

Machine Learning for Reasoning

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The major theme of my PhD thesis is to study systematic boolean solvers empirically, derive insights by analyzing their search patterns, and exploit these insights to develop novel techniques to improve systematic solvers. In one of my PhD projects [1], I studied the spreads of lemma generation during search, and discovered that typically, lemmas are generated in bursts, which are followed by a longer window of depressions in lemma generation. Within a depression window, the search does not learn any lemma. This could be problematic, if the depression window is substantially large, when it spends a considerable amount of resources to perform search actions without learning any lemmas that could lead to space pruning. I addressed this issue by devising a method that performs random exploration to escape from a substantially large depression window quickly. This exploration method is inspired by *Monte-Carlo Tree Search*, a search method to evaluate action ordering in sequential decision making, and is a key ingredient of many reinforcement learning algorithms [4].

Traditionally, the design of new search heuristics for automated reasoning has been driven by expert intuition, and rigorous experimentation. Advances in research have created a new trend of developing heuristics based on machine learning techniques [2]. In the future, I want to explore alternative methods for efficient handling of depression windows based on machine learned knowledge. Specifically, I want to delve into two issues: (i) develop machine learning models to predict the length of window of depression. This model will then help the search to take necessary actions, such as, restarting the search, heuristic value re-scoring, switching between heuristics, if a machine learning model predicts that a substantially large depression is impending. (ii) develop another model to predict search action steps, which is likely to generate a lemma in a depression window that would close the window.

Use of machine learning techniques has revolutionized problem solving in domains which were once believed to be out of reach for traditional search based methods [3]. The automated reasoning community has just started to explore this direction. I anticipate that my contributions on using machine learning in reasoning will yield more efficient solvers.

References

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