CS259: Chip Design Automation and Deep Learning - Topic 5
Improving Design Space Exploration with RL and MCTS

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Description

This project explores advanced techniques for design space exploration (DSE) in high-level synthesis (HLS), aiming to enhance methods like exhaustive search, simulated annealing, and genetic algorithms used in GNN-DSE[2] and HARP[3]. Our goal is to demonstrate the effectiveness of our approach by applying it to 10 new programs, generated by modifying loop bounds in HLSyn examples or using entirely different ones. These programs will create a solution space of over 100,000 design points. With a search time limited to 4 hours, we aim to show a clear advantage of our method over the existing search techniques in HARP.

Proposed Approach

Inspired by the AlphaZero system [1] published by Google DeepMind, we propose a method that combines Reinforcement Learning (RL) with the robust Monte Carlo Tree Search (MCTS). Our proposed method contains three main components: MCTS as the search backbone, policy learning with RL, and value estimation. Several factors support the effectiveness of this approach. First, MCTS has proven its robustness in finding optimal solution in large action spaces, which directly addresses a key challenge in design space exploration (DSE)—the overwhelming number of design points. Second, we believe that he MCTS-RL combination can handle changes in loop bounds or new examples in the HLS domain, as it doesn't require human knowledge or fixed heuristic rules.

Implementation Timeline

Week 7 (11/10-11/16): Preprocess datasets, implement framework, design experiments and evaluation criteria.
Week 8 (11/17-11/23): Train the model and execute experiments
Week 9 (11/24-11/30): Evaluate model performance, visualize results, and begin preparing the presentation.
Week 10 (12/1-12/7): Draft the final report, finalize presentation slides, and prepare for the final presentation.
Week 11 (12/8-12/12): Complete the final report and make final adjustments for project submission.

Work Division Between Team Members

Both team members will equally contribute to the literature survey, dataset preprocessing, code implementation, experimental design and execution, evaluation, and report writing.

References

[1] David Silver, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, and Demis Hassabis. Mastering chess and shogi by self-play with a general reinforcement learning algorithm, 2017.

[2] Atefeh Sohrabizadeh, Yunsheng Bai, Yizhou Sun, and Jason Cong. Automated accelerator optimization aided by graph neural networks. In 2022 59th ACM/IEEE Design Automation Conference (DAC), 2022.

[3] Atefeh Sohrabizadeh, Yunsheng Bai, Yizhou Sun, and Jason Cong. Robust gnn-based representation learning for hls. In In Proceedings of the 42nd IEEE/ACM International Conference on Computer-Aided Design (ICCAD), 2023.