Validating FF-Replan vs. a state-of-the-art propabilistic planner in a real world domain

I.C.T.M Speek, A.C. Stolwijk

Seminar Algorithms, Embedded Software, Msc Embedded Systems,
Delft University of Technology
{i.c.t.m.speek,a.c.stolwijk}@student.tudelft.nl

Abstract. This paper argues that for many real life domains dead-ends are the end of the world, and by for example human interaction the goal can still be reached. By relaxing the definition of a dead-end, we argue that for many real life domains a simpler planning algorithm, like FF-Replan, can be sufficient, and that it's not needed to have newer and sophisticated probabilistic planners.

1 Introduction

- Describe probabilistic planning problem
- Introduce planning for uncertainty
- Describe how deterministic classical planners can be used in probabilistic domains and motivate why this is interesting
- Introduce the qualities of replanning and the second planning algorithm
- Describe the need for a new domain for real world applications
- Describe the goal and tools used to reach this goal

2 Problem formulation

- Summarize shortcomings of the previous solutions
- Describe the planning problem
- Argument the choice for 2 current papers to analyze
- Define how we would like to test the planning algorithms in a domain by our choice

2.1 Probabilistic planning

2.2 Replanning

- Describe the determinization, or explain

3 Domain description

- Describe domains from IPPC
- Explain shortcomings
- Evaluate a valuable real-world domain in which we can test 2 papers
- Show PPDDL or RDDL of domain (probabilistic extension of PDDL)

4 Theoretical approach

- Describe how we are using the created domain
- show pseudo code for the 2 papers
- Introduce the improvements (or combination) of the approaches of the papers fitted for the domain

5 Empirical evaluation

- Describe the experiment setup
- Show results for the experiment
- Critically analyze the results
- Compare with results from the original papers

6 Related Work

- Discuss the related work and how their approaches are different
- Discuss the other domains and why our domain adds anything to the community
- Introduce the current state of the art papers that use deterministic approaches for probablistic domains deadling with uncertainty

Probabilistic Planning via Determinization in Hindsight (2008) [16] Hindsight optimization is an online technique that evaluates one-step-reachable states by sampling future outcomes to generate multiple non-stationary planning problems which are deterministic and can be used using search. It reinterprets FF-Replan's [9] strategy randomly generating a set of non-stationary determinized problems and combining their solutions.

Improving Determinization in Hindsight for Online Probabilistic Planning (2010) [17] Hindsight optimization has enjoyed some success for online probabilistic planning. Although it has proven to be effective for many domains, it is computationally expensive. This paper presents significant improvements. 1) a method for detecting potential useful actions, 2) exploit determinism in the domain by reusing relevant plans, 2) improves action evaluation by increasing the chance that at least one deterministic plan reaches a goal.

Probabilistic Planning in the Graphplan Framework (1999) [2] Graphplan is a successful planning algorithm for classical STRIPS domains. This paper explores the extend it can be used in *probabilistic* domains. The paper discusses two variations of Graphplan: PGraphplan and TGraphplan. PGraphplan produces an optimal plan, while TGraphplan produces a sub-optimal plan but it has increased speed. By comparing the speed and quality of the two planners the authors are able to estimate how far they are from the ideal.

Compiling Conformant Probabilistic Planning Problems into Classical Planning (2013) [11]

How Much Does a Household Robot Need To Know In Order To Tidy Up? (2013) [7] For household robot planning, it appears easy, but actually involves uncertainty. For tidying things up objects might not be there, or sensing operations might tell things wrong. This paper looks into conditions for classical planning in a replanning loop in order to solve nondeterministic partially observable open domains This paper looks into conditions for classical planning in a replanning loop in order to solve nondeterministic partially observable open domains.

Progressive heuristic search for probabilistic planning based on interaction estimates (2013) [15] In this paper a probabilistic plan graph heuristic is described which computes information about the interaction between actions and between propositions. This information is used to find better relaxed plans to compute the probability of success. This information guides a forward state space search for high probability, non-branching seed plans. These plans are then used in a planning and scheduling system that handles unexpected outcomes by runtime replanning.

Translation based approaches to probabilistic planning (2013) [12]

Reverse Iterative Deepening for Finite-Horizon MDPs with Large Branching Factors (2012) [1] The IPPC-2011 introduces more realistic MDPs to accomodate real-world systems with large branching factors cause by *natural dynamics* and a limited time for the planner to come up with a policy. For this reason planners needed to be scalable and sensitive to the expected reward maximization. Glutton introduces an offline algorithm based on LR^2TDP and relies on the fact that a succesfull policy can be produced by solving an MDP M(H) for a smaller horizon h. Incrementally solving the sequence M(1), M(2) forms the basis of LR^2TDP. By iterating on the distance from the horizon, data can be reused (and is stored in the cache untill the hash-table is full). The max-reward heuristic finds the largest horizon value h' for which already a heuristic value V is estimated. The cmputation time remains much lower because it runs quickly into states that converged while solving M(h-1). The max-reward computation relies on knowing the maximum reward any action can yield in any state or an upper bound on it.

Probabilistic planning vs Replanning Inspired by the FF-Replan entrance in the IPPC competition, this paper described a probabilistic interestingness quality of domains. It then compares probabilitsic planners with replanners in the different domains to draw conclusions. Classical planning with replanning upon failure when there is so little or so much uncertainty about the world that it is not worth modelling and reasoning about or when goals dynamically change or when the problem is too large to solve at once. Probabilistic planners are more appropriate when avoiding irreparable or costly failures. Probabilistic planning computes a plan that can handle all foreseeable contingencies and is preferable for quick reactions in closed control loops.

