Using XADDs and Symbolic Dynamic Programming to solve POMDPs

Justin Dieter
Email: jdieter@stanford.edu

***Abstract*—In many situations, it is desirable to produce an exact solution to a Partially Observable Markov Decision Process (POMDP) with continuous state and observation given initial belief points. Point Based Value Iteration (PBVI) has been extremely successful in producing approximate point based solutions. Recently, PBVI has been extended using Symbolic Dynamic Programming to provide exact point based backups for very special cases of continuous state and observation POMDPs. This paper gives a survey of this method and analyzes its effectiveness.**

I. Introduction

PBVI has proven to be successful as approximating point based backups for large scale POMDPs [1]. With sampling this can even be extended to continuous observation and state spaces. However, often POMDPs arise with extra structure that can be exploited with a symbolic method to produce exact backups [2]. An open source implementation of this algorithm in Julia is built and published and can be accessed at https://github.com/jdietz31/SDPPOMDP. Also, this paper gives a survey of the workings of the algorithm as well as an analysis of its performance on several sample POMDPs

II. Exetended Algebraic Decision Diagrams (XADDs)

Extended Algebraic Decision Diagrams (XADDs) give an excellent method for representing piecewise functions, as well as performing operations on them [3]. An XADD is a tree. There are terminal nodes that contain an expression representing a real number in terms of the given input variables. There are also, earlier nodes that contain expressions that are either equalities or inequalities and point to a further nodes decided on whether the given expression is true or false. An XADD can represent any piecewise function by starting at a root node and following the decision nodes until a terminal node is reached. While, an arbitrary continuous function can theoretically be represented by an XADD, for the purpose of the specific types of POMDPs being considered, XADDs containing only linear inequalities and linear terminal nodes are sufficient. For example the piecewise continuous function

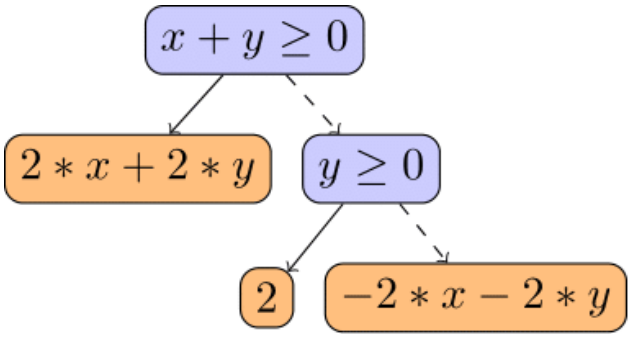

Fig. 1. An XADD version of the piecewise function in equation (1)

$$f(x,y) = \begin{cases} 2x + 2y & \text{if } x + y \geq 0 \\ -2x - 2y & \text{if } x + y < 0 \text{and } y < 0 \\ 2 & \text{otherwise} \end{cases} \quad (1)$$

is compactly represented by the XADD in figure (1).

Conclusion

The conclusion goes here.

References

[1] J. Pineau, G. J. Gordon, and S. Thrun, "Anytime point-based approximations for large pomdps," *J. Artif. Intell. Res.*, vol. 27, pp. 335–380, 2006.

[2] Z. Zamani, S. Sanner, P. Poupart, and K. Kersting, "Symbolic dynamic programming for continuous state and observation pomdps," in *NIPS*, 2012.

[3] S. Sanner, K. V. Delgado, and L. N. de Barros, "Symbolic dynamic programming for discrete and continuous state mdps," in *UAI*, 2011.