ARTIFICIAL INTELLIGENCE FOR ROBOTICS II

Assignment II

Task and Motion Planning

Group I

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Submitted to
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Preface

The work is based on Task and Motion Planning which involves the demonstration of a coffee shop. This deals with the movement of a mobile robot in a constrained environment.

Acknowledgements

We take this opportunity to express our sincere thanks to Prof. Fulvio Mastrogiovanni and Prof. Antony Thomas for their guidance and support. We would also like to express our gratitude towards them for showing confidence in us. It was a privilege to have a great experience working under them in a cordial environment. We are very much thankful to the University of Genoa, for providing us the opportunity of pursue M.Sc in Robotics Engineering in a peaceful environment with ample resources. In the end, we would like to acknowledge our parents, friends. Without their support, this work would not have been possible.

Abstract

This assignment is about Task Motion and Planning in which the task is to model mobile robot to work in a constrained environment. In this case, we took a coffee shop scenario were a robot is moving from designated starting point and reaching four regions such as r0, r1, r2, r3 and r4. Also, there are waypoints such as w0, w1, w2, w3, and w4. Robot will move along with four landmarks such as l1, l2, l3, and l4 which is used to detect the robot position, a task and motion planning problem is created. For this assignment, we used popf-tif Planner. The PDDL domain and problem files and external file VisitSolver.cpp are modified in order to accomplish the goal of this assignment.

Contents

1 Introduction

The main focus of the assignment is modeling integrated task and motion planning problems.The scenario considered here is of a coffee shop where a waiter robot needs to serve but we need to keep in mind that the task is carried out in an optimal way. To be specific (from the assignment point of view) we have considered a single-way point to a region.Our primary task was to modify the problem and domain file to obtain the proposed solution.The functions 'triggered, act-cost, dummy' play a key role in the implementations of the semantic attachment.With the help of these functions, the task planner will be able to communicate the start and end to the external model and the final results will be stored in the 'dummy variable' and assigned to 'act-cost'.For the PDDL Domain file,two durative actions are included which are explained in the methodology section.

2 Methodology

This section will describes the methodology and the approach used for this assignment to accomplish a goal.Firstly,We modified the domain and the problem file to achieve the required goal.The scenario being considered here is of a coffee shop. A robot is placed at a certain position in the environment and it must navigate to four different regions, as shown in the Figure 1. The starting position is assumed to be origin.It has to move from one waypoint to the other.Then the Euclidean distance travelled by the robot between two waypoints is calculated.Hence, the waypoints visited by the robots is calculated which gives the optimized solution.

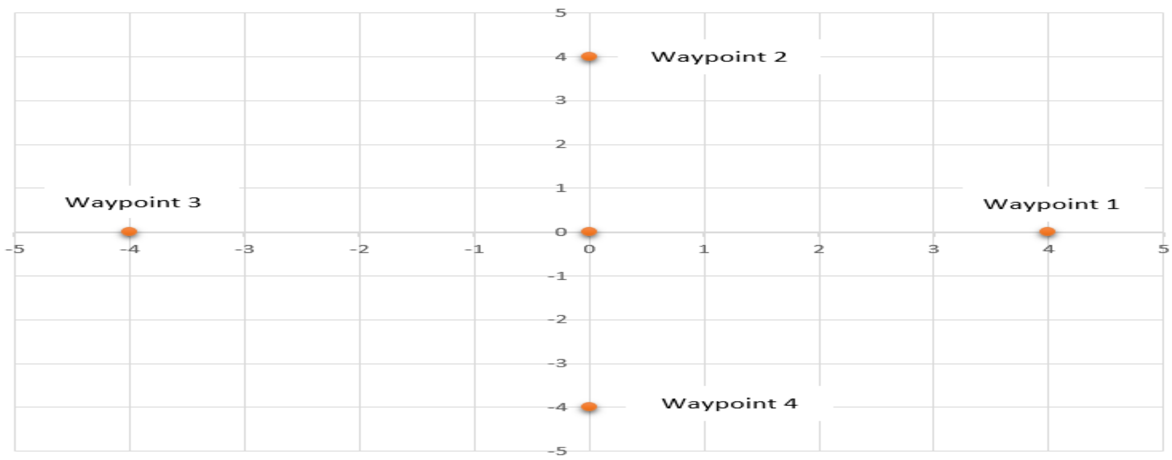

Figure 2.1: Layout of a robot navigating to regions

2.1 Semantic attachment - PDDL

Given below are the instructions for the assignment using these PDDL fluents:

- ***triggered*** : command for executing the motion considered from one waypoint to the other waypoint.
- ***dummy*** : after computing the distance, the cost is computed and assigned to this fluent.

The PDDL code activates the semantic attachment when the fluent '(trigerred?from?to)' is set to a value greater than zero. In any other case, the attachment is turned off.

