)	Graph-size (akcje,propozycje)	Mutex-count (akcje, propozycje)
1	3.283	0.004	0.34	112-114	14-20
2	4.895	0.004	0.493	141-135	120-32
3	6.121	0.007	0.648	166-156	228-50
4	7.309	0.013	0.819	191-177	344-60
suma	21.608	0.028	2.3	----------	----------

Wnioski:

Analizując powyższe wyniki możemy zauważyć, że wraz ze wzrostem liczby poziomów rosną pozostałe statystyki. Nie tylko wzrastają czasy (time-expansion, time-bc, time mutex), wzrastają również liczby akcji i propozycji dla każdego level'u algorytmu.