

Research Summary

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My main research centers around sequential decision making under uncertainty. In a complex dynamical system useful abstractions of knowledge can be essential to an autonomous agent for efficient decision making. Predictive State Representation, PSR, has been developed to provide a maintainable, self-verifiable and learnable representation of the knowledge of the world. I was very much intrigued by the PSR work, and started working on incorporating PSRs into POMDP control algorithms. Since the representational power of PSRs is equivalent to the belief state representation in POMDPs, one can imagine PSR planning algorithms, working in the context of controlling dynamical systems. In prior work [1] I developed an exact planning algorithm based on known PSR parameters. However, like all other exact algorithms, this approach has exponential complexity in the worst case. In preliminary experiments on a variety of standard domains, the empirical performance seems similar to belief-based planning.

I have also investigated ways of taking advantage of the PSR structure to improve the efficiency of the previously existed exact and approximation algorithms for POMDPs. My recent work on using core belief state in PBVI, Point-Based Value Iteration, [4] shows promising results in terms of value improvement [2]. Using the belief points lying in the intrinsic dimensions of reachable belief simplex allows us to abstract away redundancy in the problem definition where possible. Moreover the basis for the reachable simplex guides the belief point selection of the algorithm to cover the reachable points rapidly.

Working along PSR research, I am currently studying structure exploration in problem domains using mathematical properties of predictive representation. PSR groups together states which behave similarly and it holds the promise of a more compact representation than POMDPs. We point out special cases in which strict reduction in the number of states is obtained by linear PSRs [3].

Another aspect of PSR study is learning the structure of the model. The learning algorithms developed for PSRs so far are based on a suitable choice of core tests. However, knowing the model dimensions (i.e. the core tests) is a big assumption and not always possible. Finding the core tests incrementally from interactions with an unknown system seems to be computationally as difficult as POMDP model learning in general. One interesting line of thought could be considering extensions of tests from sufficiently large number of given histories and discovering the maximum possible core tests .

In summary, the objective of my research is using probabilistic approaches to assist intelligent agents in knowledge representation, reasoning and decision making, specifically to create learning and planning algorithms for predictive state representations.

References

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