2.2 VisitSolver.cpp

So the modular integration begins from here. In the beginning, the planner 'popf-tif' initializes the module using the method 'loadSolver() from the class 'visit-Solver'; the other files are parsed here ('waypoints.txt' and 'landmarks.txt'), and the class is initialized; and the fluents involved in the semantic attachment are declared to the planner.The external module is called and the action is executed by the planner.The method 'callExternalSolver()' is called when the semantic attachment is activated. Then the 'triggered' fluent is searched for value greater than zero.If it succeeds, from and to are extracted from the fluent of the string and are used to find out the waypoints.Then, the function executes and then returns the cost associated to the motion in the fluent 'dummy'. Given below are the methods implemented in this class:

- **VisitSolver::get waypoint coordinates** : get the coordinates of a waypoint referring to a region by name
- **VisitSolver::distance between regions** : Euclidean distance between two waypoints
- **VisitSolver::distance-landmark** : gets the closest landmark to a certain position

2.3 PDDL Domain and Problem

For the PDDL part of the assignment, we implemented a domain file and a problem file.In the domain file there is a durative action 'goto-region' which implements the movement part of our problem and 'calc-cost' to calculate the cost. In order for the 'goto-region' to be called at the beginning of the action, the robot must be in the starting position.This action moves the robot from the start region to the end region by setting the predicate (robot in ?v ?from) to false at the beginning and setting the predicate (robot in ?v ?to) to true at the end. In the problem file, the robot starts from the region 0 and has a goal to visits all the other regions (r0,r1, r2, r3, r4).

3 Results

This section will describe the experimental results which shows the *popf-tif* planner. The production of "popf-tif" was carryout in terms not only CPU-time required to find a results but also the quality of plan computed. This will also defines that the Euclidean distance caclulated between two regions of a mobile robot while considering a coffee shop scenario.

In order for the planner to search the best solution that has the act-cost minimized.

The *region-poses* and *waypoint.txt* files describe the planning scenario to highliht the impact of the distance Eucledian function.These files can be modified in order to depict different scenarios.

3.1 Expected Results

By using the default PDDL problem and domain file here presented the default scenario, the results obtained from the planner "popf-tif" is given below:

```
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$ ./popf3-clp dom1.pdd
l prob1.pddl
Number of literals: 10
Constructing lookup tables: [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%] [110%] [120%]
Post filtering unreachable actions:  [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%] [110%]
[120%]
No semaphore facts found, returning
No analytic limits found, not considering limit effects of goal-only operators
Not looking for earlier-is-better time-dependent rewards: no goal limits
None of the ground temporal actions in this problem have been recognised as compression-safe
Initial heuristic = 8.000
b (7.000 | 100.000)b (6.000 | 100.000)b (5.000 | 200.001)b (4.000 | 200.001)b (3.000 | 300.002)b (2.000 |
 300.002)b (1.000 | 400.003);;;; Solution Found
; States evaluated: 9
; Cost: 0.000
; Time 0.00
0.000: (goto_region r2d2 r0 r4)  [100.000]
100.001: (goto_region r2d2 r4 r3)  [100.000]
200.002: (goto_region r2d2 r3 r2)  [100.000]
300.003: (goto_region r2d2 r2 r1)  [100.000]
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$
```

Figure 3.1: Default scenario Result

After making a few changes , we get the following results :

```
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$ ./popf3-clp dom1.pdd
l prob1.pddl
Number of literals: 35
Constructing lookup tables: [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
Post filtering unreachable actions:  [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
No semaphore facts found, returning
Have identified that smaller values of (initiate_robot) are preferable
Seeing if there's a goal limit
((initiate_robot) += 1.000) affects one of the variables
((initiate_robot) = 0.000) affects one of the variables
No analytic limits found, not considering limit effects of goal-only operators
Not looking for earlier-is-better time-dependent rewards: no goal limits
None of the ground temporal actions in this problem have been recognised as compression-safe
Initial heuristic = 8.000
b (7.000 | 50.000)b (6.000 | 50.051)b (5.000 | 100.052)b (4.000 | 100.103)b (3.000 | 150.104)b (2.000 | 1
50.155)b (1.000 | 200.156);;;; Solution Found
; States evaluated: 17
; Cost: 0.000
; Time 0.00
0.000: (goto_region r2d2 r0 r4)  [50.000]
50.001: (cal_cost r2d2 r0 r4)  [0.050]
50.052: (goto_region r2d2 r4 r3)  [50.000]
100.053: (cal_cost r2d2 r4 r3)  [0.050]
100.104: (goto_region r2d2 r3 r2)  [50.000]
150.105: (cal_cost r2d2 r3 r2)  [0.050]
150.156: (goto_region r2d2 r2 r1)  [50.000]
200.157: (cal_cost r2d2 r2 r1)  [0.050]
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$
```

