SATNet: Bridging Deep Learning and Logical Reasoning using a Differentiable Satisfiability Solver

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1 Summary

The author proposes a new architecture for Integrating logical reasoning within deep learning architectures named SATNet. SATNet is a differentiable (smoothed) MAXimum SATisfiability (MAXSAT) solver that can be integrated into the loop of larger deep learning systems. This (approximate) solver is based upon a fast coordinate descent approach to solving the Semi-Definite Program (SDP) associated with the MAXSAT problem. The approximate solver into end-to-end learning systems, we can learn the logical structure of challenging problems in a minimally supervised fashion. The authors further show how to play 9x9 Sudoku solely from examples, without hard-coding any prior logical knowledge into the model.

2 Strengths of the proposal

1. While many of the "differentiable logical reasoning" systems that we know of require fairly handspecified logical rules, SATNet provides a step towards integrating symbolic reasoning and deep learning, which is considered as a long-standing goal in artificial intelligence.
2. One of the main contribution is to develop and derive a differentiable smoothed MAXSAT solver that can be embedded within more complex deep architectures. More importantly, this solver enables effective end-to-end learning of logical relationships.

3 Weaknesses of the proposal

1. When initializing SATNet, the user must specify a maximum number of clauses that the layer can represent. The authors advise this to be low, but this would imply the representation is still a low-rank structure and may not be feasible in all domains.
2. The optimization in the logical reasoning domain still remains a question as to how the coordinate gradient descent algorithm performs on any random network backbone.

4 Results

The authors have presented a low-rank differentiable MAXSAT layer that can be integrated into neural network architectures and tested the MAXSAT layer approach in three domains whicht are traditionally difficult for neural networks: learning the parity function with single-bit supervision, learning 9x9 Sudoku solely from examples where the results show that they beat the other logical reasoning differentiable satisfiability solver with 98.3% accuracy on a traditional sudoku problem, and solving a "visual Sudoku" problem that generates the logical Sudoku solution given an input image of a Sudoku puzzle with a 63.2%. The differentiable MAXSAT promise in allowing deep networks to learn logical structure without hard-coding of the relationships between variables.

5 Discussion

We should be looking at the possibilities of incorporating known rules into the system(prior logical rules) and exploiting structures of the clause matrix to make the model robust and effective. Also, if author would like to extend his research in unsupervised SDP domain with a fast coordinate descent approach, we can reaffirm the proposal