The following structural properties are identified for comparing probabilistic planning with replanning:

- 'dead' end states
- the degree to which the probability of reaching a deaad end state can be reduced through choice of actions
- number of distinct trajectories
- presence of mutual exclusion

If there are no dead ends, a replanner will always succeed. It is impossible to improve on the unavoidable dead ends (positive probability of reaching when executing which cannot be reduced without reucing the probability of reaching the goal).

A probabilistic planning problem is considered to be probabilistically interesting if and only if it has all the following structural properties:

- there are multiple goal trajectories;
- there is at least on pair of distinct goal trajectories, τ and τ ', that share a common sequence of outcomes for the first n-1 outcomes, and where τ_{n} and τ'_{n} are distinct outcomes of the same action; and
- there exist two distinct goal trajectories τ and τ' and outcome o $\in \tau$ and o' $\in \tau'$ of two distinct actions a = act(o) and a'= act(o') such that executing a strictly decreases the maximum probability of reaching a state where a' can be executed.

Problems that fail to be *probabilistically interesting* are actually classical planning problems in disguise and for those replanners are more appropriate. A replanner can also perform optimally for probabilistically interesting planning problems whenever the 'most promising' goal trajectory is the correct thing to do. They create several domains to explore the issue of replanning vs. probabilistic planning.

Following existing domains were said to be probabilistically interesting:

- Drive
- Exploding blocksworld
- Pitchcatch
- Schedule
- Tireworld

They conclude by stating that the negative perception of probabilistic planning by the ICAPS community was inaccurate. They state that a synthesis of planning and replanning techniques could make a larger number of probabilistic planning problems pacticably solvable than is currently possible.

7 Domain description

Following the theoretical comparison of probabilistic planning and replanning techniques by Little and Thibauw a baseline test for *probabilistically interesting* domains is proposed. Problems that fail this test were deemed to be classical planning problems in disguise [6]. To validate our planners in a real-world domain we will analyze previous and current domain description for the 'probabilistically interestingness' using this baseline test, adjust them to what we consider as being a real-world domain and test it again. Using these

FF-Replan participated in IPPC-04 (and IPPC-06) solving problems that had been specified in the Probabilstic Planning Domain Description Language (PPDDL) whereas Gourmand has been tested on the set of IPPC-11 problems specified in Relational Dynamic Influence Diagram Language (RDDL)[10].

7.1 Planning problem definition

8 Conclusion

- Conclude on the success of the 2 approaches
- Conclude the work done in the paper
- Hint to some future work developments

9 Some papers

- [4]
- [9]
- [14]
- [16]
- [13]
- [3]
- [12]
- [15]
- [11]
- [8]
- [7]
- [6]
- [5]
- [1]
- [10]

References

1. Mausam A. Kolobos, P. Dai and D.S. Weld. Reverse iterative deepening fro finite-horizon mdps with large branching factors. 2012.

2. Avrim Blum and John C. Langford. Probabilistic planning in the graphplan framework. In *IN PROCEEDINGS OF THE FIFTH EUROPEAN CONFERENCE ON PLANNING*, pages 8–12, 1999.
3. Blai Bonet and Hector Geffner. Planning under partial observability by classical replanning: Theory and experiments. In *Proceedings of the Twenty-Second international joint conference on Artificial Intelligence-Volume Volume Three*, pages 1936–1941. AAAI Press, 2011.
4. Jörg Hoffmann and Bernhard Nebel. The ff planning system: Fast plan generation through heuristic search. *Journal of Artificial Intelligence Research*, 14:2001, 2001.
5. T. Keller and P. Eyerich. Prost: Probabilistic planning based on uct. 2012.
6. I. Little and S. Thibaux. Probabilistic planning vs. replanning. 2007.
7. Bernhard Nebel, Christian Dornhege, and Andreas Hertle. How much does a household robot need to know in order to tidy up? In *Proceedings of the AAAI Workshop on Intelligent Robotic Systems, Bellevue, WA*, 2013.
8. S. Russel S. Srivastava, L. Riano and P. Abbeel. Using classical planners for tasks with continuous operators in robotics. In *Intelligent Robotic Systems: Papers from the AAAI 2013 Workshop*. AAAI Press, 2013.
9. A. Fern S. Yoon and R. Givan. Ff-replan: A baseline for probabilistic planning. 2007.
10. S. Sanner. Relational dynamic influence diagram language (rddl): Language description. 2008.
11. R. Taig and R.I. Brafman. Compiling conformant probabilistic planning problems into classical planning. In *Proceedings of the Twenty-Third international conference on Automated Planning and Scheduling*. AAAI Press, 2013.
12. Ran Taig. Translation based approaches to probabilistic planning. AAAI Press, 2013.
13. Florent Teichteil-Königsbuch. Fast incremental policy compilation from plans in hybrid probabilistic domains. 2012.
14. Florent Teichteil-Königsbuch, Ugur Kuter, and Guillaume Infantes. Incremental plan aggregation for generating policies in mdps. In *Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems: volume 1-Volume 1*, pages 1231–1238. International Foundation for Autonomous Agents and Multiagent Systems, 2010.
15. M.D. R-Moreno Y. E-Martin and D.E. Smith. Progressive heuristic search for probabilistic planning based on interaction estimates. 2013.
16. Sung Wook Yoon, Alan Fern, Robert Givan, and Subbarao Kambhampati. Probabilistic planning via determinization in hindsight. In *AAAI*, pages 1010–1016, 2008.
17. Sungwook Yoon, Wheeler Ruml, J Benton, and Minh B Do. Improving determinization in hindsight for online probabilistic planning. In *Proc. of the 20th Int. Conf. on Automated Planning and Scheduling (ICAPS)*, 2010.