Figure 3.2: Modified Scenario Result

In figure 3.3, is shown change in cost value by the default scenario code (code givem as requiremnet file). In figure 3.2 cost is 0.0and after changes cost is 8.0

```
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$ ./popf3-clp -x /home
/ankurkohli007/Desktop/AI4RO2/popf-tif/popf-tif/domains/visits_domain/dom1.pddl /home/ankurkohli007/Deskt
op/AI4RO2/popf-tif/popf-tif/domains/visits_domain/prob1.pddl /home/ankurkohli007/Desktop/AI4RO2/popf-tif/
popf-tif/modules/visitmodules/build/libVisits.so /home/ankurkohli007/Desktop/AI4RO2/popf-tif/popf-tif/dom
ains/visits_domain/region_poses
Number of literals: 35
Constructing lookup tables: [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
Post filtering unreachable actions:  [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
No semaphore facts found, returning
Have identified that smaller values of (initiate_robot) are preferable
Seeing if there's a goal limit
((initiate_robot) += 1.000) affects one of the variables
((initiate_robot) = 0.000) affects one of the variables
No analytic limits found, not considering limit effects of goal-only operators
Not looking for earlier-is-better time-dependent rewards: no goal limits
None of the ground temporal actions in this problem have been recognised as compression-safe
Initial heuristic = 8.000
b (7.000 | 100.000)b (6.000 | 100.002)b (5.000 | 200.003)b (4.000 | 200.005)b (3.000 | 300.006)b (2.000 |
 300.008)b (1.000 | 400.009);;;; Solution Found
; States evaluated: 17
; Cost: 8.000
; External Solver: 0.000
; Time 0.00
0.000: (goto_region r2d2 r0 r4)  [100.000]
100.001: (cal_cost r2d2 r0 r4)  [0.001]
100.003: (goto_region r2d2 r4 r3)  [100.000]
200.004: (cal_cost r2d2 r4 r3)  [0.001]
200.006: (goto_region r2d2 r3 r2)  [100.000]
300.007: (cal_cost r2d2 r3 r2)  [0.001]
300.009: (goto_region r2d2 r2 r1)  [100.000]
400.010: (cal_cost r2d2 r2 r1)  [0.001]
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$
```

Figure 3.3: Cost Result

But tuning the distance-euc function in VisitSolver.cpp we calculated the actual cost i.e. Euclidian Distance between the two regions as shown in figure 3.3

```
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$ ./popf3-clp -x /home
/ankurkohli007/Desktop/AI4RO2/popf-tif/popf-tif/domains/visits_domain/dom1.pddl /home/ankurkohli007/Deskt
op/AI4RO2/popf-tif/popf-tif/domains/visits_domain/prob1.pddl /home/ankurkohli007/Desktop/AI4RO2/popf-tif/
popf-tif/modules/visitmodules/build/libVisits.so /home/ankurkohli007/Desktop/AI4RO2/popf-tif/popf-tif/dom
ains/visits_domain/region_poses
Number of literals: 35
Constructing lookup tables: [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
Post filtering unreachable actions:  [10%] [20%] [30%] [40%] [50%] [60%] [70%] [80%] [90%] [100%]
No semaphore facts found, returning
Have identified that smaller values of (initiate_robot) are preferable
Seeing if there's a goal limit
((initiate_robot) += 1.000) affects one of the variables
((initiate_robot) = 0.000) affects one of the variables
No analytic limits found, not considering limit effects of goal-only operators
Not looking for earlier-is-better time-dependent rewards: no goal limits
None of the ground temporal actions in this problem have been recognised as compression-safe
Initial heuristic = 8.000
b (7.000 | 100.000)
Euclidian distance travelled between two regions: 2.000b (6.000 | 100.002)b (5.000 | 200.003)
Euclidian distance travelled between two regions: 2.828b (4.000 | 200.005)b (3.000 | 300.006)
Euclidian distance travelled between two regions: 2.828b (2.000 | 300.008)b (1.000 | 400.009)
Euclidian distance travelled between two regions: 2.828;;;; Solution Found
; States evaluated: 17
; Cost: 10.485
; External Solver: 0.000
; Time 0.00
0.000: (goto_region r2d2 r0 r4)  [100.000]
100.001: (cal_cost r2d2 r0 r4)  [0.001]
100.003: (goto_region r2d2 r4 r3)  [100.000]
200.004: (cal_cost r2d2 r4 r3)  [0.001]
200.006: (goto_region r2d2 r3 r2)  [100.000]
300.007: (cal_cost r2d2 r3 r2)  [0.001]
300.009: (goto_region r2d2 r2 r1)  [100.000]
400.010: (cal_cost r2d2 r2 r1)  [0.001]
ankurkohli007@ankurkohli007:~/Desktop/AI4RO2/popf-tif/popf-tif/planner/release/popf$
```

Figure 3.4: Final Results

Finally, after calculation euclidian distance between two regions and we got the final distance in the terms of cost i.e. 10.485.

4 References

[1] Thoma, A., Mastrogiovanni, F and Baglietto, M. (2019). Task-motion planning for navigation in belief space. International Symposium on Robotics Research (ISRR).

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[3] Bernardini, S. (2017). Boosting search guidance in problems with semantic attachments. Proceedings of the International Conference on Automated Planning and Scheduling. Vol. 27. No. 1.

[4] Fox M.; Long D.(2006). Modelling Mixed Discrete-Continuous Domains for Planning. Journal of Artificial Intelligence Research 27 235–297.